

Reflections on Fukushima

NRC Senior Leadership Visit to Japan, 2014



NRC Reflections on Japan

Three years after the March 11, 2011, natural disaster and nuclear accident in Fukushima, Japan, the leadership and staff of the U.S. Nuclear Regulatory Commission (NRC) continue to express their sadness at the loss of life and destruction caused by the earthquake and tsunami. At the same time, the NRC stands in awe and admiration of the resilience and determination of the Japanese people as they rebuild their communities and their lives. The NRC sees Japan as an inspiration to the world and commends its Japanese colleagues for openly sharing the lessons learned from the accident with the international community. The knowledge gained from this work is invaluable and allows both nuclear power plant operators and regulators around the world to better understand the effects of extreme natural events and to take actions to enhance safety.



Air filtering system for the Unit 4 Diesel Generators at the Fukushima Daiichi Nuclear Power Site.



NRC Team and members of the Japan Nuclear Regulation Authority.



Destroyed store in Tomioka, Fukushima Prefecture, Japan.

Acknowledgments

Organizing and executing an international trip for a group of 14 people was a significant task. Many hours were put into the effort, both here in the United States and in Japan, to ensure that this trip was a success. The senior leadership team wishes to extend the following acknowledgement and personal thanks to those who contributed significantly to the successful execution of this activity:

The People and Government of Japan. We want to thank the people and government of Japan for hosting our visit and for providing us with access to the sites. We are grateful to the leadership and staff of the Japan Nuclear Regulation Authority for assistance and engagement with us during this visit. Our strong cooperative relationship allowed this visit to be a success. We especially want to acknowledge and thank the staff and leadership of the Tokyo Electric Power Company, Inc. (TEPCO), especially Mr. Takafumi Anegawa, Secretary-General of TEPCO's Nuclear Reform Special Task Force; Dr. Takeyuki Inagaki, the Daiichi Maintenance Manager during the accident; Mr. Ikuo Izawa, the Daiichi Shift Manager during the accident; Mr. Naohiro Masuda, the Daini site manager during the accident; and Mr. Takeshi Takahashi, the current Daiichi site manager. Your open and candid discussions with us on the events surrounding the accident at Fukushima made the trip invaluable. We also want to thank Dr. Dale Klein, President of the TEPCO Reform Commission and former Chairman of the U.S. Nuclear Regulatory Commission (NRC), for his assistance in facilitating this visit and the staff and management of Toshiba and IHI Corporation manufacturing facilities.

The U.S. Embassy in Tokyo, Japan. We want to convey personal thanks to the staff, especially Christopher Hulick and Junko Nagama, for facilitating this visit during a period when their time and resources were stretched. We also want to thank and acknowledge the translators that were secured for our visit. The support was outstanding.

The Office of International Programs. Many thanks to the team for their support, especially Mary Carter, for ensuring that each of our travel logistics were taken care of and for ensuring that we had ground transportation and interpreters. We want to especially recognize Kirk Foggie, the NRC Office of International Programs Desk Officer for Japan, for providing outstanding support on this trip. Kirk's expert knowledge in Japanese culture, NRC-Japan relations, and layout and locations on the ground and his network of personal relationships in Japan were invaluable to us.

The Japan Lessons-Learned Project Directorate of the Office of Nuclear Reactor Regulation. Many thanks to Dave Skeen and the Japan Lessons-Learned Project Directorate for their support in providing the team with the necessary background on the accident at Fukushima and for information on Japanese regulations. We want to specifically thank Billy Jessup for his assistance with the trip's Sharepoint site.

The Office of Public Affairs. We want to thank the Office of Public Affairs, specifically Roger Hannah, for expert work in capturing and preparing the knowledge management video and arranging various permissions to allow us to capture this activity.

The Office of the Executive Director for Operations. We want to convey our thanks to the staff in the Office of the Executive Director for Operations for its support in this endeavor and to acknowledge Olga Kasaskeris for ensuring that we had the necessary contracts and requisitions in place for travel. We want to especially acknowledge and thank Cindy Rosales-Cooper, our Executive Technical Assistant for Research and International Activities, for taking the vision, organizing it, and executing it successfully. We are grateful for the long hours that you put in on this trip and its subsequent knowledge management activities.



Decontamination/clean-up worker in Tomioka, Fukushima Prefecture, Japan.

Table of Contents

Acknowledgments	i
Introduction	1
Overview of the Accident	1
Purpose of the Visit	1
Overarching Insights from the Visit to Japan	2
In Japan	4
Compilation of Essays – Personal Reflections	
Michael R. Johnson	6
Eric J. Leeds	8
Glenn M. Tracy	10
James T. Wiggins	12
William M. Dean	14
Victor M. McCree	16
Cynthia D. Pederson	18
Marc L. Dapas	20
K. Steven West	22
Scott Flanders	24
David L. Skeen	26
Roger D. Hannah	28
Cindy Rosales-Cooper	30
Kirk Foggie	32



Japan and U.S. Flags at the NRC delegation meeting with the Japanese Nuclear Safety Institute (JANSI).

Introduction

The senior leadership of the U.S. Nuclear Regulatory Commission's (NRC's) reactor and preparedness programs visited Japan from February 16–23, 2014. The purpose of that visit was to provide an opportunity for the group to gain firsthand experiences and insights into the March 2011 accident at the Fukushima Daiichi Nuclear Power Plant site.

This NUREG report is a compilation of personal reflective essays from the group of senior managers and staff that participated in the February 2014 visit to Japan and includes a video of individual interviews and the April 24, 2014 Knowledge Management Seminar: Reflections on Fukushima.

The titles and offices of the senior managers and staff reflect individual positions as of February 2014.

Overview of the Accident

On March 11, 2011, at 2:46 p.m. (Japan Standard Time), the 9.0-magnitude Great East Japan Earthquake (Tohoku) moved the country of Japan approximately 8 feet eastward¹ and dropped its northeastern coastline by about 2 feet.² It occurred 80 miles east of Sendai, Honshu, Japan, at a depth of 18.6 miles and resulted in massive damage to much of Japan's north coastline. This earthquake set off a chain of tsunamis from the Pacific Ocean floor ranging in height from 9 to 38 feet that traveled at approximately 435 miles per hour.³ The largest of these tsunamis destroyed about 347 square miles of the Japanese eastern coastal region and resulted in over 19,000 deaths.⁴ One of these tsunamis, approximately 50 feet (15 meters) in height, flooded the Fukushima Daiichi and Daini nuclear power generating stations within 1 hour after the earthquake and precipitated events that caused the meltdown of Daiichi Units 1, 2, and 3.⁵ A series of tsunamis then inundated the Daiichi site just 8 minutes after the first one.

The reactors at the Fukushima Daiichi and Daini are located 6 miles apart in the Japanese Prefecture of Fukushima. The Daiichi site has six boiling water reactors (BWRs) and is located just outside the towns of Okuma and Futaba. Daini, which is south of Daiichi, has four BWRs and is near the towns of Tomioka and Naraha. Both sites are owned and operated by

¹ Japan's coastline was thrust 2.4 meters eastward (U.S. Geological Survey).

² See the World Nuclear Association Web site at <http://www.world-nuclear.org/info/safety-and-security/safety-of-plants/fukushima-accident/>.

³ The information was obtained from the U.S. Geological Survey.

⁴ None of these deaths were the result of the nuclear accident.

⁵ Daini was hit by the first tsunami wave 37 minutes after the earthquake. Daiichi was hit at 4 minutes after the earthquake.

Tokyo Electric Power Company, Inc. (TEPCO). The reactor units at Daiichi and Daini responded as planned to the earthquake; all units experienced a normal reactor trip, and the safety systems functioned as designed. Approximately 41 minutes after the earthquake, the Daiichi site was inundated with water and debris from the tsunami. The tsunami destroyed the diesel generators, electrical switchgear, batteries, seawater pumps for the main condenser circuits, the auxiliary cooling circuits, and the residual heat removal cooling system. This destruction led to a complete station blackout. To further complicate the situation, Daiichi almost immediately lost the 125-volt direct current batteries for Units 1 and 2 and subsequently for Unit 3, thus leaving the operators without instrumentation, controls, or lighting. Within 4 days, Units 1, 2, and 3 would experience significant core damage. Many official reports document and catalog the core damage.

The International Atomic Energy Agency (IAEA) categorizes the accident at Fukushima Daiichi as a Level 7 event on the International Nuclear Event Scale (the highest on the IAEA scale). It is considered the worst civil nuclear accident in the past 30 years.⁶ Three Daiichi and Daini staff members lost their lives as a result of the earthquake and tsunami; however, no loss of life has been attributed to the nuclear accident at Daiichi.

Purpose of the Visit

The scale of the accident, the actions taken, and the consequences of the Fukushima accident made it very important for this team to visit the Fukushima site and to obtain firsthand insights of the actions taken both during and after the accident by the TEPCO operators and managers, the Japanese regulators, and nuclear industry representatives. From an historical perspective, the greatest changes to the U.S. nuclear regulatory system were instituted in the aftermath of the 1979 accident at Three Mile Island (TMI). For example, after the accident at TMI, the NRC did the following:

- Focused on all human aspects of nuclear power operations. TMI illuminated the need for operators and managers to ensure that plants are staffed with properly trained operators and that qualified engineers are available on site in responsible positions to help diagnose and cope with a severe accident.
- Enhanced the analysis and communications of operating

⁶ Note that the 1986 Chernobyl accident is considered the worst civil nuclear accident in history. The 1979 accident at TMI is considered the worst civil nuclear accident in the United States.

experience between the NRC and industry. After TMI, the NRC began to systematically use its generic communications process to issue bulletins and generic letters to licensees to apprise them of emerging issues with generic implications.

- Changed its internal processes and practices, including revisions to the emergency response procedures and staffing and to the NRC's inspection and oversight process. These changes improved the emergency preparedness and response program, for example through the issuance requirements, and also included the staffing of resident inspectors at each nuclear power plant site. Before TMI, the NRC had resident inspectors at only some sites.

Within days of the accident at Fukushima, the Commission convened a Near-Term Task Force of experts to review the accident and to make recommendations to enhance reactor safety in the United States. The task force issued its recommendations in July 2011, and the NRC organized a Japan Lessons-Learned (Fukushima) Steering Committee and subsequently a Directorate with staff to implement these lessons. The team of senior managers that traveled to Japan represents the majority of the Fukushima Steering Committee. Additionally, these senior managers are responsible for leading the NRC's efforts to ensure that the U.S. nuclear power plant fleet is adequately prepared to withstand or mitigate an accident scenario similar to what Fukushima experienced. The responsibility to ensure that U.S. industry has taken the necessary steps to implement the lessons learned from Japan rests within the programs of these leaders.

The timing of this visit was important as well. Although the accident at Fukushima has many lessons learned, the NRC has primarily focused on issuing orders, initiating rulemaking, and requesting information to address several of those lessons that the Commission determined that the agency should address without delay. The NRC is currently at a critical time in its post-Fukushima activities because the staff is in the process of reviewing licensee plans to meet orders to ensure that they are sufficient, and the agency will soon be engaging licensees to verify their implementation of these orders at all sites.

Overarching Insights from the Visit to Japan

To properly reflect on and compare insights, the senior management team built time into its schedule for reflective discussions. During these discussions, the team aligned around the following three key messages from its week in Japan:

1) Ensure that the nuclear industry and the NRC are prepared for the unexpected.

The team came back from Japan with the overwhelming need to ensure that the nuclear industry and the NRC are prepared for the unexpected. Although the agency recognized the importance of preparing for the unexpected within days of the accident, the experiences and insights that the team gained on this trip reemphasized its significance. The Daiichi Units 1 and 2 shift manager during the accident told the team that he and the other operators at Daiichi "had been trained and were convinced that what happened could have never happen[ed]." He further stated, "What we saw was much worse!" At the 2009 30th anniversary of the accident at TMI, Edward Frederick, the TMI Unit 2 reactor operator who turned off the makeup pump that partially caused the accident, stated that "the entire industry, NRC included, [were] completely unprepared for what...happened" at TMI. The accidents at TMI and Fukushima reinforce a common insight that the nuclear industry and the NRC must prepare for the unexpected by accomplishing the following:

- Recognize and accept that the unexpected can occur and remain vigilant to identify and address previously unrecognized hazards and vulnerabilities, and address these hazards and vulnerabilities in a timely manner.
- Ensure the development of strategies (e.g., procedures, hardware, trained personnel) to address the unexpected.
- Ensure the capability of installed equipment to provide time to execute these strategies.

2) Ensure that licensees have a deep understanding of their plants and that both the NRC and the industry maintain technical expertise.

The team developed a greater appreciation for the importance of ensuring that licensees have a deep understanding of their plants and that both the NRC and the industry maintain technical expertise. In the meetings at TEPCO headquarters, Mr. Takafumi Anegawa, Secretary General of TEPCO's Nuclear Reform Special Task Force, told the team that one of TEPCO's main lessons learned from Fukushima was that it has to invest more in training to ensure that operations staff and managers understand the plant. He said that before the accident, TEPCO functioned as a management company with little technical expertise and relied heavily upon contractors to know the design and details of the plant and to perform maintenance and plant modifications. As a result, TEPCO had only a small number of employees who really knew the Daiichi plant at a detailed design level. This situation is a striking comparison to one of the main lessons learned from the TMI accident—"the need for operators and managers to ensure that plants are staffed with properly trained operators and that qualified engineers are available onsite." The NRC must ensure that:

- The agency maintains a core group of managers and staff (the right people with the right knowledge and experience), in house to be able to react quickly and make logical decisions during an accident, and who understand the importance of the modifications, procedures, and training made at individual plants as part of the Fukushima lessons learned.
- Licensees maintain a core group of managers and staff (the right people with the right knowledge and experience), in house to be able to react quickly and make logical decisions during an accident, and who understand the importance of the modifications, procedures, and training made at individual plants as part of the Fukushima lessons learned.

3) Ensure that U.S. licensees fully implement, maintain, and appropriately exercise the measures that will be established based on the post-Fukushima actions directed by the NRC.

Lastly, the senior management team returned home with a greater resolve to ensure that U.S. licensees (1) fully implement, (2) maintain, and (3) appropriately exercise the measures that will be established based on the post-Fukushima actions required by the NRC. The Near-Term Task Force recommendations, as modified and expanded by the Fukushima Steering Committee, provide a logical set of activities that the NRC and industry need to implement to enhance safety at U.S. nuclear power plants. Although significant progress has been made to define the necessary safety enhancements since 2011, the tangible implementation of those enhancements, although they are currently underway, will not be completed for a period of time. The NRC needs to ensure that the plans are (1) appropriate, (2) completed in a timely manner, and (3) maintained.

In addition to its focus on the above three overarching insights, the team had the following personal reflections and thoughts on the additional key insights. The personal reflective essays of each person who traveled to Japan further discuss these insights.

- Achieve the appropriate balance between prevention and mitigation.
- Maximize the lessons learned from Japan into the NRC's own regulatory framework.
- Ensure that licensees are appropriately protected against natural hazards.
- Ensure that the NRC maintains a regulatory culture that does not disincentivize operators/industry to make improvements.
- Reinforce the incident response decisionmaking regime with the NRC's Federal partners.
- Take action to prevent and to mitigate the unexpected accident to preserve the public trust.
- Consider whether significant gaps exist in the NRC post-Fukushima approach for U.S. licensees.
- Consider the unexpected offsite consequences.
- Recognize that the Japanese did their best under extremely challenging circumstances.
- Recognize that we should not expect heroism.
- Reflect on the international cooperative aspects of the NRC's engagement with Japan.
- Consider the approaches implemented in other countries.

In Japan

The senior management team began its visit in Japan with tours of Toshiba's manufacturing facilities in the Yokohama region of Tokyo. This portion included a tour of the IHI Corporation nuclear component manufacturing facility. The second day afforded a visit to the seven-unit Kashiwazaki-Kariwa site that is located on the west side of Japan. This site has undergone significant safety upgrades as a result of a very large earthquake in 2007 and is currently implementing additional changes in response to the Fukushima accident. The team spent the third day in Tokyo in meetings with the Japanese Nuclear Regulation Authority (JNRA), the NRC's counterpart agency; the newly created Japanese Nuclear Safety Institute, which is modeled after the U.S. industry's Institute of Nuclear Power Operations; and TEPCO's headquarters office. The team visited the four-unit Fukushima Daini site on the fourth day and the six-unit Fukushima Daiichi site on the fifth day.

Nearly 3 years after the earthquake and tsunami, life has returned to normal in many ways for the vast majority of people. On the train ride from Tokyo to Iwaki, the group saw business men going to work in their suits with their briefcases or backpacks, blue collar workers going to work in their work clothes with their lunch kits, and children in their school uniforms on their way to school.

On the 18-mile bus ride from Iwaki city to J-Village, which is located just outside the 12-mile exclusion zone (approximately 14 miles from the Fukushima Daiichi site), the team saw that the Japanese had repaired much of the damage from the earthquake and tsunami. Just outside J-Village, which was a training center in Japan for the men's and women's national soccer teams before the accident, most roads have been rebuilt, homes and businesses have been repaired and are reopened, and boats and cars that were deposited along the coastline by the tsunami have been removed. However, many reminders of the destruction are still evident. J-Village is now the staging area for workers going to the Fukushima Daiichi site. There are remnants of the many once green soccer fields that are now muddy parking lots for the 4,000 workers who are bused to the plant site every day or that are being used as storage areas for equipment and material bound for the site.

After each member of the visiting NRC team received a whole body count, the team members boarded another bus to the Fukushima site. The bus took them through the police barricade on the road to the plant site. Driving to the site on this road enabled team members to see abandoned rice paddies that are now overgrown with weeds and grass. Many of the abandoned fields now have stacks of large black garbage

bags of contaminated soil or long rows of green tarps covering contaminated soil, plants, and other material. Driving through the town of Tomioka, which is outside Daini and is only about 8 miles from Fukushima Daiichi, allowed team members to see concrete evidence of earthquake damage to several buildings with broken terra cotta roof tiles, cracks in some buildings, some houses that were visibly leaning, awnings that had fallen off, broken windows, empty store fronts with products still on the shelves, and diners with plates and silverware on the tables. Near the beach front on the lower end of town where the tsunami struck, a once thriving train station had been swept away; only the concrete platform and the railroad track remain. The back end of a car that was picked up by the tsunami and smashed into the front of a beachfront restaurant still protrudes from the restaurant onto the sidewalk.

The following pages of this NUREG knowledge management report contain the personal reflections of each member of the group of NRC senior managers and staff who traveled to Japan on this trip. Some of the insights and reflections are similar; however, these similarities reinforce the overarching insights that the team developed while visiting Japan.



Temporary cables at the Fukushima Daini Nuclear Power Site.



Abandoned stores in Tomioka, Fukushima Prefecture, Japan.



NRC Team looking at Units 3, 2, and 1 of the Fukushima Daini Nuclear Power Site.

Michael R. Johnson

Deputy Executive Director for Operations



I had entertained the idea of travelling to Japan with the office directors and regional administrators for some time. I knew it would require a significant investment of resources at a time when we could potentially face another Government shutdown or sequester. We were also dealing with many high-priority issues,

including the oversight of operational safety and security of the operating units, implementation of Fukushima lessons-learned orders, requests for information (the mitigating strategies order and seismic and flooding reanalyses), and oversight of units under construction. However, we pressed ahead, and I was rewarded with one of the most impactful experiences of my career.

Of course, the earthquake, tsunami, and resultant accident at Fukushima had been well chronicled by the time we arrived, and actions to address the lessons learned are well underway by the NRC and our licensees. Yet, riding through towns and past houses and businesses that still lay abandoned with weeds growing up through cracks in parking lots and sidewalks; seeing the damaged plants at Fukushima Daiichi; speaking with operators and supervisors who were on site on March 11, 2011; and visiting Fukushima Daini (which faced similar challenges as a result of the earthquake and tsunami but avoided an accident) strengthened my resolve to ensure that improvement actions are effective and lasting.

I left with many insights, but the one that is most prominent for me came as a result of an afternoon meeting we had at TEPCO headquarters. We spoke with the maintenance supervisor who was on duty in the Emergency Response Center at Fukushima Daiichi and the shift supervisor who was on shift at the time of the earthquake and tsunami. They described the tremendous challenges that they faced during the first 100 hours. In the Unit 1 and 2 combined control room with no lighting or instrumentation and with little communications; in the plant amid debris in darkness, high temperatures, and high radiation; and onsite during repeated aftershocks and tsunami warnings, the operators worked heroically under great stress and fatigue to restore functions and to attempt to mitigate the damage. The challenges they faced were unexpected and unprecedented. The shift supervisor (speaking through an interpreter) stated, “[Before the accident] we frequently

conducted drills. I was convinced we would never see anything worse. What happened was totally bigger. Today my view is 180 degrees different. I have come to know, you must always be prepared for something worse.”

We must prepare for the unexpected. Implied in this statement is recognition of the fact that the unexpected can occur. Certainly the accident at Fukushima Daiichi demonstrates this with unmistakable clarity. To prepare, we must be continuously vigilant to uncover new information and to understand emerging potential safety or security concerns, and we must take appropriate actions to address them. We must ensure that plants are adequately protected against expected hazards. TEPCO, in its lessons-learned report states that the accident at Fukushima Daiichi might have been avoided through ample preparation. In addition, we must ensure that plants have equipment and strategies that can be successfully employed to address challenges beyond what is expected.

Just 12 kilometers south of Fukushima Daiichi, Fukushima Daini also struggled with the earthquake and tsunami. At Daini, operators developed and implemented strategies to deploy portable equipment and materials “on the fly,” enabling the plant to survive the unexpected. In an accomplishment that is legendary, the site superintendent deployed 200 people, who successfully laid 9 kilometers of temporary cable in 30 hours in order to restore reactor core cooling from electrical sources on site that survived the flooding. For me, this reemphasizes the importance of the actions that the Commission directed through orders that plants develop, implement, and maintain strategies and equipment to maintain and restore core cooling, containment, and spent fuel pool cooling following beyond-design-basis external events. In addition to the importance of the use of strategies and portable equipment at Daini, I noted that the installed equipment that remained functioning following the earthquake and tsunami (although slight) contributed to the successful efforts of plant personnel to mitigate the event. For example, control room lighting, instrumentation, and communications between the control room and the Emergency Response Center were maintained throughout the event. Although in no way diminishing the enormity of the challenges faced, the availability of this equipment helped the operators and personnel maintain awareness of plant parameters, develop restoration strategies, and determine the effectiveness of actions being implemented. Thus, Fukushima Daini also reemphasizes the important role that installed plant equipment plays in enabling plants to survive the unexpected.



Daiichi Unit 3.

“...we must be continuously vigilant to uncover new information and to understand emerging potential safety or security concerns, and we must take appropriate actions to address them.”

Michael R. Johnson



Paper cranes (Japanese symbol of hope) made by NRC employees on display in the Emergency Response Center at Fukushima Daiichi.”

Eric J. Leeds,

Director of the Office of Nuclear Reactor Regulation



At the end of almost every day of our visit, the group of senior NRC managers took time to reflect, to discuss what we learned, and to record our thoughts. The trip, what we saw and what we experienced, reinforced to us that the Fukushima lessons learned that we are requiring the industry to implement are critical to

ensure an accident like the one at Fukushima does not happen in the United States. Our message is that we have to ensure that the licensees fully implement, maintain, and exercise the Fukushima lessons learned. Those words—fully implement, maintain, and exercise—were chosen very carefully, with distinct meaning and relevance.

First, “fully implement” means that we are resolved that each licensee must implement each Fukushima lesson learned thoroughly and completely. Because these actions will take years to fully implement, we must ensure that we do not allow the licensees to lose focus or to allow the business of the day to obscure our vision. Following the TMI accident, the NRC published a listing of TMI action items in NUREG-0737, “Clarification of TMI Action Plan Requirements,” issued November 1980, to ensure that all the actions required were captured for knowledge management. About 7 or 8 years later, a member of Congress asked the agency to provide a status update of the TMI action items. The staff had not kept adequate records and had to scramble to recreate an accounting. Once the dust settled, we found that although many licensees had fully implemented the TMI lessons learned, some had not. We are resolved that we do not repeat that experience with the Fukushima lessons learned.

What we mean by “maintain” is that once the lessons learned have been implemented, the NRC staff should routinely inspect and ensure that the equipment, procedures, and capabilities developed by the licensees remain intact. Once again, past experience has indicated that not all licensees will maintain these actions without NRC oversight. Following the Fukushima accident, the NRC issued a temporary instruction to our inspectors to examine the equipment and procedures, under Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54(hh), that had been established after the

terrorist attack of September 11, 2001. Our inspectors found that some licensees had not maintained the equipment. Hoses were missing, pumps had been moved, and modifications at some plants had been made to the plant so that the supplemental equipment could no longer be used to perform its intended function. We must ensure that licensees maintain the equipment, procedures, and capabilities that are required in response to the Fukushima accident.

And finally, we expect licensees to exercise the mitigating strategies and other procedures and processes learned from the Fukushima accident on a regular basis. While surveying the damage at Fukushima Daiichi, we were struck by the operators’ reports that they had never contemplated many of the strategies they tried to implement to save the plant. They had never practiced these emergency actions. Operators could not find the connections to allow emergency equipment to provide power or water. Many operators were asked to use equipment and take manual actions that they had never before attempted. The first time that an operator is required to use an emergency procedure cannot be on the day of the event. We must ensure that licensees regularly exercise the strategies and emergency procedures developed in response to the Fukushima accident. This course of action is the best method to successfully save a stricken nuclear power plant.



Snow on the Japanese countryside on the way to the Kashiwazaki-Kariwa Nuclear Power site.



NRC delegation inside Unit 4 of the Fukushima Daiichi Nuclear Power Site.

“The first time that an operator is required to use an emergency procedure cannot be on the day of the event. We must ensure that licensees regularly exercise the strategies and emergency procedures developed in response to the Fukushima accident.”

Eric J. Leeds



Water storage tanks at the Fukushima Daiichi Nuclear Power Site.

Glenn M. Tracy

Director of the Office of New Reactors



Our comprehensive tour of key reactor sites and our extensive interactions with Japanese officials regarding the details and impact of the March 2011 earthquake and subsequent Fukushima Daiichi accidents are, without question, the most impactful experiences I have had during my 32 years in the nuclear field. I feel very fortunate to work for an agency

that provided me this unique and important experience as a regulator.

Like my NRC colleagues, the images of the damaged reactor site and nearby uninhabitable villages and the horrific conditions under which operators displayed their courage and conviction through their heroic attempts to prevent core damage and mitigate the consequences of the multiple-unit accidents are indelible.

Several themes from this experience resonated with all of us, including ensuring that (1) the NRC and industry are prepared for the unexpected, (2) our licensees fully implement, maintain, and realistically exercise the post-Fukushima actions directed by the agency, and (3) the NRC and industry maintain the depth and breadth of their technical expertise. Additionally, my continued reflections lead me to emphasize certain matters I consider particularly important.

First, time during any crisis is both limited and precious. Our Japanese colleagues repeatedly emphasized that, without question, time was the most important factor during their response following the massive unexpected tsunami. Time is an asset; the lack of time is an overwhelming handicap. The very nature of any crisis includes uncertainty, complexity, and frequently agony, combined with time restrictions during which action must be taken to avoid disaster. Planning for a future crisis mandates addressing the critical need for ample time amidst unforeseen obstacles.

Second, when adding defense in depth to nuclear reactors, we must strive to achieve the proper balance between hardened, installed safety systems and portable backup equipment. The insights I gained from our tour and detailed discussions with management at Fukushima Daini emphasized for me the limitations and potential vulnerabilities of an overreliance on portable equipment. Our Japanese colleagues deem

the prevention of a core melt at Fukushima Daini, through the use of portable assets, as “a close call,” and I agree. They described the extraordinary, innovative, and heroic actions to implement solutions to avoid core meltdown. The complexity of the challenges that they faced highlight the difficulty and limitations in implementing operator mitigating actions with portable equipment. They also demonstrate the need for time to successfully complete such actions amidst unexpected challenges or extreme conditions. Clearly, the availability of hardened systems, installed plant safety systems, or alternate hardened systems can provide crucial additional time for operators in a crisis.

Lastly, the NRC staff should continue to closely monitor and reflect upon the actions that our international partners have taken in response to the Fukushima Daiichi accident. Several nations have installed additional flooding barriers and alternate safety equipment, have ensured the timely availability of portable equipment, have established associated system connections, and have exercised their use with local responders. The actions of our international partners can continue to inform our own regulatory actions with respect to additional defense in depth and the proper balance for installed or portable equipment. These insights can also help focus our timely, efficient, effective, and realistic regulatory action for any new proposals to address seismic and flooding requirements or other safety measures.

In conclusion, the energy source we oversee demands respect. The potential consequences to our communities, loss of public trust, and costs for postaccident cleanup are significant—as is our duty to protect the public and the environment.



Unit 4's Spent fuel pool at the Fukushima Daiichi Nuclear Power Site.



Original signage at the J-Village National Soccer Training Center.

“The energy source we oversee commands respect. The potential consequences to our communities, loss of public trust, and costs for post-accident cleanup are significant— as significant as is our duty to protect the public and the environment.”

Glenn M. Tracy



The NRC Team at the Fukushima Daiichi Unit 4 Spent Fuel Pool.

James T. Wiggins

Director of the Office of Nuclear Security and Incident Response



The visit to the Daiichi plant and its surroundings provided us with the opportunity to see what TEPCO has accomplished since the accident. Although we should not downplay the importance of the accident and the effects of the accident on the plant, the staff, and the nearby population, TEPCO has clearly done much

to stabilize the units, to lower the state of contamination on site, and to recover large parts of the surrounding area to the point at which the population can reenter the area for at least part of the day. The team came away from the visit impressed with the dedication that the site staff displayed during the event and with what TEPCO has accomplished over the last 3 years. The team heard a number of accounts by TEPCO staff that were present during the early stages of the event that spoke to the resilience of members of the staff as they were forced by circumstances to perform tasks that could be characterized as heroic and for which the outcome of those actions was highly uncertain. We heard of the long hours of continued work, without relief, in harsh environments on site. During our visit, we observed that the site staff appeared to be diligently focused on the continuing need to address radioactive water at the facility and to continue actions that were moving the site toward decommissioning. We saw no signs of complacency in the site staff's approach.

For me personally, upon getting to the site, I expected to see much worse conditions both on site and off site. Likely, the difference between the conditions I saw and what I expected speak to the industriousness of the plant staff and the fundamental ruggedness of the designs of the facilities. The Daiichi plant survived the earthquake reasonably well because of the inherent conservatism in the design of its systems, structures, and components; the tsunami drove the problem, causing the long-term loss of electrical power, instrumentation, and eventually core cooling and the containment. Hydrogen explosions likely caused by core damage significantly affected three of the units. However, the spent fuel pools, including those in the affected units, all remained intact. The local population evacuated the area before people received significant dose. Therefore, at some level, there was success among all the failures.

At the Daiichi plant, we learned from a discussion with a TEPCO manager that, before the event, the Japanese regulator, the Nuclear and Industrial Safety Agency, had imposed a facility change process that, in his opinion, provided TEPCO with a disincentive against making safety and reliability improvements to the plant. He told us that, for a change to be made at the facility, the regulator required the licensee to submit for review an analysis that must explain why the change was necessary and why the prior condition was “wrong.” To the team, this seemed to introduce a dynamic in which the licensee would have to indicate or admit that its prechange design or operations were unsafe, which is something that licensees are not apt to do. This regulatory process seemed to provide an unintended barrier to making enhancements. The team did not try to validate this assertion by the TEPCO manager. However, we came away from the discussion with a reminder that well-intended regulatory actions might lead to significant unintended effects. We need to be careful that our processes promote enhancements to safety and security and that they do not introduce unnecessary, artificial, or hidden barriers.



Corroded switch gear at the Fukushima Daiichi Nuclear Power Site.



Aerial photo of the Daiichi site projected onto the floor at the TEPCO Fukushima Visitor and Educational Center.

“We need to remember that well intended regulatory actions might lead to significant unintended effects. We need to be careful that our processes promote enhancements to safety and security and that they do not introduce unnecessary, artificial, or hidden barriers.”

James T. Wiggins



Contaminated waste storage in Fukushima Prefecture.

William M. (Bill) Dean

Regional Administrator of Region I



Regional administrators do not travel internationally very often due to the necessary focus we must maintain on the safety and security of the NRC's reactor and material licensees. Therefore, the trip that the regional administrators made to Japan with other NRC senior managers was a unique experience on many

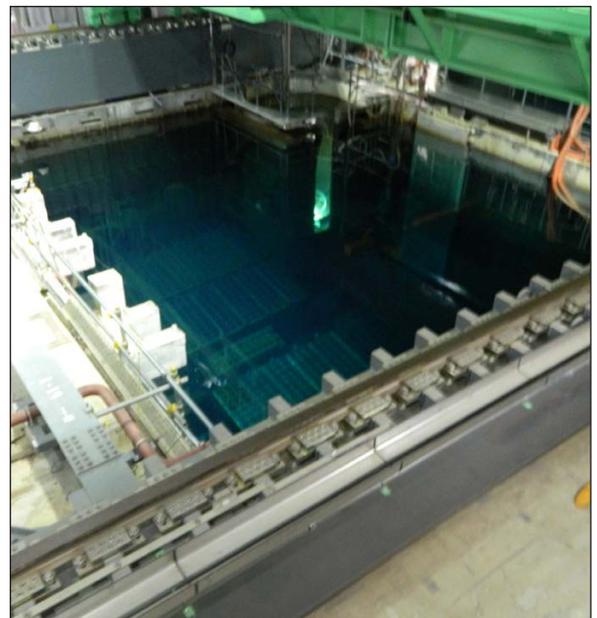
levels. Most importantly, it enabled us to observe firsthand the far-reaching impacts of a nuclear disaster—not only its physical effects on the facility and the surrounding countryside but also its impact on a nation's psyche and its people. Every organization we met with, whether they represented industry or the regulator, offered us a heartfelt apology for their role in allowing the accident to occur and for adversely affecting the worldwide nuclear community, revealing how deeply this event has affected the country.

What resonated with each and every one of us is that we cannot allow a Fukushima-like event to occur in the United States. What we saw and heard bolstered my confidence that the NRC has appropriately focused its attention on the most important lessons learned from Fukushima. I firmly believe that the NRC's regulatory framework and its dedicated and knowledgeable staff have provided a great service to our Nation in fulfilling our public health and safety mission over the years. However, as Fukushima taught us, we cannot predict how or when the next "unthinkable event" will occur. Therefore, the ongoing efforts to provide for greater defense in depth and to enhance safety through the implementation of post-Fukushima lessons learned will make nuclear power plants in the United States more resilient when the unexpected occurs. These efforts will also ensure that we do not have to rely on heroic efforts of plant operators, such as the individuals who devoted themselves to combatting the challenges that they faced at Fukushima Daiichi and Daini.

The agency's primary mission-essential function is to monitor and respond to safety and security events involving NRC-licensed facilities or associated materials. The Nation's incident response framework has evolved through the years, most recently following events, such as the terrorist attacks of September 11, 2001; the Gulf oil spill; and hurricanes Katrina and Sandy. The NRC's incident response framework has likewise evolved. For example, the recent comprehensive

emergency preparedness (EP) rulemaking incorporated a number of changes based on lessons learned from the 2001 terrorist attacks and our (and the Federal Emergency Management Agency's (FEMA's)) experiences over decades of conducting EP exercises and responding to events. Similarly, we are pursuing changes to our EP regulations to incorporate lessons learned from Fukushima. Most notably, these changes involve how a licensee can better (1) respond to a multiple-unit event and (2) harmonize emergency operating procedures with severe accident management guidelines or other similar procedures.

For me, this trip underscored how important it is to have a well-structured radiological incident response regime that is periodically exercised, including the use of postulated events that exceed a plant's design basis. We frequently engage with licensees, FEMA, and our State and local emergency response organizations in exercises that do this very thing. Although this well-practiced radiological EP framework has not been necessary during an actual response to a radiological event, it has been a significant contributor in the successful response to several real-life nonradiological events. However, we also need to periodically engage with our other Federal partners to ensure that national decisionmaking protocols are well understood, especially as they pertain to the roles and responsibilities of local officials, States, the NRC, and the rest of the Federal Government. The national exercise involving an incident at a nuclear plant, which is scheduled to occur in 2015, is a perfect example of the type of evolution that will support this need.



Unit 4's Spent fuel pool at the Fukushima Daiichi Nuclear Power Site.



NRC delegation with 2 of the Fukushima Fifty heroes at the TEPCO headquarters in Tokyo, Japan.

“A highlight of the trip was to hear the first-hand accounts of what transpired at Fukushima Daiichi during the early hours and days of the accident from Mssrs. Inagaki and Izawa, who were among the heroic ‘Fukushima Fifty’.”

William M. (Bill) Dean



Cables and hoses at the Fukushima Daiichi Nuclear Power Site.

Victor M. McCree

Regional Administrator of Region II



What I saw and heard during our visit to Japan was truly unforgettable. Among the many things that made a lasting impression on me were the vivid personal accounts of what occurred when the earthquake and tsunami struck the Fukushima Daiichi and Daini sites. As I listened to people's moving personal accounts of that

day and the days that followed, the anguish in their voices was apparent. I learned that the operators at Daiichi and Daini were faced with unprecedented plant conditions, including the loss of normal and emergency alternating current power (causing station blackout). At Daiichi, the event included the loss of direct current power, requiring operators to work in total darkness with no plant control room instrumentation.

In their efforts to mitigate the impact of the event, workers displayed remarkable professionalism, perseverance, and heroism as they labored under extremely dangerous working conditions. Numerous strong aftershocks occurred, and the threat of additional tsunamis persisted. Operators and emergency responders worked for days without sleep and had to combat fatigue and frustration from frequent setbacks. At Daiichi, the onsite hazards and elevated radiation levels were a particular concern. As a result, many operators expressed fear of being injured or killed. Despite these fears, they showed remarkable courage in carrying out their duties to the best of their abilities. At Daini, operators laid almost 6 miles of temporary electrical cable in 24 hours and replaced critical motors to restore cooling water flow to protect the reactors. At Daiichi, operators withstood dangerous conditions and high-radiation levels to establish a ventilation path to reduce containment pressure. In addition, many workers did not know for weeks about the fate of their friends and family members.

When asked for his thoughts on the most significant lesson from the Fukushima accident, Mr. Ikuo Izawa, shift manager for Fukushima Daiichi Units 1 and 2 on March 11, 2011, stated, "The impact of the tsunami was totally bigger than what we expected, trained, prepared for, or believed was possible—it was unimaginable. We must always be prepared for the possibility that something much bigger can happen." As I reflected on the experiences of the operators at both

Fukushima sites, I became even more convinced that operators at U.S. plants should never be placed in a position that requires heroic efforts to ensure the safety of the plant. This position is not meant to devalue the importance of personal qualities when faced with unexpected events—qualities, such as knowledge and experience to handle crisis, persistence and focus to face adversity, and optimism and endurance to combat fear. Instead, it recognizes that the NRC and industry should not rely on heroic efforts alone to prevent or mitigate, or both, the adverse consequences of an accident; they should ensure that an appropriate balance of capability exists in equipment, processes, procedures, and people.

It has been said that the "price of freedom is eternal vigilance." I believe that the accident at Fukushima Daiichi proves that the price of safety is also eternal vigilance and that it provides evidence of how "well and faithfully" we discharge our official duties. The lessons from Fukushima should deepen our vigilance as we display a questioning attitude and verify each licensee's compliance with its current license. This vigilance includes ensuring that plants are adequately protected against expected hazards and confirming the appropriateness of licensee actions to address potential safety issues. Fukushima also reminds us to remain vigilant by being alert to new information that could affect plant safety and to ensure that equipment and strategies employed to address challenges beyond what is expected are actually capable of doing so.



Decontamination/clean-up worker in Tomioka, Fukushima Prefecture, Japan.



Left to Right: Cynthia Pederson, Victor McCree, Eric Leeds, and Michael Johnson listen to Mr. Naohiro Masuda, former Daini Superintendent, explain the events of March 11, 2011.

“We must ensure sufficient prevention and mitigation capability and not expect heroism from operators.”

Victor M. McCree



Destroyed home in Tomioka, Fukushima Prefecture, Japan.

Cynthia D. Pederson

Regional Administrator of Region III



I feel very fortunate to have had the opportunity to join my colleagues in visiting Japan in February 2014. The experience was truly enlightening and sobering. Our hosts were very gracious, and you could tell that they were deeply bothered by what had happened in their country and at their plants. Even though it was nearly 3 years after

the accidents, you could still hear the anguish in their voices as they apologized to us and to the world.

As the bus took us through the communities adjacent to Fukushima Daiichi and Daini, we could see the damage caused by the devastating earthquake and tsunami of March 11, 2011. However, what struck me even more was the impact of radioactive contamination—huge mounds under tarps composed of contaminated soil that had been scraped off the rice fields, stacks of large black bags that contained other contaminated materials in the fields waiting to go to some unknown disposal location, and workers in anticontamination clothing trying to recover the vast areas that had been lost to the accident at Daiichi.

These used to be thriving communities with people living regular lives, working and raising families, with implicit trust that they were being protected from nuclear calamity. In the village of Tomioka, we saw how these lives had been disrupted. There were empty buildings, abandoned cars in driveways, products left behind on store shelves, and cups still sitting on the tables of a local restaurant. Currently, Tomioka has no electricity or water in an effort to prevent people from returning. We came upon a building that looked deserted and overgrown with weeds and were told this had been the visitors' center for Daini. TEPCO had to bring in temporary power to the building to show us a video of people in the community and at the nuclear plant before the accidents. In an auditorium without heat, we were the first ones to see this video since the accident. It was nearly surreal to watch what had been and realize what was outside. It left me with an incredible emptiness and sadness. This I will not forget.

The people of Tomioka are not allowed to return and may not be for years to come. However, they are the lucky ones—the ones who will be able to reclaim their homes one day. People from other communities may not be so lucky.

These citizens and families trusted that the company operating the plant and the regulator would keep them safe. I cannot imagine that those families ever thought they would be forced from their homes. Their hopes and dreams and the lives that they knew were washed away on those days in March 2011, along with the trust that they had in the nuclear plant and the regulator. Now that it is lost, how can it ever be regained? What can be done? We do not have answers to these questions.

My experiences confronted me with indelible images of what happens if we fail to “act to prevent and prepare to mitigate.” As a result, my commitment to prevent such accidents is even more personal. I believe that we must adopt a mindset of continually challenging ourselves to ask questions, such as the following: What have we not thought of? What is the next unimaginable thing that could happen, like TMI or Fukushima? Where is that weakness or set of circumstances that we have not yet identified that can lead to another nuclear disaster? Our cautionary tale is that the Japanese did not think an accident could happen at their facilities.

If prevention fails, we must be prepared for the unexpected by having the equipment, procedures, training, and emergency plans to mitigate unknown events. The nuclear industry; individual licenses; and we, the regulator, must ensure that an accident can be mitigated before any offsite impacts occur. Having permanent and temporary equipment available to combat the situation, having the people on hand or accessible to respond to what will likely be a totally unexpected and unanticipated set of conditions, and having the command and control to do the right thing to protect the public are vitally important. In this regard, I feel strongly that the licensees in this country must fully implement, maintain, and exercise the measures that are being established based on the post-Fukushima actions directed by the NRC. If we are not successful, we too will breach the public trust.

The last line of defense is to evacuate the public to ensure its safety through the use of emergency plans. However, if we ever find ourselves at this point, I will feel as if we have failed.

I do not ever want the NRC or our colleagues, here and in other countries, to have to face the aftermath of such accidents and to fail the public in such a catastrophic way. It is imperative that we all do our part to keep the public safe.

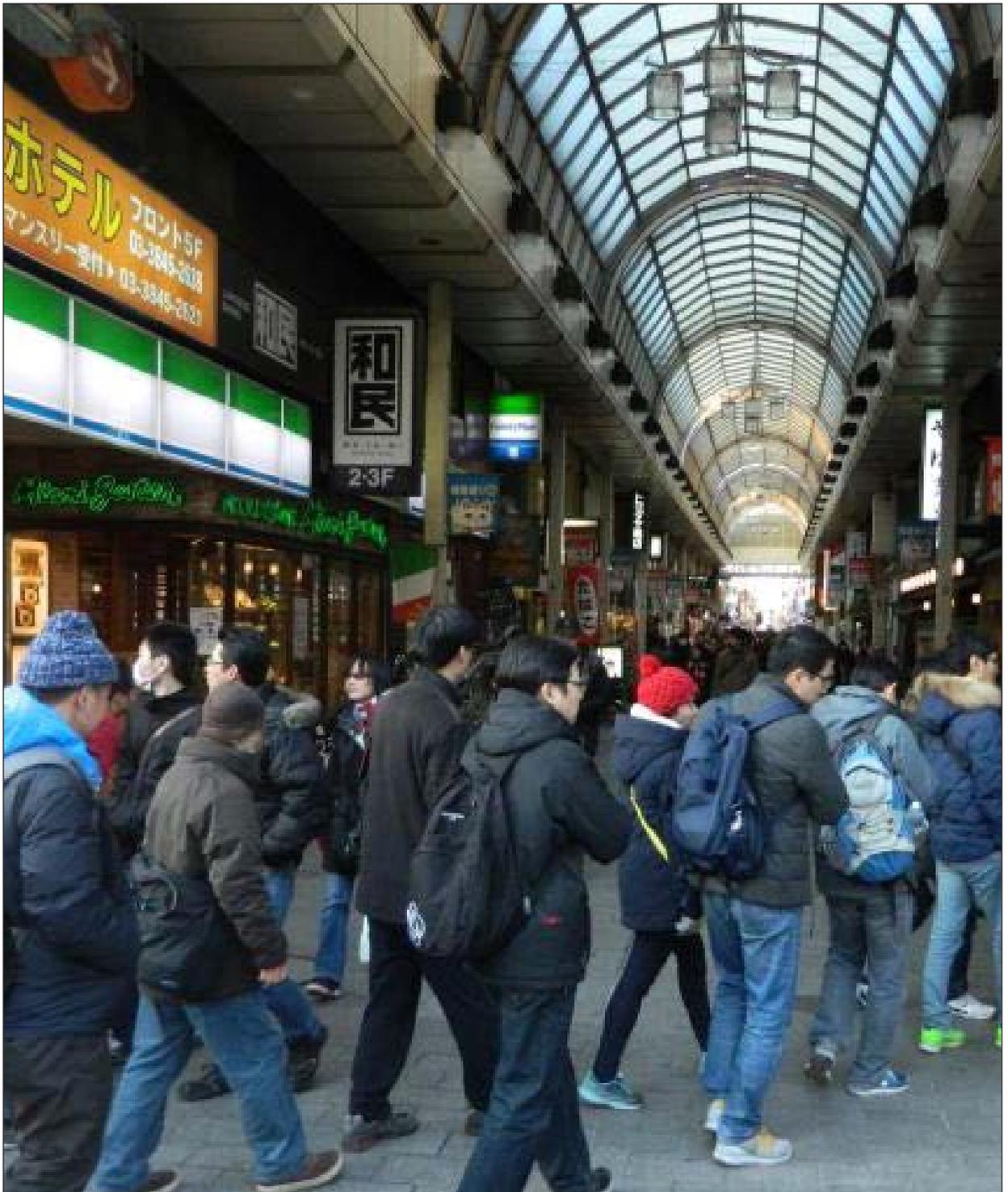


Photo of Japanese citizens near a train station in Tokyo, Japan.

“My commitment to prevent such accidents is even more personal. I believe that we must adopt a mindset of continually challenging ourselves to ask questions... If we are not successful, we...will breach the public trust.”

Cynthia D. Pederson

Marc L. Dapas

Regional Administrator of Region IV



The trip to Japan in February was a remarkable experience for me. It was highly informative and particularly rewarding in terms of the insights provided by our Japanese counterparts with respect to the impact of the Great East Japan Earthquake and associated tsunami on the Fukushima sites, the significant

safety measures being established at all of the operating reactor sites, the tremendous recovery efforts underway to clean up the land contamination from the Fukushima accident, and the country's revised regulatory structure. In particular, the description by the various TEPCO operators and site management directly involved in the event response to the Great East Japan Earthquake and associated tsunami at both Fukushima Daini and Daiichi was compelling in terms of the almost unimaginable challenges faced by TEPCO in trying to prevent core damage to the associated reactors.

Many of the insights derived from our discussions with the various TEPCO employees, Japanese regulators, and industry/vendor representatives were reinforced by our direct observations. Even though it has been 3 years since the Great East Japan Earthquake occurred, the extent of devastation caused by that earthquake and resulting tsunami is clearly visible. Driving through the surrounding towns of Tomioka and Naraha, one of which had been a vibrant seaside village and resort community, we saw countless houses and businesses that had been reduced to mere rubble, evidence of large landslides and uprooted trees, huge piles of top soil cleared from fields under large green tarps as a result of the extensive ongoing land decontamination efforts, police enforcing access restrictions at various checkpoints, and numerous workers wearing protective clothing to prevent personal contamination. For me, one of the more striking visuals was a roadside café in which I could still see coffee cups and plates on the counter, almost as if people were in the midst of having breakfast or lunch when they had to get up and evacuate due to the natural disaster and associated radioactive releases from the plant.

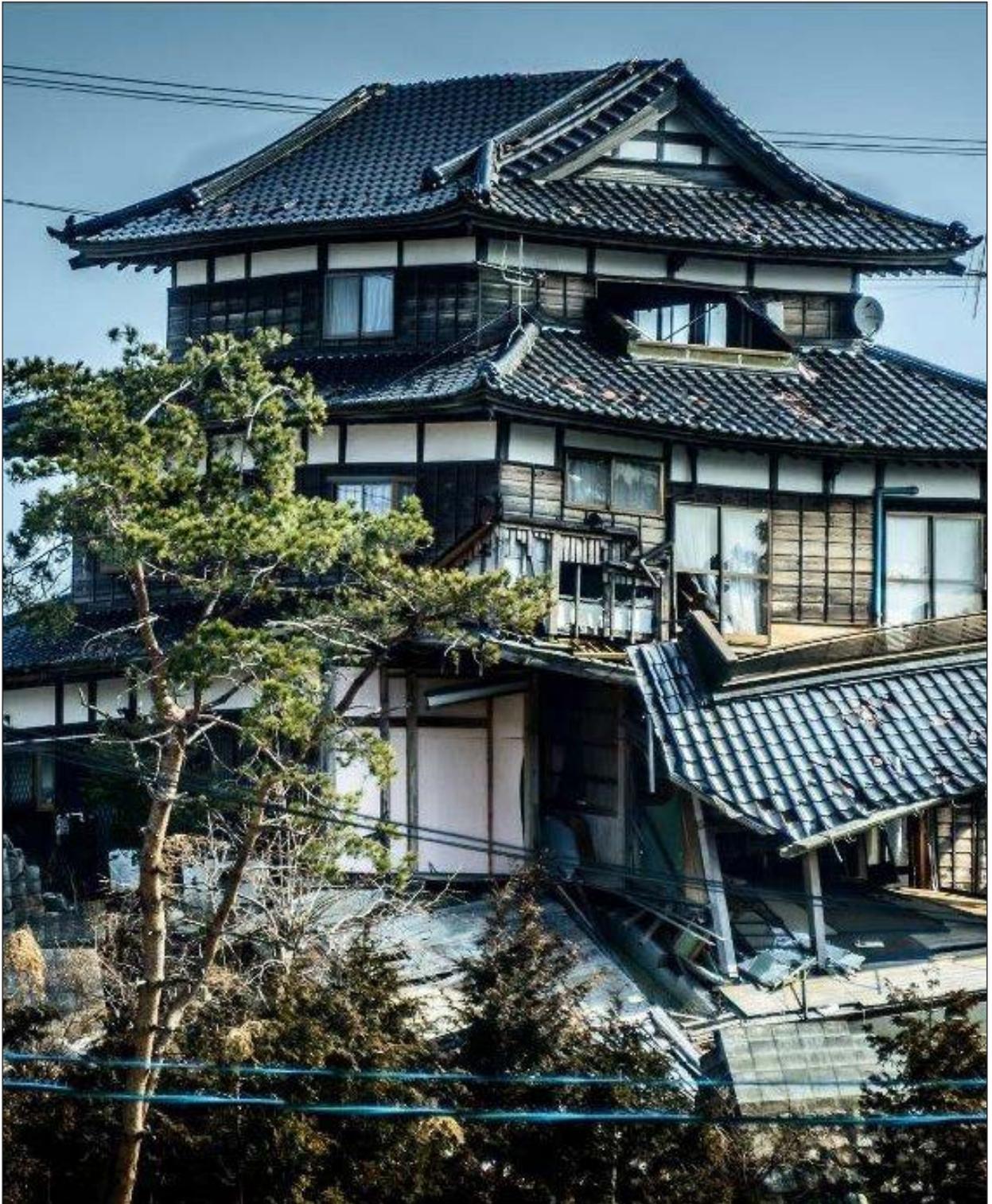
I was also struck by the resiliency and perseverance of the TEPCO operators, shift management, and emergency response center staff in responding to the Fukushima accident despite daunting challenges, the almost continual setbacks

encountered, the risk of personal injury or death in dealing with the extreme plant conditions, and the fact that they did not know for weeks whether their families were safe. Hearing these TEPCO employees describe what they faced and then seeing the actual physical configuration of equipment at the Fukushima sites left an indelible impression on me regarding the importance of being prepared for the unexpected. In that context, I considered the safety measures and enhancements that the NRC has required the U.S. industry to follow in terms of both accident prevention and mitigation in followup to the recommendations of the Near-Term Task Force that was chartered to identify lessons learned from the Fukushima accident. I concluded from what I saw and heard that we do not have any significant gaps in the approach that we are exercising here in the United States to ensure that both the regulator and the industry are prepared for the unexpected. The key in my view is to ensure that these safety measures are rigorously implemented and maintained.

Another important lessons learned that TEPCO shared with us relates to overreliance on contractors. The extensive use of contractors by TEPCO to accomplish work activities presented an unanticipated challenge in that after contractors had been directed to evacuate the site, the remaining onsite staff did not possess the knowledge or skills to accomplish critical recovery actions. These actions included installing and connecting instrumentation and temporary power supplies, terminating cable ends, and operating fire trucks and portable equipment. This previously unrecognized lack of skills by the onsite staff limited the effectiveness of some recovery actions and, therefore, required alternative approaches, all of which cost TEPCO valuable time in responding to the accident. This lesson learned underscores the importance of ensuring that event response staff have the requisite skills to complete required actions in a timely manner to ensure that public health and safety are not put in jeopardy.



David Skeen and Scott Flanders in Unit 5 Spent Fuel Pool at the Fukushima Daiichi Nuclear Power Site.



Earthquake damaged home in Tomioka, Fukushima Prefecture, Japan.

“We must ensure that both the regulator and industry are prepared for the unexpected.”

Marc L. Dapas

K. Steven West

Deputy Director of the Office of Nuclear Regulatory Research



During February 2014, I traveled to Japan as a member of a team of NRC senior executives. The trip was a unique opportunity to explore with the Japanese the 2011 earthquake and tsunami, the reactor accidents at Fukushima Daiichi nuclear power station, and the far-reaching effects and consequences of those events.

In response to its lessons learned from the Fukushima events, Japan has made substantive changes to its regulatory system. Intent on improving nuclear safety and restoring public trust, it established clear separation between promotional activities and regulatory activities. It created a new regulatory system, including the new JNRA, with a chairman and four commissioners. It developed and adopted new regulatory requirements for reactors, it enhanced its EP system, and it is working to improve its transparency and openness with the public. Most recently, to improve its technical competence and capabilities, JNRA merged its technical support organization—the Japan Nuclear Energy Safety Organization—into JNRA. During discussions with JNRA, we learned that it was in the process of creating a new safety research and standards office similar to ours.

I was impressed with the extent of the regulatory reforms that Japan has implemented in a fairly short period of time. During a meeting with the team, the JNRA staff demonstrated its commitment to implementing its new regulatory system and to improving nuclear safety and public confidence in its country. During a tour of the Kashiwazaki Kariwa plant, we observed several plant modifications that TEPCO had made to comply with JNRA regulations. These modifications include redundant hardened filtered vents to control containment pressure and a 50-foot tall seawall constructed between the Sea of Japan and the power station. We first learned about the extent of some of the modifications, such as the redundant vents, when we saw them during the site visit. Seeing one installed filtered vent side by side with a second under construction was enlightening. Moreover, such finds were thought-provoking. On the one hand, outside of Japan, some might view two filtered vents for a single containment as unnecessary. However, when this measure is considered

within the Japanese paradigm, which would almost certainly include large sites with many reactors, a history of powerful earthquakes, tall tsunamis, uninhabitable towns and villages, and a desire to restore public trust and confidence, the need for redundant vents could be viewed in a much different light.

Over the years, cooperation on research programs of mutual interest between the NRC and the Japanese regulator proved to be an effective way to share data and information. The results of our cooperative and collaborative projects have contributed to public health and safety in both countries and have added value to many regulatory decisions and applications. Visiting and touring the Kashiwazaki Kariwa and the Fukushima stations and seeing firsthand some of the technical issues that the Japanese regulator and industry face as they contemplate the possibility of restarting their nation's reactors under a new regulatory system while decommissioning the Fukushima Daiichi reactors emphasized to me the vital roles that research and development, technical information exchanges, and operating experience should play as they move forward. The NRC and nuclear regulators around the world also stand to gain through Japan's initiatives in these areas. Consequently, it was satisfying to learn that the new JNRA will continue its cooperative and collaborative projects with the NRC and is considering new collaborations. Examples of ongoing and future JNRA research involve probabilistic risk assessments and their applications, fire safety, severe accidents, human reliability analyses, and seawater injection.

The perspectives I have shared here only scratch the surface of what I learned while in Japan. Before closing, I will share the two experiences that most impressed me. The first was seeing firsthand the damage and the evidence of human suffering caused by the earthquake, the tsunami, and the radioactive contamination around the Fukushima station. Many survivors were displaced from their towns and villages. We were told that those who left the most heavily contaminated areas may not be allowed to permanently return. The second experience was touring the two Fukushima nuclear power stations and hearing from individuals who experienced the earthquake and tsunami and who responded to the resulting events. Their stories about unexpected and changing plant conditions and setbacks; extreme working conditions, such as total darkness, elevated temperatures, and radiation levels; fears of injury and death; and the fact that they did not know the fate of family members were riveting and inspiring.

In Japan, I gained new insights into how the Japanese view nuclear safety, how their views were changed by the accident at Fukushima Daiichi, and how their new ways of thinking have been applied by both the regulator and the nuclear industry. I am satisfied with what I and the team accomplished, knowing



Row of fire trucks at the Fukushima Daiichi Nuclear Power Site.

“I left Japan secure in the knowledge that our Near Term Task Force Report has served us well and that the actions that we have taken are appropriately focused on the lessons learned from Fukushima Daiichi and on public health and safety.”

K. Steven West

that those we met from both the regulator and the industry valued the opportunity to share their stories and answer our many questions. They also appreciated our views on the lessons learned from Fukushima Daiichi and on subjects, such as reactor safety, safety culture, and event response. I left Japan secure in the knowledge that our Near-Term Task Force Report has served

us well and that the actions that we have taken are appropriately focused on the lessons learned from Fukushima Daiichi and on public health and safety. Through our continuing commitment to complete our post-Fukushima actions, we will achieve the necessary safety enhancements for our commercial nuclear fleet.

Scott Flanders

Director of the Division of Site Safety and Environmental Analysis, Office of New Reactors



In February 2014, I had the privilege to travel to Japan with a team of NRC senior managers. Having the opportunity to spend a week visiting three nuclear sites, including the Fukushima Daiichi site, and meeting with operators from the Fukushima Daiichi and Daini plants and the JNRA with this team of senior regulators was

truly a rewarding experience. Each day, we met to reflect on the day's events, culminating with a session that reflected on the full week. In each session, we discussed what we heard and saw and how it relates to the actions we are taking in response to the Fukushima Daiichi accident. The diversity of experience and perspective from the team members made the group discussions very enriching.

Traveling by bus from Iwaki to Daini and Daiichi, we observed towns that suffered tsunami and earthquake damage. As we got closer to the sites we observed more damage, and then we began to see rows and rows of green tarps that covered neatly stacked bags of contaminated soil. Our guide informed us that access to certain towns was restricted to daytime hours and that access for others was not permitted without special approval. After hearing the guide's discussion, I concluded that many of the people who resided in these areas either chose not to return, or were not permitted to return, to rebuild their homes and towns.

Once we arrived at the Daini site, the plant manager, along with several plant operators, explained the impact that the earthquake and tsunami had on the plant and the actions they took to protect it. Before visiting the Daiichi site, we were given a similar briefing by the maintenance manager and one of the operators in the control room at the time of the earthquake. This particular operator worked for 36 straight hours without knowing whether his family was safe. To hear his story and the accounts of many of the other plant employees who responded to the event was truly moving. The discussions were very valuable because of how forthright they were in describing the event, the actions they took, and their emotions during the event.

Following the discussions, we toured the site and observed much of the still evident damage resulting from the event. We saw remnants of the concrete sea wall; damaged switchgear, the insides of which were completely corroded from the saltwater; and shredded steel structures. We even saw a light fixture that still had water inside it. Although it is difficult to assess seismic damage solely by visual observation, based on the discussion with the managers and operators, the safety systems performed as expected until the tsunami hit. Frankly, this was not a surprise to me given the ground motions experienced at the site, the inherent seismic margin typically found in a nuclear power plant as a result of all the nonseismic loads that a plant is designed to withstand, and the extensive seismic work that the Japanese undertook following the 2007 Great Chuetu-Oki Earthquake that affected the Kashiwazaki Kariwa plant. The operators and managers with whom we spoke lauded TEPCO's decision to construct seismically isolated emergency response centers at all three of their sites; all the operators and managers said that these facilities were vital in their efforts during the Fukushima event.

Just as the Japanese worked to implement lessons learned to their plants after the 2007 earthquake, they are working earnestly to implement lessons learned from the Fukushima event. At the Kashiwazaki Kariwa plant, we observed a number of enhancements being made to the plant, many of which are similar to the Near-Term Task Force recommendations. Based on the work of my Division, I focused on the changes being made to protect against flooding. Failure to protect structures, systems, and components important to safety from flooding is critical because a "cliff edge" may exist beyond the height or capacity of the flood protection such that potentially significant safety consequences could occur if a flood were to exceed the height or capability of the available flood protection.

Some of the changes being made at Kashiwazaki Kariwa to protect against flooding include physical barriers with a margin well beyond the design-basis tsunami hazard, enhanced seals, and mitigating strategies to help protect the plant against floods that exceed even the new flood barriers. Clearly, these changes reflect a philosophy that we heard several times during the week: "Be prepared for the unexpected." Although we heard this philosophy several times during the week, this concept was not new to our team. Some of the key Fukushima lessons-learned actions that we are implementing, including mitigating strategies, are based on that same philosophy. Extreme natural events, such as the one that occurred in Japan in 2011, are typically thought of as rare or not expected. Our understanding of what is expected, both the frequency of occurrence and the consequences, is based on our level of



Scott Flanders and Glenn Tracy listening to Mr. Naohiro Masuda in the Fukushima Daini Control Room simulator.

“Continuing to increase our knowledge of natural hazards is critical to improving our ability to determine what we should expect so that we ensure that plant designs and licensing bases are appropriate.”

Scott Flanders

knowledge. Continuing to increase our knowledge of natural hazards is critical to improving our ability to determine what we should expect so that we ensure that plant designs and licensing bases are appropriate. Similarly, increasing our understanding of how rare natural events can affect our facilities is important so that we can be as prepared as is reasonably possible for the unexpected. Being prepared for the unexpected is a goal that we must continually strive to meet. The consequences, like those

we saw on our bus ride to Fukushima Daini and Daiichi, are too great. Although the impacts of natural hazards are devastating, we must endeavor to ensure that they are not compounded by a nuclear power reactor accident. This trip has reaffirmed my belief that Near-Term Task Force Recommendation 2 is an important step toward ensuring that U.S. plants are adequately protected against natural hazards.

David L. Skeen

Director of the Japan Lessons-Learned Project
Directorate, Office of Nuclear Reactor Regulation



Even though this was my third trip to Fukushima in the last 3 years, watching the small towns, farms, and rice paddies in the countryside roll by as I sit on the Super Hitachi 3 train from Ueno Station in Tokyo during the 2-hour trip to Iwaki Station in Fukushima Prefecture and then the 50-minute bus ride from Iwaki

to the staging area at J-Village, I am once again amazed by the resilience of the Japanese people. A lot of progress has been made in the last 3 years.

I first visited the Fukushima Daiichi site in December 2011—9 months after the accident—and then again in December 2012 with Chairman Macfarlane before my latest visit with NRC senior managers in February 2014. I am fortunate to have been able to observe firsthand the progress being made in and around the site over the last 3 years. My third visit to the site is much different from the first. When we first visited the site, we had to dress out in full anticontamination clothing (Tybek suits) and respirators at J-Village (the former training facility for the Japan national soccer team) and had to pass through a police checkpoint as soon as we left J-Village, which is about 14 miles from the site. On this third visit, we did not have to pass through the police checkpoint until we got much closer to the plant, nor put on the Tybek suits and respirators, until we arrived at the plant site—a clear sign that the levels of airborne and fixed contamination have dropped significantly in the areas beyond the boundary of the plant site.

It is also evident from traveling to the site on the two-lane highways that much work has been done to rebuild them because some of them had been reduced to one-lane roads due to the earthquake damage when we visited in 2011. We also saw decontamination crews working in some areas along the way to the plant site to remove contaminated vegetation, and we saw neat rows of tarp-covered mounds of contaminated soil and vegetation that were several hundred feet in length or rows of large black plastic garbage bags filled with similar materials. None of this activity was evident during our first visit.

Upon arriving at the entrance to the Fukushima Daiichi site, we saw that it still looks very much like a typical nuclear power plant at the main entrance gate. A guard house with many security guards checks vehicles entering and exiting the site, and an administration building that processes workers houses some offices and conference rooms. As we pass through the security check point on the bus, the first things that come into view are the rows and rows of tanks storing contaminated water that continues to be generated at the site every day to cool the fuel debris in the three damaged reactors.

One of the first things that I notice is the sheer number of tanks that are now occupying what was once a forest area or open ground when I first visited the site. There are thousands of tanks—blue horizontal cylindrical tanks and vertical gray bolted tanks—and concrete pads where even more storage tanks will be located. Still, that is the only sign that this is not a typical nuclear power plant—until the bus rounds the corner and crests the hill. Then, laid out below is the unbelievable sight of the canvas-covered Unit 1 and the still intact Unit 2 with its blue background and white clouds painted on the sides. Unit 3 has now had most of the debris from the upper portion of the reactor building removed with only remnants of the refueling machine, which fell into the spent fuel pool, still sticking up above the refueling floor. The new Unit 4 fuel removal structure is in place and covers the refueling deck.

Although Units 1 and 2 appear much the same as they did the first time that I saw them, the progress made on Units 3 and 4 is impressive. On my first trip, the debris had not yet been cleared from the Unit 3 or Unit 4 reactor buildings, and the remnants of the steel and concrete upper floors and the collapsed roofs were still in place. Even on my second visit 1 year ago, the debris had been removed from the Unit 4 refueling deck; however, only a hole in the ground was beside Unit 4, and rebar was being installed in preparation for pouring the basemat for the new fuel removal structure. Remarkable progress has been made over the past year to complete construction of the massive Unit 4 fuel removal structure and to clear debris from the top of the Unit 3 reactor building. The Unit 3 debris removal is perhaps even more impressive because it all had to be done using robotic cranes and cutting tools due to the high levels of radiation on the refueling deck resulting from the Unit 3 explosion.

Although much progress has been made, the view of the destroyed reactor buildings from the hill overlooking the site is still as unbelievable as the first time that I saw the site after the accident. It is still hard to believe that anything could have



Aerial photo of the Fukushima Daiichi Units 1, 2, and 3 after the accident.

“Three years ago, I would never have believed that a single event could so completely destroy a single reactor, let alone four reactors at the same site—and yet right here in front of me, the truth is undeniable.”

David L. Skeen

caused this type of destruction that Japan will have to deal with for the next 30 to 40 years. Three years ago, I would never have believed that a single event could so completely destroy a single reactor, let alone four reactors at the same site—and yet right here in front of me, the truth is undeniable.

As a nuclear safety regulator, what have I learned from this previously unimaginable event? During the last 3 years, I have read many accounts of the accident and have discussed with my Japanese colleagues the actions taken by operators on shift at various stages of the accident, including accounts from some of the operators themselves. I have concluded that those operators and their managers, who tried to prevent the cores from melting and then dealt with the subsequent hydrogen explosions, did everything they possibly could to prevent that terrible outcome. They are all heroes, although they are not viewed as such by many of their countrymen. The failure was not due to the operators' efforts; instead, it was due to the fact that neither the licensee nor the regulator had prepared the operators to cope with such a scenario. When we asked the operators at both Fukushima Daiichi and Fukushima Daini (which survived the tsunami) what

they learned from the accident, we got very similar answers. The most important thing that they said is to be “prepared for the unexpected.” Many of the operators told us that they just did not believe that such an event could actually happen, and, therefore, they had never prepared for such an event.

In the United States, we are currently taking steps to “prepare for the unexpected.” The major contributors necessary for preparing for the unexpected include orders that we have issued to ensure that licensees can cope with an extended loss of alternating current power and a loss of the ultimate heat sink, the installation of additional spent fuel pool instrumentation to ensure that operators are aware of the inventory in the pool, and the installation of containment venting systems that are capable of operating even after a core damage accident. Had similar preparations been in place 3 years ago at the Japanese units, “Fukushima Daiichi” may never have become such a well-known name because the operators may have been able to prevent the cores from melting, and the subsequent hydrogen explosions that caused widespread contamination may have never occurred.

Roger D. Hannah

Senior Public Affairs Officer, Region II



I feel fortunate to have been part of the trip, hearing from those who were there when the accident happened and seeing firsthand the stark effects. If I had to pick a single word to tie my experiences in Japan together, that word would be the people—

- the people who once occupied the abandoned homes and businesses and schools near the plant—some of them knowing they can never go home again
- the people who worked at the plant during and immediately after the accident, desperately trying to keep the situation from worsening
- the people who now work at the site, donning protective clothing each day as they slowly tackle the mammoth cleanup
- the people across Japan who are struggling with their faith in their country's government and companies and with their view of nuclear power

During our trip, we spent many hours talking about the technical aspects of the accident, the heroism of the operators and other plant staff, and how those lessons are being applied to U.S. nuclear plants. Although some discussion of people did arise, most of us could apparently not even find the words to adequately express what we had seen and heard.

Although we were able to hear from some people who were working at the plant during the accident, I wish I could have talked to more people who have been displaced or affected in some other way. I also wish I could have spent more time in the area; however, even the few hours that we were there placed images in my memory that will stay with me.

I have always felt that the most important people for the NRC, nuclear plant operators and all others concerned about nuclear safety, should be those people inside or closest to the plants. Seeing the abandoned homes and businesses in Japan gave me the strongest evidence that my feelings have been right.

As all of us at the NRC go about our daily activities, whether inspecting facilities, reviewing information, writing regulations, or answering questions, we need to always remember that the most important people are those people

working at, and living closest to, the facilities that we regulate. We can do our best to ensure that it never happens; however, if something does go wrong, the people nearest the event have the most to lose.



Safety signs at the Fukushima Daiichi Nuclear Power Site.



“Abandoned cars and the absence of people harshly illustrate the lingering effects of the accident on the people who once lived and worked near the plant.”

Roger D. Hannah



Contaminated waste storage near Tomioka, Fukushima Prefecture, Japan.

Cindy Rosales-Cooper

Executive Technical Assistant for Research and International Activities, Office of the Executive Director for Operations



When Michael Johnson approached me about organizing and participating in a senior leadership visit to Japan, I knew this was a rare opportunity. Having spent my entire NRC career involved with international activities, I knew that what he envisioned was extraordinary and precedent setting for the

leadership and the knowledge management activities of this agency. The visit to Japan proved to be one of the most rewarding international activities I have been a part of.

We built time into the itinerary for the team to have daily reflections and opportunities to share thoughts and insights gained from our meetings and site visits. I found these reflection times extremely interesting as I listened to the leadership team speak passionately about how we at the NRC must do all that we can to ensure that an accident with the magnitude of Fukushima never happens in the United States or anywhere else. If I step back and observe these discussions as a member of the public, I come away with the assurance that the nuclear safety watchmen on our towers are awake, aware, and ready.

Although I felt that this zeal for ensuring that an accident like Fukushima never happens in the United States is admirable and necessary, I also felt like the leadership team was taking on an extremely heavy burden. I want today's leadership and the NRC's leadership 20 years from now to never forget that—unlike TMI or Chernobyl—the accident at Fukushima was precipitated by extreme natural hazards that are beyond human control—an earthquake and a tsunami. Nevertheless, as TEPCO has acknowledged, if it had instituted certain protocols in advance of the tsunami, the core melts could have been prevented or better mitigated. Therefore, I feel that the work that our agency is doing in implementing the lessons learned from Fukushima is of paramount importance and will help us prepare for the unexpected.

On the fourth day, I boarded the train to Iwaki with mixed emotions. I had seen pictures and video clips of the devastation in the Fukushima Prefecture and expected that, once face to face with it, I would become emotional. I had

tears in my eyes the night before as we listened to Dr. Takeyuki Inagaki, the Daiichi maintenance manager, walk us through the first 100 hours of the accident. I could not imagine what he and the other workers felt as they struggled in the dark to save their community. As we listened to the conditions the plant workers were subjected to, such as lack of food, water, medicine, or sanitation accessories and facilities, I was left dumbstruck. I could not imagine what it was like for women and men to be stuck in a place without lights, water, and properly equipped bathrooms. I think we owe it to operators and regulatory staff alike to ensure that they have what they need to meet their basic needs during an emergency.

As we boarded the bus at J-Village, I remembered how enthusiastic I had felt on March 10, 2011, sitting in a meeting with our Japanese counterparts discussing plans for future collaboration and compared it to what I felt the very next day as we watched the devastating incidents unfold. However, as we pulled onto the two-lane, patched, and battered road to the town of Tomioka, what I saw and felt were familiar pangs brought on by the sight of utter devastation. I saw destruction—lifeless towns, empty houses, overturned cars, buildings with caved roofs, and abandoned preschools and playgrounds. I suddenly remembered how I felt going back to my hometown of New Orleans 3 months after Hurricane Katrina and helping my grandfather dig through the wreckage of his house. My mother and brother forged through muck and mud to salvage items that held precious memories. I recalled how it felt to see my beloved high school in rubble. As I looked out the window of the bus, I remembered well the damage that water and immense flooding can cause. There was one major difference here, however. New Orleans had no land contamination or exposure to radiation that would prevent residents from returning home.

I imagined that returning home is what was and still is on the minds of the 135,000 residents and evacuees of Fukushima and other nearby Prefectures still living in shelters as a result of the nuclear accident and the tsunami. I was extremely saddened when I learned that approximately 1,600 of these evacuees died, not because of the earthquake, tsunami, or even the nuclear accident, but simply because the shelters were not prepared to provide for their physical and mental needs. Many of these deaths were elderly people who died within weeks to a month after the disaster. This additional tragedy leaves me with a sense of urgency that more attention needs to be paid to offsite consequences. Although I recognize that the NRC's regulatory responsibility is limited beyond the site boundary, we owe it to the public to ensure that lessons like these are shared and properly implemented with the Federal, State, and local authorities responsible for evacuees and shelters. I cannot help but pause and think that a majority of these 1,600 people lost their lives at places that they were told to go to in order to save their lives.



A ferry rests on top of a building as a result of the Tsunami in Iwate Prefecture, approximately 100 miles north of Fukushima Daichi.

“I want today’s leadership and the NRC’s leadership 20 years from now to never forget that—unlike TMI or Chernobyl—the accident at Fukushima was precipitated by extreme natural hazards that are beyond human control—an earthquake and a tsunami.”

Cindy Rosales-Cooper



Shoreline drive from the town of Iwaki on the way to J-Village.

Kirk Foggie

International Relations Officer, Lead for Japan Activities, Office of International Programs



During the past 8 years, I have been fortunate to be the primary liaison for the NRC with its regulatory counterparts in Japan. I have accompanied many NRC staff and leaders to Japan, and I knew that I should not pass up the opportunity to support the February 2014 senior executive delegation visit to Japan.

In March 2011, the NRC staff traveled to Japan to support the U.S. Embassy during the Fukushima accident. Senior management asked me to join the first group of NRC staff members going to Japan shortly after the accident to assist in this effort. During the initial response, the NRC Japan site team needed to convey opinions and messages to the ambassador and other Japanese government officials that required a special skill set to minimize the possibility of rapidly changing perceptions of the situation. Throughout the first weeks of the Fukushima accident, I participated in Japanese senior level meetings as part of the site team. This was an honor because most foreigners are not invited to observe closed meetings in Japan. As more site team members were invited to meetings, we became more comfortable with the structure and further engaged our counterparts. The NRC staff and their Japanese counterparts found great value in these interactions, which increased in frequency over time. The NRC site team interaction with the Japanese during the accident and my interaction with the support of the staff of the Japan Lessons-Learned Project Directorate is the current foundation of the agency's rapport with Japan. To have this group of senior executives travel to Japan for continuing discussions on the NRC's cooperation on Fukushima furthers the level of communication between the United States and Japan.

During the February 2014 mission, the Japanese opened each meeting with a heartfelt apology to the world for the inconvenience that Fukushima had caused the nuclear industry. They provided detailed descriptions of actions taken and open and frank answers to the questions raised by the delegation. Many of the senior executives were surprised by the level of openness and transparency that our Japanese counterparts showed. These actions expressed by our

counterparts reemphasized the maturity of the cooperative relationship with Japan. The humility of the Japanese industry also surprised the delegation; however, for the Japanese, the accident is still a personal loss, and they are determined to share their lessons with the world.

Having visited the Fukushima site 2 months before the senior executive site visit, I was surprised at the amount of progress. The Japanese are resilient in many ways, including their determination to rebuild and move forward. The Japanese continue to make strides in cleaning the Fukushima area, and although the focus of the senior leadership visit was on the accident sequence, I believe all NRC staff members who visit Fukushima and the surrounding affected area can learn much from the postaccident cleanup activities.



NRC team tour the Torus Room of Unit 5 at the Fukushima Daiichi Nuclear Power Site.



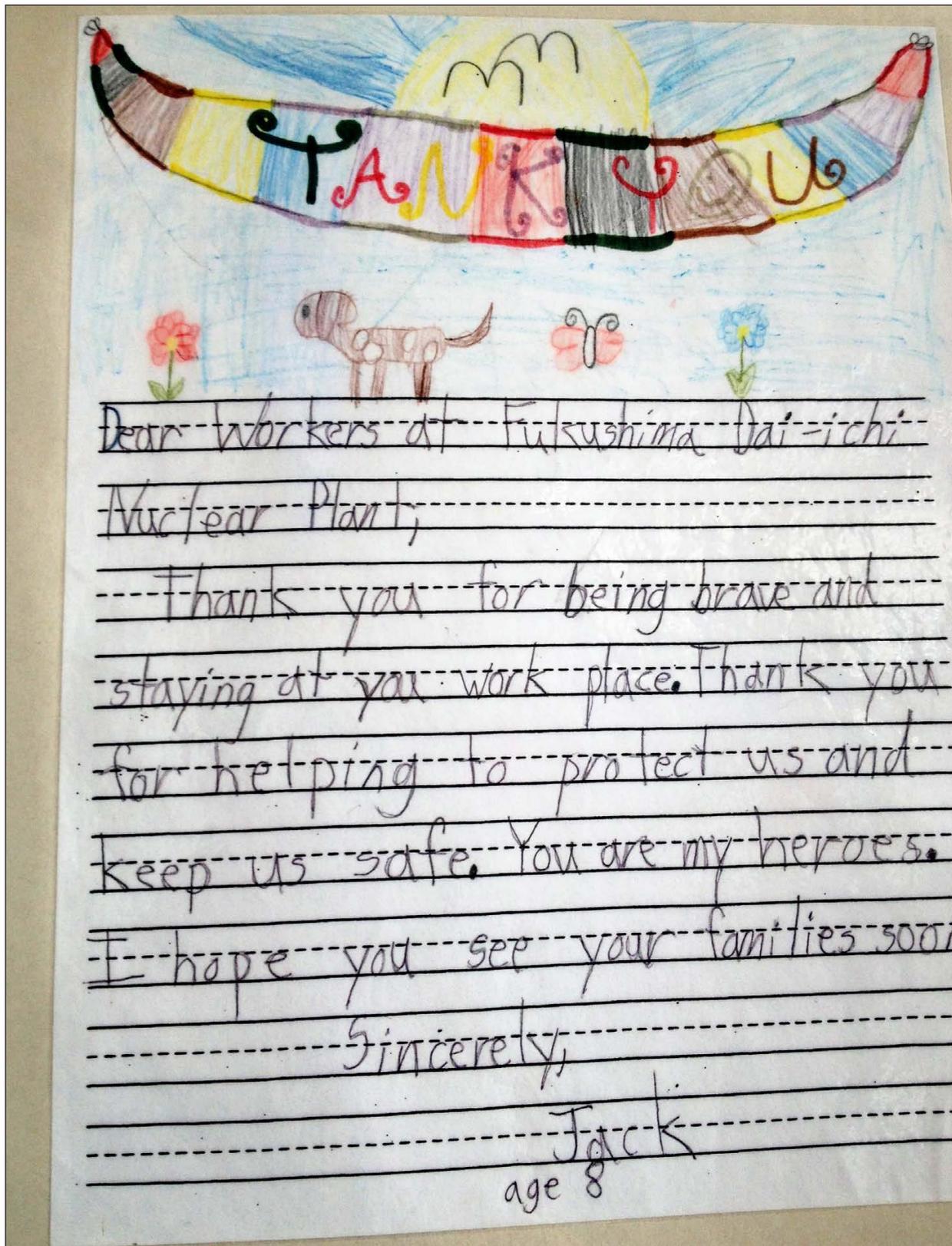
Victor McCree and Kirk Foggie exit the J-Village visitor center.

“Many of the senior executives were surprised by the level of openness and transparency that our Japanese counterparts showed. These actions expressed by our counterparts reemphasized the maturity of the cooperative relationship with Japan.”

Kirk Foggie



Residential area in Tomioka, Fukushima Prefecture, Japan.



California elementary student Jack to Fukushima Daiichi workers displayed at J-Village.

NRC FORM 335 (12-2010) NRCMD 3.7	U.S. NUCLEAR REGULATORY COMMISSION	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREGKM-008
BIBLIOGRAPHIC DATA SHEET		
<i>(See instructions on the reverse)</i>		
2. TITLE AND SUBTITLE Reflections on Fukushima: NRC Senior Leadership Visit to Japan, 2014	3. DATE REPORT PUBLISHED	
	MONTH December	YEAR 2014
5. AUTHOR(S) C. Rosales-Cooper, M. Johnson, E. Leeds, G. Tracy, J. Wiggins, B. Dean, V. McCree, C. Pederson, M. Dapas, K.S. West, S. Flanders, D. Skeen, R. Hannah, K. Foggie		6. TYPE OF REPORT Technical
		7. PERIOD COVERED (Inclusive Dates) 2014
8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.) Office of the Executive Director for Operations U.S. Nuclear Regulatory Commission Washington, DC 20555-0001		
9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.) Same as above		
10. SUPPLEMENTARY NOTES		
11. ABSTRACT (200 words or less) The senior leadership of the U.S. Nuclear Regulatory Commission's (NRC's) reactor and preparedness programs visited Japan from February 16–23, 2014. The purpose of that visit was to provide an opportunity for the group to gain firsthand experiences and insights into the March 2011 accident at the Fukushima Daiichi Nuclear Power Plant site. This NUREG report is a compilation of personal reflective essays from the group of senior managers and staff that participated in the February 2014 visit to Japan and includes a video of individual interviews and the April 24, 2014 Knowledge Management Seminar: Reflections on Fukushima.		
12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.) Senior Leadership visit to Japan, Office Directors visit to Fukushima, NRC visit to Fukushima	13. AVAILABILITY STATEMENT unlimited	
	14. SECURITY CLASSIFICATION <i>(This Page)</i> unclassified <i>(This Report)</i> unclassified	
	15. NUMBER OF PAGES	
	16. PRICE	



NUREG/KM-0008
December 2014



@NRCgov

