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AUTHOR: Director Dimitri de Morea (Collective Good Inst.)

AFFILIATION:

ADDRESSEE: CHRM Allison Macfarlane

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From:	Dimitri de Morea [director@collectivegood.info]
Sent:	Thursday, August 16, 2012 7:24 PM
To:	CHAIRMAN Resource
Cc:	CMRSVINICKI Resource; CMRAPOSTOLAKIS Resource; CMRMAGWOOD Resource; CMROSTENDORFF Resource; director@collectivegood.info
Subject:	Fukushima & SNF Pools - A Serious, and On-going, National and International Security Threat to the United States
Attachments:	SNF_Pools_Fukushima_US_Security_Threats.pdf

The Honorable Allison M. Macfarlane
Chairman
U.S. Nuclear Regulatory Commission

Dear Chairman Macfarlane,

I am Dimitri de Morea, director of the *Collective Good Institute*, and I currently lead an inter-disciplinary research team that has investigated the on-going crisis at the Fukushima-Daiichi complex, as well as threats posed by spent nuclear fuel (SNF) pools in North America.

In the process of our in-depth research, our team has arrived at the conclusion that the Fukushima-Daiichi nuclear complex, and the issue of SNF storage pools across North America (and around the world), both pose a serious, and on-going, national and international security threat to the United States.

A good portion of the U.S. leadership is already well aware of the serious risks posed by SNF pools in North America. However, what may not be as widely known is the on-going, and serious, threats still posed today by the Fukushima-Daiichi complex in Japan (and indeed abroad). Should these threats materialise, radioactive releases could be 100 to 850 times the first Fukushima event. This would potentially have significant impacts on U.S. public health, safety, agriculture, fisheries and oceans, employment, trade, and the national economy. The most vulnerable areas would clearly be the West Coast states of California, Oregon, and Washington.

Needless to say, Japan being the third largest economy in the world, if a new disaster event occurred, the impacts on the already weakened international economy would be substantial. Obviously the potential implications of all this are quite large.

We urge you to examine all the scientific evidence, and the extensive and credible news sources. The attached report, containing all this evidence, is entitled: *"National and International Security Threat Analysis, Risks posed by Spent Nuclear Fuel Pools at the Fukushima-Daiichi Complex, in North America, and Abroad."*

Please do not hesitate to contact us if you would like to discuss the results of our analysis further, or if if we can be of any assistance to you.

We thank you for your attention.

Sincerely,

Dimitri de Morea, Director
The Collective Good Institute

Cc:

Honorable Steven Chu, Secretary, U.S. Department of Energy
Honorable Janet Napolitano, Secretary, U.S. Department of Homeland Security
Honorable Hillary Clinton, Secretary, U.S. Department of State
Honorable James R. Clapper, Director of National Intelligence
Honorable Lisa P. Jackson, Administrator, U.S. Environmental Protection Agency
Honorable W. Craig Fugate, Administrator, U.S. Federal Emergency Management Agency
Honorable U.S. Senators from California, Oregon and Washington
Honorable Governors from California, Oregon and Washington

Dimitri de Morea, Director
Collective Good Institute
director@collectivegood.info
Tel: 778-232-1089

National and International Security Threat Analysis, Risks posed by Spent Nuclear Fuel Pools at the Fukushima-Daiichi Complex, in North America, and Abroad

by Dimitri de Morea,
and the *Collective Good Institute* research team.

August 15, 2012

A report addressed to the following United States officials:

The Honorable Steven Chu, Secretary of the Department of Energy.
The Honorable Janet Napolitano, Secretary of the Department of Homeland Security.
The Honorable Hillary Clinton, Secretary of the Department of State.
The Honorable James R. Clapper, Director of National Intelligence.
The Honorable Lisa P. Jackson, Administrator of the Environmental Protection Agency.
The Honorable W. C. Fugate, Administrator of the Federal Emergency Management Agency.
The Honorable Allison M. Macfarlane, Chairman of the Nuclear Regulatory Commission.
The Honorable Senators from California, Oregon and Washington.
The Honorable Governors of California, Oregon and Washington.

For inquiries regarding this report,
please contact Dimitri de Morea at
director@collectivegood.info

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I. Executive Summary

A. Overview of Spent Nuclear Fuel (SNF), SNF Storage Options, and SNF Pool Fires

Spent Nuclear Fuel (SNF), often referred to as "nuclear waste," is an inevitable by-product of the nuclear energy production process. SNF remains radioactive for thousands of years, and needs to be stored appropriately, for obvious public health, and national and international security reasons.

After being spent or used up, the SNF is extracted from the nuclear core, and initially gets stored in wet pools (i.e. "wet storage"), as a necessary stage of nuclear energy production. The SNF rods must be stored for 3 to 10 years in these wet pools, before they can be transferred to another wet pool, or to a dry cask storage system (what is referred to as "dry storage"), the latter still being considered an interim or temporary storage system. Safe, cool, and secure storage is required for thousands of years (as the SNF continue to emit heat and radioactivity). So far, for a host of complex reasons, no country in the world has yet developed a permanent solution (such as a geological repository) for SNF.

SNF pools exist in all countries around the world that have nuclear power, again, as they are a necessary stage of nuclear energy production. All countries (with the exception of Germany) have a predominance of wet storage, or SNF pools, versus dry cask storage. In the United States it is approximately 75% wet storage to 25% dry storage. In neighboring Canada, the ratio of overall SNF storage is: 70% wet storage, 30% dry storage.

There is broad scientific consensus that dry storage is by far the safer storage option (relative to wet storage), once the obligatory wet storage period has passed. There are several reasons for this, one of the primary ones being that it requires no source of power to remain cool (and is therefore much less vulnerable to external risks, and system failures).

SNF pools, or wet storage, present a number of significant risks related to pool drainage (partial or full), which can lead to pool fires and consequently, large radioactive releases (all the more so when wet pools are densely packed, as they generally are in most countries, due to decades of nuclear reactor operation and the lack of a permanent disposal option).

The following events can lead to pool drainage (partial or full), which then can lead to a SNF pool fire: seismic activity, tsunamis, tornadoes, station blackouts, terrorist acts, cooling systems or other technical failures, hydrogen explosions, flooding of plant (due to seasonal activity, and/or climate change), human error or plane crashes. Keep in mind several of these can occur together or in a chain (such as the March 2011 disaster at Fukushima-Daiichi), causing additional system stressors and risks, and preventing appropriate personnel response.

The possibility of SNF pool fires depends upon the presence, and occurrence, of the aforementioned, site-specific risks, consequent pool drainage, and the inability of personnel to respond appropriately. The probability of a SNF pool fire event is generally considered to be very low. **However, science cannot assess, with any absolute certainty, the actual probability of such an event (greatly weakening the reliability of probability estimates). A SNF pool fire can take up to 100 hours to occur** (if it relates to cooling system failures), **or under specific conditions, such a fire can occur in a matter of hours only. Such a SNF pool fire is what leads to significant radioactive releases (of elements which remain radioactive for hundreds of years, such as Cesium 137).** The more radioactivity is contained in the pool, the more radioactivity will be released in the event of a SNF pool fire. Fukushima Plant 4, for example, contains 10 times the equivalent of the Chernobyl release,

in terms of Cesium 137. **While the probability of a SNF pool fire is estimated to be very low, again its occurrence cannot be categorically ruled out by science, and the potential threat emanating from such events is very serious, and can result in substantial releases of radioactivity, many times larger than the original Chernobyl disaster.**

B. Overview of the Fukushima Crisis – SNF Pool Fire Risks – An On-Going and Serious National and International Security Threat

Most readers will be aware of the March 2011 disaster at the Fukushima-Daiichi nuclear complex. What may not be as well known are the continuing, and serious, risks that exist at that complex, both for Japan and for the international community.

The real and on-going present risk at Fukushima-Daiichi is that of that of a SNF pool fire (at plants 4, 5, 6 and 7), which could lead to substantial releases of radioactivity. Such a fire in a SNF pool would result from a partial or full drainage of the water in the fuel pool (as explained above).

The site-specific conditions of concern at the Fukushima-Daiichi complex are:

- Serious seismic activity: Japan is the most seismically active country in the world.
- Tsunamis: Japan is the most tsunami-prone country in the world.
- An active fault line off the coast of the Fukushima complex.
- Station blackout (loss of power from the grid, and loss of back-up power): much higher risk than average, due to high seismic and tsunami activity.
- Structural vulnerability (due to the March 2011 disaster, and hydrogen explosion) at Plant 4, which holds a major SNF pool.
- Cooling system vulnerabilities already demonstrated at Plant 4.
- Organizational corruption and mismanagement at TEPCO (the entity managing the Fukushima complex).
- Japanese government inaction and/or slowness.
- Human error: work conditions at the Fukushima complex are challenging.

The specific on site conditions at the Fukushima-Daiichi complex therefore present clear, on going and multiple risk factors, which could trigger, at any time, very dangerous fires in the SNF pools, at plants 4, 5, 6 and 7.

The amount of radioactive material held at the Fukushima-Daiichi complex:

- Plant 4: estimated to contain 10 times the amount of Cesium 137 released at Chernobyl.
- Plants 5, 6 and 7: estimated to contain 15 times the amount of Cesium 137 released at Chernobyl.
- Total of 10,893 SNF assemblies sitting in pools at the whole complex.
- The grand total for potential Cesium 137 release from the entire Fukushima-Daiichi complex is estimated at about 85 times that of Chernobyl.

The potential radioactive release, should a new disaster occur, could thus be:

- **Anywhere from 10 to 85 times Chernobyl, in terms of Cesium 137** (depending upon a host of complex, on-the ground matters, including weather conditions).

- Given that the first Fukushima nuclear disaster is currently estimated at 1/10 of Chernobyl, **the new potential nuclear threat coming from Fukushima could be anywhere from 100 to 850 times the magnitude of the first event**.

Should a new nuclear disaster occur, depending upon the severity of the radioactive release, it could likely **represent a national and international security threat to the United States, with significant impacts on public health, safety, agriculture, fisheries and oceans, employment, international trade, and the national and international economy.** Needless to say, Japan being the third largest economy in the world, if a new disaster event occurred, the impacts on the already weakened international economy would be substantial. Obviously the potential implications of all this are quite serious.

In such a situation, depending upon weather conditions, **the U.S. Government, and the American People, would have a response time measured, not in months or weeks, but in days only**. In other words, the urgency level here, in terms of response and preparedness, is very high, and it is essential to ensure that all the relevant U.S. agencies (including, of course, the Nuclear Regulatory Commission), be fully warned and prepared. It is also essential to have a fully developed plan for the major cities, states and the nation *prior* to such an event.

The *Collective Good Institute* does not know what the full impacts of a new nuclear disaster (caused by SNF pool fires) would be for United States. The main goal of the *Collective Good Institute*, and its present analysis, is to protect the common good by taking on an educational and precautionary role. **In short, we seek to alert the U.S. government and civil society, with regards to the real, on-going, and urgent threat posed by the Fukushima Daiichi complex to the nation**.

C. SNF Pools in North America and Abroad - National and International Security Threats

What the Fukushima crisis should bring to the fore for public officials, policy makers and leaders in the United States is a much larger and more important area of concern, namely, the issue of the storage of SNF at wet pools across North America, and indeed around the world, and, just as crucially, the issue of the life cycle of SNF storage.

While North American plants (in the United States and Canada) face nowhere near the seismic risk of Japan, the other traditional threats leading to SNF pool fires remain a serious concern: tornadoes, station blackouts, terrorist acts, cooling systems or other technical failures, hydrogen explosions, flooding of plant (due to seasonal activity and/or climate change), human error or plane crashes. Again, the possibility of SNF pool fires depends upon the presence, and occurrence, of the aforementioned, site-specific risks, consequent pool drainage, and the inability of personnel to respond appropriately

The U.S. leadership should also keep in mind that its national and international security could be seriously compromised by other sovereign nations' management of SNF storage pools, especially if said management is not of the highest standards. **To avoid potential, future large nuclear releases that could disrupt not just the host country itself, but the integrity of the national territory of the United States, and the stability of the international economy itself, international excellence in SNF pool management is essential.**

We must ask ourselves: if Japan did not wake up to the dangers of its SNF storage pools at Fukushima until over a full year after the first disaster (and only due to behind-the-scenes, serious international pressure), what will it be like in the future in other countries (such as India, China, or South East Asian nations, where nuclear energy is expanding)? This is a troubling question to say the least, but for the protection of the public, and of U.S. vital interests, it is one that the U.S. leadership must ask itself, and it is one that it must address directly.

Clearly, this is a high-priority matter for study, analysis and response on the part of the U.S. leadership and foreign policy department, as SNF pool mismanagement in foreign countries can have large impacts on the national and international security of the United States, as well as on the stability of the international economy.

The Fukushima-Daiichi disaster of March 11, 2011, has already impelled the U.S. Nuclear Regulatory Commission (and the Canadian Nuclear Safety Commission) to develop some new measures for the enhancement of the safety and security of nuclear plants, and SNF pools. This is an encouraging and salutary response, but it does speak to our previous lack of preparedness for such a threat. **And currently, the U.S. Nuclear Regulatory Commission (NRC) unfortunately still considers wet storage to be just as safe as dry storage, and the NRC is not encouraging a national shift to dry storage.**[1]

Furthermore, the fact that the U.S. NRC, the main regulatory institution, is *not regulating* to ensure a shift from wet to dry storage means that appropriate and timely measures to preserve the national security of the United States are presently not being taken. The level of threat, and potential disruption to American society, warrants that the U.S. not entrust this responsibility to any single regulatory institution (especially one whose regulatory capacity seems seriously impaired or ineffective).[2] Since these matters potentially impact the U.S. nation itself (not to mention the international community itself), and since the impacts would be serious and long lasting, **the policy for SNF storage should not be determined by a single regulatory body, or administration.** Indeed, this is an urgent matter of national debate, not just in Congress, but also in civil society at large. It would be in the national interest to gather all the available expertise from all parties, in order for Congress to debate, and eventually legislate, with a broad national consensus behind it (if possible), all the more so that this is truly a non-partisan issue.

In conclusion, the main goal of the *Collective Good Institute*, and its present analysis, is to protect the common good by taking on an educational and precautionary role. **We seek to alert the U.S. government and civil society with regards to the real, on-going, and urgent threat posed by the Fukushima-Daiichi complex to the U.S. nation, and the on-going potential threat posed by SNF pools in North America (and around the world).**

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[1] The scientific consensus is that dry storage is safer, and more secure, than wet storage, and clearly the preferable option. See: "Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report," National Academy of Sciences (NAS), National Research Council, 2006.

[2] Real concerns exist regarding the regulatory independence, and efficiency, of the U.S. NRC. For a recent example of this see: "Court Forces a Rethinking of Nuclear Fuel Storage," New York Times, June 8, 2012.

2. Introduction: Scope and Goal of our Analysis

The sole objective of the *Collective Good Institute*, in this present report, is to analyze the dangers posed by Spent Nuclear Fuel (SNF) storage pools at the Fukushima-Daiichi complex and, more generally in North America (and around the world), to the national and international security of the United States.

The *Collective Good Institute* is a non-partisan, ad-hoc think tank, affiliated with no official organization, whether academic, private, political, national or governmental. It is not affiliated with any pro-nuclear, or anti-nuclear, organization of any sort. Finally, the *Collective Good Institute* has never taken any stance, whether in favor or against, on nuclear energy in general, or on specific nuclear energy policies.

The sole mission of the *Collective Good Institute* is educational, and its only aim is to protect the collective good of citizens and nations. The current focus of the *Collective Good Institute* has been, and continues to be, the on-going "Fukushima Crisis," and threats posed by SNF storage pools in North America and around the world.

Having identified a clear, and present, national and international security threat to the United States, in the form of the present site conditions at the Fukushima-Daiichi complex, the *Collective Good Institute* aims to protect the collective good by taking on an educational and precautionary role. **In short, we seek to alert the U.S. government and civil society, with regards to the real, on-going, and urgent threat posed by the SNF pools at the Fukushima-Daiichi complex to the U.S. nation**.

Additionally, we seek to warn the **U.S. government and civil society with regards to the threats posed by SNF storage pools located across the United States (and in Canada, near the U.S. border). Finally, we seek to warn the United States of an emerging threat to international security, related to potential, future SNF pool crises in other countries, in particular the emerging nuclear energy markets of China, India and South East Asia.**

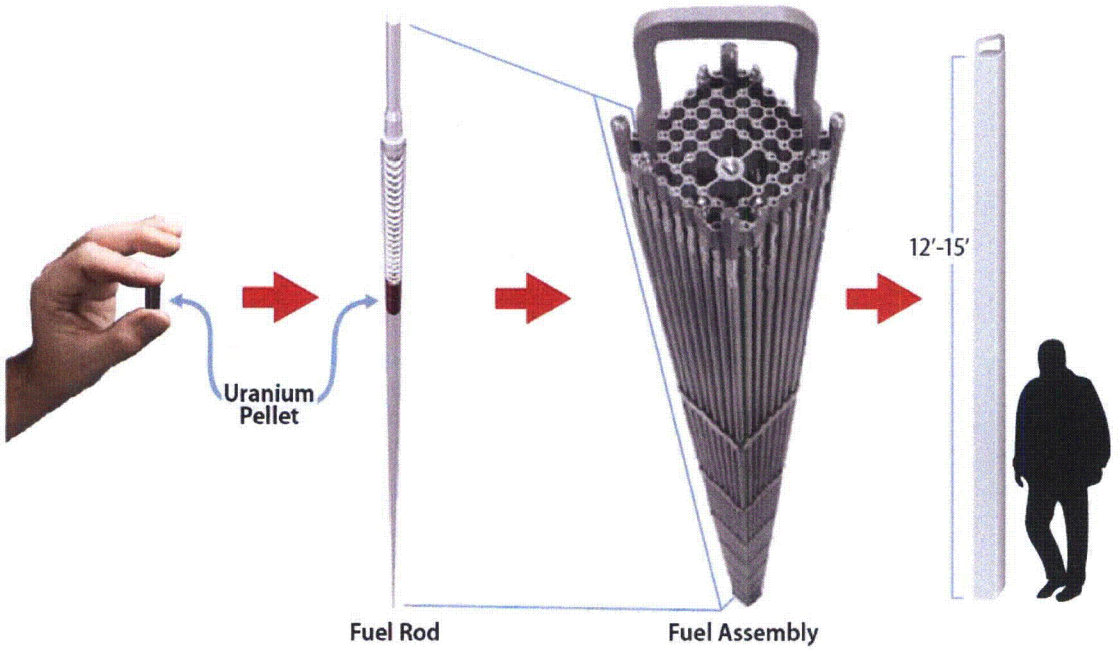
For all the sources that have informed our analysis, we refer you to our extensive list of scientific and news sources in Appendix A.

3. Overview of Spent Nuclear Fuel (SNF) and SNF Storage Options

Spent Nuclear Fuel (SNF), often referred to as "nuclear waste," is an inevitable by-product of the nuclear energy production process. SNF remains radioactive for thousands of years, and needs to be stored appropriately, for public health, and national and international security reasons.

After being spent or used up, the SNF, in the form of a nuclear fuel assembly (see Figure 1), is extracted from the nuclear core, and initially gets stored in wet pools (i.e. "wet storage"), as a necessary stage of nuclear energy production. The SNF rods must be stored for 3 to 10 years in these wet pools before they can be transferred to another wet pool, or to a dry cask storage system (what is referred to as "dry storage"), the latter still being considered an interim or temporary storage system. Safe, cool, and secure storage is required for hundreds of years (as the SNF still emits heat and radioactivity, and represents a security risk). So far, for a host of complex reasons, no country in the world has yet developed a permanent solution (such as a geological repository) for SNF.

Figure 1: Nuclear Fuel Assembly



Source: CRS-produced graphic using SNF assembly image from General Electric Company.

Note: Illustrates a typical light water reactor nuclear fuel assembly used in U.S. commercial nuclear power reactors, and may not resemble fuel for research reactors, naval nuclear propulsion reactors, or nuclear power reactor fuel in other countries.[3]

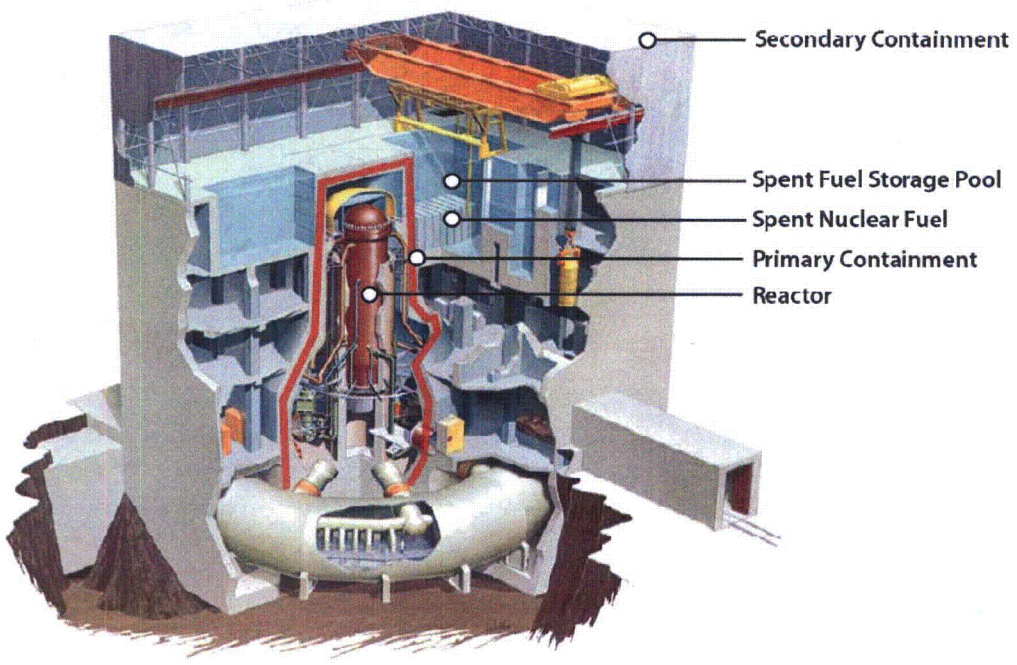
[3] "U.S. Spent Nuclear Fuel Storage", Congressional Research Service, James D. Werner, May 24, 2012

We will not go into all the details of this here, but it also important to keep in mind that SNF pools vary in their location, and design, depending upon the type of nuclear reactor model, whether Pressurized Water Reactors (PWRs) or Boiling Water Reactors (BWRs). In the case of BWRs, such as at the Fukushima-Daiichi complex, this means that the SNF storage pool is located inside the secondary containment structure of the nuclear reactor itself, as well as are many critical control systems. The SNF storage pools are also located, by design, several stories above ground level.

What this really means is that, with BWRs, when things go badly, not only is the reactor at risk, but so are the SNF pools themselves (clearly a major safety design flaw – that is likely insurmountable due to the need for rod assemblies to be transported from very near the reactor). And in fact, what happened at the Fukushima-Daiichi complex, with its multiple hydrogen explosions at Plants 1, 2, 3 and 4, is precisely an illustration of this additional threat to SNF pools. The densely packed SNF pool at Plant 4 was in fact damaged by a hydrogen explosion, which thus places it, currently, at a higher risk of pool drainage (partial or full), should there be an additional shock (such as another large earthquake and tsunami).

SNF pools exist in all countries around the world that have nuclear power, as they are a necessary stage of nuclear energy production. All countries (with the exception of Germany) have a predominance of wet storage, or SNF pools, versus dry cask storage. In the United States, the ratio of

Figure 2: SNF Pool Storage Location in a Boiling Water Reactor model



Source: GE-Hitachi Nuclear Energy.
Note: Illustrates a GE Mark I BWR design, which is one of a number of BWR designs.[4]

[4] "U.S. Spent Nuclear Fuel Storage", Congressional Research Service, James D. Werner, May 24, 2012

overall SNF storage is roughly: 75% wet storage to 25% dry storage. In neighboring Canada it is 70% wet storage, 30% dry storage.

There is broad scientific consensus that dry storage is by far the safer storage option (relative to wet storage), once the obligatory wet storage period has passed (5 to 10 years on average).[5] There are several reasons for this, one of the primary ones being that it requires no source of power to remain cool (and is therefore much less vulnerable to external risks, and system failures), and it can be more widely distributed than an individual SNF pool, thereby reducing the possibility of a larger radioactive release (relative to a densely packed SNF pool). Any superior team of nuclear experts,[6] which has carefully examined all the evidence, arrives at the same conclusion: once the obligatory wet storage period has passed, dry storage is clearly the preferable option in terms of safety and security. It's fairly clear, from examining the SNF management histories of different countries that the main blockages to dry storage are: financial limitations, institutional inertia, mismanagement, regulatory failures and/or corruption.

SNF pools (wet storage), present a number of significant risks related to pool drainage (partial or full), which can lead to large radioactive releases, all the more so when wet pools are densely packed, as they generally are in most facilities and countries (due to the fact that nuclear facilities have been storing SNF for decades, and due to fact that no permanent solution for SNF storage has yet been developed by any country, for a host of complex reasons).[7]

The following events can lead to pool drainage (partial or full), which then can lead to a SNF pool fire: seismic activity, tsunamis, tornadoes, station blackouts, terrorist acts, cooling systems or other technical failures, hydrogen explosions (at the reactor plant), flooding of plant (due to seasonal activity and/or climate change), human error or plane crashes. Keep in mind several of these can often occur together or in a chain (such as the March 2011 disaster at Fukushima-Daiichi), causing additional system stressors and risks, and preventing appropriate personnel response.

The possibility of SNF pool fires depends upon the presence, and occurrence, of the aforementioned, site-specific, risks, consequent pool drainage, and the inability of personnel to respond appropriately. **A SNF pool fire can take up to 100 hours to occur** (if it relates to cooling system failures), **or under specific conditions, such a fire can occur in a matter of hours only.** Such a SNF pool fire is what leads to significant radioactive releases (of elements which remain radioactive for hundreds of years, such as Cesium 137). To learn more about the scientific consensus on the possibility of SNF pool fires, see the U.S. National Academy of Sciences public report from 2006.[8]

The more radioactivity is contained in the pool, the more radioactivity will be released in the event of a SNF pool fire. Fukushima Plant 4, for example, contains 10 times the equivalent of the Chernobyl release, in terms of Cesium 137. Plants 5, 6 and 7 contain 15 times the equivalent of the Chernobyl release.[9] This would indicate that limiting the density of SNF pools, as much as is feasible, would be advisable on safety, and security, grounds.

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[5] "Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report", National Academy of Sciences (NAS), National Research Council, 2006.

[6] Such as the U.S. National Academies in 2006, compromised of the National Academy of Sciences and the National Academy of Engineers. See NAS 2006 report (cited above).

[7] For more on this see "Managing Spent Fuel from Nuclear Power Reactors: Experience and Lessons from Around the World", International Panel on Fissile Materials, September 2011.

[8] The analysis, and scientific conclusions were furthermore validated, and agreed with, by the U.S. Nuclear Regulatory Commission, an entity not always at the forefront in terms of nuclear waste management.

[9] Based on U.S. Department of Energy Data. See also: Robert Alvarez (2012), in sources.

It would also seem prudent, and essential to national security, to limit the grave dangers associated with SNF pools, for United States and other countries, by quickly moving as much of their SNF stock to dry storage as is economically feasible, and by rapidly legislating in this domain to ensure an efficient and speedy shift away from medium and long-term wet storage.[10]

4. Overview of Fukushima Disaster

The Fukushima-Daiichi nuclear disaster began on the late afternoon of March 11, 2011, with a 9.0 earthquake followed by a 46-foot-high tsunami. The Daiichi nuclear power plant was hit badly, and the damage was substantial. In an about an hour, the plant lost power from the grid, its back-up diesel generators were brought down by the tsunami, and the technical systems (pipes, pumps etc.) needed to keep the four reactors and nuclear fuel pools cool were severely impacted. Beginning that day, a large nuclear disaster ensued (currently estimated at about 1/10 of Chernobyl in terms of radioactive releases).

The Fukushima-Daiichi complex was stabilized - as much as possible - by TEPCO (Tokyo Electric Power Company, the entity managing the Fukushima complex), about three months after the initial event. At that point the site contained three nuclear melt-downs (at plants 1, 2 and 3), and vulnerable spent nuclear fuel pools at plant 4 (the most at risk), and plants 5, 6 and 7 (structurally undamaged).

The *Collective Good Institute* will not give a history of events, as this is already very well documented in many credible news sources (see Appendix A).

5. Current Situation at Fukushima Complex – Risk Analysis

The real and on-going present risk at Fukushima-Daiichi is that of that of a propagating fire[11] **in the SNF pools (at plants 4, 5, 6 and 7), which could lead to substantial releases of radioactivity**. Such a fire in a SNF pool could result from a partial or full drainage of the water in the fuel pool (and the inability of the personnel to keep the pool full, and cooled properly, for whatever reasons).

For the scientific consensus on the possibility of propagating zirconium cladding fires in spent nuclear fuel pools see Alvarez 2003 and the US National Academies/National Research Council paper of 2006 (we will abbreviate this as NAS to distinguish this from the Nuclear Regulatory Committee). According to the NAS 2006 report, under certain conditions, a propagating zirconium cladding fire is possible in a matter of only hours, and would result in serious radioactive releases. In other words, under specific conditions, in the event of pool drainage, the required response time to prevent a disaster from happening would be very short (i.e. a matter of hours only).

The following events can lead to pool drainage (partial or full), which then can lead to a SNF storage pool fire (which, in turn, causes serious radioactive releases): seismic activity, tsunamis, tornadoes, station blackouts, terrorist acts, cooling systems or other technical failures, hydrogen explosions, flooding of plant (due to seasonal activity or due to climate change), human error or plane crashes.[12] Keep in mind several of these can often occur together or in a chain (such as at Fukushima-Daiichi),

[10] The conclusion in fact reached by the scientific team of the 2006 NAS report.
[11] The scientific term for this type of fire is a propagating zirconium cladding fire.
[12] See the scientific literature on SNF storage in Appendix A, Section 1, of our report for more details.

causing additional system stressors and risks. Also keep in mind that nuclear reactor control rooms rarely have instrumentation to monitor the pools' water levels and chemistry.

The list of risks is unfortunately not short, and the exact statistical probability (though estimated to be very low) is unknown, and cannot be accurately forecast by science. This is due, for the moment, to the present state of nuclear reactors (none of which were designed for preventing fuel pool fires),[13] and to the state of science itself (which, for example, cannot precisely and categorically predict the occurrence of earthquakes, tsunamis, plane crashes, or terrorist acts). In other words, presently, there can be no statistical certainty that the event will not occur. We hope the U.S. national security team, the relevant U.S. administrations, and individual U.S. states, understand how troublesome this fact is, especially in regards to the many SNF pools that are to be found in the United States (and in Canada).

The occurrence of a fuel pool drainage situation, leading to a fuel pool fire, depends upon a number of different variables including the site-specific conditions of each plant (i.e. the unique elements or vulnerabilities of a specific site, which could lead to a pool drainage event).

To determine the potential national, and international, security threat of Fukushima, we must therefore have an excellent understanding of the actual site-specific conditions there. As it stands, as of July 2012, the overall situation at the Fukushima-Daiichi complex is currently as follows:

- Three on-going full nuclear meltdowns at Plants 1, 2 and 3.
- Badly damaged structures due to the quake, the hydrogen explosions at Plants 1, 2 and 3, and an explosion and fire at Plant 4 in the first month after the quake.
- Nearly all of the 10,893 spent fuel assemblies are stored in pools vulnerable to future, major earthquakes.
- The cooling systems for the fuel pool at Plant 4 have failed twice already just in the month of June 2012, and are clearly of poor quality and still vulnerable.
- Geography that makes Japan the most seismically active, and tsunami-prone, country in the entire world (in other words, Japan is the very worst place, geographically speaking, on the planet to have nuclear power generation). Historically, here is the record of a combination of a major earthquake (7.4 and above) plus a tsunami in Japan[14]: 869 (8.6 quake), 1361 (8.2), 1498 (8.6), 1605 (7.9), 1703 (8.0), 1771 (7.4), 1854 (8.4), 1896 (8.5), 1933 (8.4), 1944 (8.1), 1968 (8.2), 2006 (8.3), and last but sadly not least, March 11, 2011 (9.0).
- An active fault line off the coast of the Fukushima complex.
- An agency in charge of managing the site (TEPCO), which has a long, officially-documented history of corruption and mismanagement. Also keep in mind that as of April 2012, a full year after the first disaster already occurred, TEPCO's plans for transferring the spent nuclear fuel at Plant 4's pool would not officially begin until the end of 2013 (since then, the plans have been accelerated – see bullet below). In other words, a full year after the first disaster, TEPCO

[13] "Improving Spent-Fuel Storage at Nuclear Reactors," Robert Alvarez, Issues in Science and Technology, Winter 2012.
[14] See Appendix A, Section 5, of our report.

either did not fully understand the grave risk of potential SNF pool fires (and consequent large nuclear releases), or was negligent regarding the new substantial, unwarranted risks posed by the possibility of fuel pool fires at Plants 4, 5, 6 and 7. Either option is very troubling to say the least.

- An overall government with a well-documented history of collusion with the nuclear industry, and a seeming blindness to the urgency of the current problem at the Fukushima complex. Consider a national government waiting around for over a year (until June 2012), while a real possibility of a new nuclear release anywhere up to 85 times Chernobyl could occur, devastating the country anew, and one begins to understand how worrisome the political and managerial response is to the on-going Fukushima Crisis. The top-level international leadership seems to have understood this in the last three months, and applied real diplomatic pressure on Japan (as one can surmise from US Senator Wyden's actions in April 2012, and the recent, announced acceleration of the cleanup at Fukushima by the Japanese Nuclear Minister).[15] Even though this is finally, and properly (one hopes) on the Japanese government's radar screen, the transfer of rods from Plant 4 is still a large endeavor that will take many months, at a minimum, to complete (due to the damaged conditions of Plant 4).

- Plant 4, is estimated to contain 10 times Chernobyl worth of Cesium 137.

- In addition, plants 5, 6 and 7 (structurally undamaged so far) at Fukushima contain 15 times Chernobyl worth of Cesium 137.

- The grand total for potential Cesium 137 release from the entire Fukushima-Daiichi complex is estimated at about 85 times that of Chernobyl.[16]

The specific on site conditions at Fukushima-Daiichi therefore present clear, on going and multiple risk factors (in terms of the possibility of SNF pool fires at plants 4, 5, 6 and 7). To summarize, the site-specific risks, which could lead to fuel pool drainage and fires, are:

- Serious seismic activity, Japan being the most seismically active country in the world. Exact risk forecast: unknown (but its much higher than most places in the world).
- Tsunamis: again Japan is the most tsunami-prone country in the world. Exact risk forecast: unknown (but its much higher than most places in the world).
- Station blackout: loss of power from the grid, and loss of back-up generators (exactly what happened the first time at Fukushima). Exact risk forecast: unknown (but it is much higher than for most other nuclear plants in the world, due to high seismic and tsunami activity).
- Structural vulnerability at Plant 4 (due to the first quake, the fire and the explosion in the first month). Exact risk forecast: unknown (because we need a credible analysis, other than one realized by TEPCO, and because we cannot precisely predict the occurrence of earthquakes).
- Cooling system vulnerabilities, which failed twice already in just the month of June 2012. Exact risk forecast: likely very low that this alone would cause pool drainage and fire (as long as the site remains accessible to personnel).
- A dense fuel pool at Plant 4 (we do not know the exact fuel pool densities at Plants 5, 6, and 7, but they are lower than plant 4). This causes a higher risk of pool fire. However, the fuel rods

[15] See Reuters June 2012 article in Sources.
[16] See Appendix A, Sections 2 & 3.

at all plants are beyond 12 months of cooling (which reduces risk – although the risk is still present, even after 12 months of cooling).[17] Exact risk forecast: unknown.[18]

- Organizational ineptitude and mismanagement: see TEPCO and Japanese government discussion above (and sources). Exact risk forecast: unknown, but track record not at all good.
- Human error: exact risk forecast is unknown, but work conditions at the Fukushima complex are well below average due to the ambient radioactivity, and the poor conditions of the plants (i.e. the risk for human error is higher than average).
- A terrorist act: given the specific history and conditions in Japan, the risk would seem very low. However, in the present historical times, one can never be fully sure in this realm, as there is always the possibility of international terrorism. Exact risk forecast: unknown (and science has no way to predict occurrence in this instance as well).

When tallying the real site-specific threats present at the Fukushima complex, and considering that *precise* risk forecasts cannot be ascertained by science, and that many risks are higher than average, the *Collective Good Institute* concludes that the potential risk for a new nuclear disaster at the Fukushima complex is indeed real and on-going (and, again, its exact statistical probability cannot be estimated). It is also essential to keep in mind that this disaster could occur at any time. Furthermore, should such an event occur, the radioactive releases could be quite substantial, and could present a national and international security threat to United States, evolving in a complex manner in a number of different realms. We will speak very briefly of the potential impacts after an overview of the potential radioactive releases.

Potential Radioactive Release (depending upon how a disaster would unfold exactly on the ground):

- **10 to 85 times Chernobyl, in terms of Cesium 137** (depending upon a host of complex, on-the ground matters, including among others, weather conditions during the days following such an event).

- The first Fukushima nuclear disaster is currently estimated at 1/10 of Chernobyl. In other words, **the new potential nuclear threat coming from Fukushima could be anywhere from 100 to 850 times the magnitude of the first event.**

- The level of disruption to the Japanese economy that has already occurred due to the March 2011 disaster gives one a good idea of what this new potential threat means for Japan itself (and for the stability of the world economy).

[17] See NAS 2006 report (cited above).
[18] And the NAS 2006 report concludes as well that further research is needed in this area.

6. Fukushima Complex – An Urgent National and International Security Threat

Unfortunately, should such an event occur, and we are obviously speaking hypothetically, the impacts would not be limited to Japan, given the size of its economy (3rd largest in the world) and given the potential for large radioactive releases.

In the event of a new nuclear disaster, ranging from 10-85 times Chernobyl, it seems clear, without knowing the real scope and magnitude of impacts, that the West Coast of the United States would be hit first to some extent, dependent upon the extent of radioactive release, dispersion over the Pacific, and weather-conditions. In such an event, the following U.S. interests could be impacted to varying degrees:

- Public health and safety: potential for air, water, and food contamination, especially in the first months after the major event (with higher risks to children and women).
- Oceans and fisheries: as it stands, we are already seeing some impacts on the United States from the first Fukushima disaster (for example, a non-negligible percentage of fish exports from Japan to the North America are already impacted by high levels of radioactivity).[19] Should a serious event occur at Fukushima again, the Pacific fisheries industries would undoubtedly be impacted, as would the Pacific Ocean itself (to degrees that cannot be estimated yet, but that could be monitored).
- Tourism industry (on the West Coast of the United States especially).
- Agriculture (due to air and water contamination): this depends on the magnitude of the event, on meteorological conditions during the event, and on the extent of dispersion of radioactivity as it travels through the Pacific. Many variables would need to be tracked very carefully by the relevant U.S. authorities, in the days and months following such an event.
- Psychological impacts on the citizenry: psychological trauma, and illness, is well known in the field of psychology to have important and detrimental impacts on people (obviously), but it also has measureable, direct impacts on the economy (in terms of impairment at work and loss of work). It is also important to keep in mind that the large majority of the citizenry is not well informed regarding the science of radiation exposure and its associated health risks. And from this uninformed place (likely aggravated by fear in a disaster situation), citizens could make mass decisions that end up having detrimental impacts on the economy (say on agriculture and fisheries). In other words, plans for extensive public education campaigns would be advisable, and could better protect the economy of the United States in such an instance.
- International economic impacts: a new disaster at Fukushima would obviously represent a very substantial blow to the Japanese economy. This would, in turn, negatively impact international trade, and the stability of the world economy (already vulnerable due to other international matters).
- National economic impacts: see previous bullets, and the impact on various American economic sectors.

The above list represents only a summary, introductory overview of some the *possible* impacts on the national security of United States. To be clear: the *Collective Good Institute* does not know what the full impacts of a new, potential nuclear disaster (emanating from spent nuclear fuel pools at Fukushima) would be for the United States. Ideally, this whole matter should be fully examined by an independent, interdisciplinary, panel of top experts in their fields, appointed by the U.S. government.

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[19] See Appendix A, Section 6.

It is also essential to understand that in such a nuclear disaster situation, depending upon weather conditions, the U.S. Government, and the American People, would have a response time measured, not in months or weeks, but in days only. **In other words, the urgency level here, in terms of response and preparedness, is very high, and it is essential to ensure that all the relevant U.S. agencies be fully warned and prepared.** It is also essential to have a fully developed plan for the major cities, states and the nation *prior* to such an event (with a special focus on the West Coast of the United States).

7. SNF Pools in North America and Around the World – Analysis of Threats to National and International Security

SNF pools exist in all countries around the world that have nuclear power, as they are a necessary component of nuclear energy production, as explained in chapter 3 of this report. All countries (except Germany) have a predominance of wet storage, or SNF pools, versus dry cask storage. And so far, no country in the world has yet built a permanent storage solution for SNF (such as a central, geological repository). In the United States, the choice of a permanent geological repository at Yucca Mountain in Nevada was scrapped in 2010, and there seems to be very little chance of rapid progress in this area in the coming years.[20] As a result, temporary storage of SNF (whether wet or dry storage) will likely go on, and be a concern, for decades to come.

In the United States, approximately 75% of SNF is stored in wet pools (61,000 tons in total, as of 2007, largest stock in the world).[21] In neighboring Canada, wet pool storage is 70% of its grand total of SNF storage (38,400 tons in total as of 2007, 2nd largest stock in the world). The exact location of SNF pools in the United States clearly matters for risk assessment purposes, since risk must be studied, and determined, on a site-by-site basis. However, their location in Canada matters as well, because many sites are near the U.S. border (but, obviously, since they are not under U.S. jurisdiction, this is a matter that can only be addressed by foreign policy and diplomacy).

What the Fukushima crisis should bring to the fore for public officials, policy makers and leaders in the United States is a much larger and more important area of concern: namely, the issue of the storage of SNF at wet pools across North America, and indeed around the world, and, just as crucially, the issue of the life cycle of SNF storage.

While North American plants (in the United States and Canada) face nowhere near the same level of seismic risk as Japan,[22] the other traditional threats leading to SNF pool fires remain a serious concern: tornadoes, station blackouts, terrorist acts, cooling systems or other technical failures, hydrogen explosions, flooding of plant (due to seasonal activity or climate change), human error or plane crashes.

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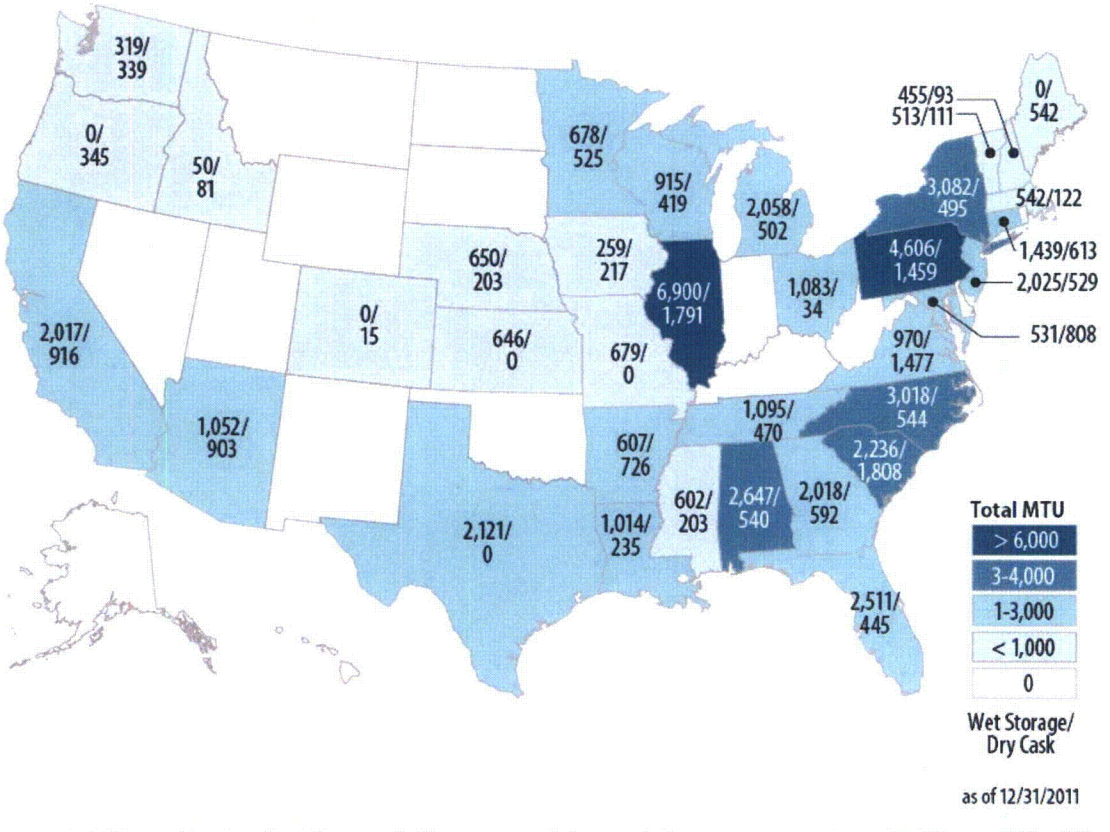
[20] See "Court Urged to Order Decision on Nuclear Waste Site," New York Times, May 2, 2012.

[21] "U.S. Spent Nuclear Fuel Storage" Congressional Research Service report, J. D. Werner, May 24, 2012, p.4.

[22] Seismic risk, however, remains an area to be monitored in North America as well.

Figure 3: SNF Storage Map (with ratio of wet to dry storage)



So

urce: "U.S. Spent Nuclear Fuel Storage" Congressional Research Service report, James D. Werner, May 24, 2012, p.23.

The U.S. leadership should also keep in mind that its national and international security could be seriously compromised by other sovereign nations' management of SNF storage pools, especially if said management is not of the highest standard. And really, given the large risks posed by SNF storage pools, "highest standard" should not be a relative concept. **To speak plainly: to avoid potential, future large nuclear releases that could disrupt not just the host country itself, but the integrity of the national territory of the United States, and the stability of the international economy, international excellence in SNF storage pool management is essential** (in terms of, for example, overall technology, pool monitoring systems, personnel, SNF life cycle management, security, regulatory bodies and mechanisms, institutional integrity or lack of corruption).

The poor managerial record of TEPCO, and the incredibly long response time of the Japanese government – more than a full year after the first disaster - to the very real danger posed by its SNF pools at the Fukushima-Daiichi complex, should be a cause of very serious concern to the U.S. leadership. **We must ask ourselves: if a country as advanced as Japan did not respond to the dangers of its SNF storage pools at Fukushima until over a full year after the first disaster (and only due to behind-the-scenes, serious international pressure), what will it be like in the future in other countries (such as India, China, or South East Asian nations, where nuclear energy is**

expanding)?[23] This is a troubling question to say the least, but for the protection of the American public, and the vital interests of the nation, it is one that the U.S. leadership must ask itself, and clearly it is one that it must address directly.

Clearly, this is a high-priority matter for study, analysis and response on the part of U.S. leadership and American foreign policy, as SNF storage pool mismanagement in foreign countries can have large impacts on the national and international security of the U.S., as well as on the stability of the international economy.

The Fukushima-Daiichi disaster of March 11, 2011, has already impelled the U.S. Nuclear Regulatory Commission (and the Canadian Nuclear Safety Commission) to develop some new measures for the enhancement of the safety and security of nuclear plants, and SNF pools. This is an encouraging and salutary response, but it does speak to our previous lack of preparedness for such a threat. **And currently, the U.S. Nuclear Regulatory Commission (NRC) unfortunately still considers wet storage to be just as safe as dry storage, and the NRC is not encouraging a national shift to dry storage.**

The safety of SNF pools is clearly on the radar screen of members of the top U.S. leadership,[24] (including the Obama Administration itself, since, among other things, diplomatic pressure was recently applied on Japan). However, the fact that the U.S. NRC, the main regulatory institution, is *not regulating* to ensure a shift from wet to dry storage, means that all the **appropriate and timely measures to preserve the national security of the United States are presently not being taken.**

The level of threat, and potential disruption to American society, warrants that the U.S. not entrust this responsibility to any single regulatory institution (especially one whose regulatory capacity seems seriously impaired or ineffective).[25] **Since these matters potentially impact the U.S. nation itself (not to mention the international community), and since the impacts would be serious and long-lasting, the policy for SNF storage should not be determined by a single regulatory body, or administration.** Indeed this is an urgent matter of national debate, not just at Congress, but in civil society at large … for it would be in the national interest to gather all the available wisdom from all parties, in order for Congress to debate, and eventually legislate, with a broad national consensus behind it (if possible), all the more so that this is truly a non-partisan issue.

To conclude: should a new nuclear disaster at Fukushima-Daiichi occur, it would likely represent an urgent national and international security threat to the United States, with significant impacts on public health, safety, agriculture, fisheries and oceans, employment, international trade, and the national and international economy. Obviously, the implications are quite large.

The main goal of the *Collective Good Institute*, and its present analysis, is to protect the common good by taking on an educational and precautionary role. **In short, we seek to alert the American government and civil society with regards to the real, on-going, and urgent threat posed by the Fukushima-Daiichi complex to the U.S. nation, and the potential threat posed by SNF pools in North America (and around the world).**

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[23] See New York Times, Southeast Nations Look at Nuclear Power, November 27, 2011.
[24] Blue Ribbon Commission on America's Nuclear Future. Report to the Secretary of Energy, January 2012.
[25] Real concerns exist regarding the regulatory independence, and efficiency, of the U.S. NRC. For a recent example of this see: "Court Forces a Rethinking of Nuclear Fuel Storage," New York Times, June 8, 2012.

Authors

The Collective Good Institute is an ad-hoc think tank devoted to better understanding and protecting the Collective Good. With a host of global stressors on the environment, and societies, the collective or public good is under increasing threat. The goal of the *Collective Good Institute* is to help citizens, civil society and the public sector better understand and respond to these global challenges.

Upon realizing the gravity of the "Fukushima crisis," and the "Spent Nuclear Fuel Pool crisis," and the potential threat it poses to the citizens of the United States, Canada and Japan, the team was assembled under the leadership of Dimitri de Morea. Top-level experts were drawn from the fields of conventional and alternative energy, nuclear security, public policy, philosophy, economics, and defense. The aim of the team was to produce clear, excellent, and scientifically accurate analysis, for the use of citizens, elected officials and political leaders, with the overarching goals of preparedness, and protection of the collective good.

The *Collective Good Institute* is a non-partisan, ad-hoc, think tank, affiliated with no official organization, whether academic, private, political, national or governmental. Its sole mission is educational, and its only aim is to protect and serve the collective good of citizens and nations. The recent focus of the *Collective Good Institute* has been, and continues to be, the on-going "Fukushima-Daiichi Crisis," and the national and international threats posed by spent nuclear fuel storage pools in North America, and around the world.

Dimitri de Morea, M.A., CCC, is a counselor, executive coach and public speaker. He is the co-founder, and director of the think tank, the *Collective Good Institute*. He holds a Bachelors degree in Economics and History from the University of California at Berkeley, a Masters degree in Multimedia Management from Université de Paris, and Masters degree in Counseling Psychology from the California Institute of Integral Studies. A native speaker of English and French, he has worked as a researcher and policy analyst at the United Nations in Geneva, and at the University of California at Berkeley. He has also worked as a social and web entrepreneur in San Francisco, and co-founded City CarShare, leading its policy and research team. City CarShare went on to become one of North America's largest car-sharing organizations. In addition to his work at the *Collective Good Institute*, he advises and coaches leaders, writes, and lectures frequently on personal development, leadership and topics relating to the critical issues of our age.

For inquiries regarding the present report, please contact Dimitri de Morea at:
director@collectivegood.info

Appendix A: Scientific and News Sources

1. SPENT NUCLEAR FUEL POOLS & RISK OF FIRE - GENERAL

Scientific/Institutional Sources:

U.S. Spent Nuclear Fuel Storage
Congressional Research Service May 2012
www.fas.org/sgp/crs/misc/R42513.pdf
An excellent, very detailed, and current overview of spent nuclear fuel storage in the US, prepared for Congress. Note that on page 31 of "U.S. Spent Nuclear Fuel Storage", the author misquotes the 2006 National Research Council paper listed below in this list of sources. He writes that the 2006 National Research Council paper concludes that "such an accident ...so unlikely that no specific action was warranted." However, a quick glance at the referenced page shows that this is actually a quote from a previous Nuclear Regulatory Commission study, which was included in their review, and that this is **not** the conclusion of the 2006 National Research Council paper. The 2006 National Research Council report concludes that in fact spent nuclear fuel pool fires are a very real risk. Other than this single research mistake the report is quite an excellent overview of the spent nuclear fuel management situation in the United States.

Managing Spent Fuel from Nuclear Power Reactors - Experience and Lessons from Around the World
International Panel on Fissile Materials Sept 2011
http://fissilematerials.org/library/2011/09/managing_spent_fuel_from_nucle.html

Improving Spent-Fuel Storage at Nuclear Reactors
Robert Alvarez, Issues in Science and Technology, Winter 2012
http://www.issues.org/28.2/alvarez.html

CRS Report RL34234, Managing the Nuclear Fuel Cycle: Policy Implications of Expanding Global Access to Nuclear Power
Congressional Research Service Mar 2011
www.fas.org/sgp/crs/nuke/RL34234.pdf

Nuclear Power Reactors in the World
International Atomic Energy Agency 2010 Edition
http://www-pub.iaea.org/MTCD/Publications/PDF/iaea-rds-2-30_web.pdf

The Future of the Nuclear Fuel Cycle: An Interdisciplinary MIT Study
Massachusetts Institute of Technology MIT 2010
web.mit.edu/mitei/docs/spotlights/nuclear-fuel-cycle.pdf

CRS Report R40202, Nuclear Waste Disposal: Alternatives to Yucca Mountain
Congressional Research Service Feb 2009
www.fas.org/sgp/crs/nuke/R40202.pdf

Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report
National Research Council 2006
http://www.nap.edu/catalog.php?record_id=11263#description

Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States
Science and Global Security, Alvarez et al, 2003
http://www.irss-usa.org/pages/documents/11_1Alvarez.pdf

Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82. NUREG/CR-4982 and BNL-NUREG-52093
Brookhaven National Laboratory 1987
http://www.osti.gov/bridge/servlets/purl/6135335-5voofL/6135335.pdf

NRC Study Shows the Serious Consequences of a Fukushima-Type Accident in the US
Union of Concerned Scientists July 2011
http://allthingsnuclear.org/post/8243137367/nrc-study-shows-the-serious-consequences-of-a

U.S. and Canadian Regulator Responses to Fukushima Crisis:

U.S. Nuclear Regulatory Commission Response to Fukushima Crisis
NRC Website, last update July 2012
http://www.nrc.gov/reactors/operating/ops-experience/japan-info.html
Be sure to click on the links for Tier 1, Tier 2, and Tier 3 priorities.

Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Daiichi Accident
US NRC July 2011
http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf

Blue Ribbon Commission on America's Nuclear Future
Report to the Secretary of Energy, Jan 2012
http://brc.gov/sites/default/files/documents/brc_finalreport_jan2012.pdf

Canada Nuclear Safety Commission Response to Fukushima Crisis
CNSC Website, last update July 2012. Overview:
http://nuclearsafety.gc.ca/eng/mediacentre/updates/2011/japan-earthquake/index.cfm#3

Presentation by Executive Vice President Ramzi Jammal to External Advisory Committee, Aug 2011
http://nuclearsafety.gc.ca/eng/pdfs/Presentations/VP/2011/August-5-2011-Jammal-Briefing-to-External-Advisory-Committee_e.pdf
The web page and the presentation PDF below it give an excellent overview of the CNSC's domestic response to the Fukushima crisis to date.

Media Sources:

Court Forces a Rethinking of Nuclear Fuel Storage
New York Times Jun 2012.
http://www.nytimes.com/2012/06/09/science/earth/court-says-nuclear-agency-must-rethink-fuel-storage.html?_r=1&smid=fb-share
"The Nuclear Regulatory Commission acted hastily in concluding that spent fuel can be stored safely at nuclear plants for the next century or so in the absence of a permanent repository, and it must consider what will happen if none are ever established, a federal appeals court ruled on Friday. The Indian Point nuclear power plant on the banks of the Hudson River in Buchanan, N.Y. The initial 40-year licenses at the two operating reactors there expire in 2014 and 2016. In a unanimous opinion, a three-judge panel of the Court of Appeals for the District of Columbia said that in deciding that the fuel would be safe for many decades, the commission did not carry out an analysis of individual storage pools at reactors across the country, treating them generically instead. The

commission also did not adequately analyze the risk that cooling water will leak from the pools or that the fuel will ignite, the court wrote."

Risk From Spent Nuclear Reactor Fuel Is Greater in U.S. Than in Japan, Study Says
New York Times May 2011
http://www.nytimes.com/2011/05/25/business/energy-environment/25nuke.html?_r=2
"The threat of a catastrophic release of radioactive materials from a spent fuel pool at Japan's Fukushima Daiichi plant is dwarfed by the risk posed by such pools in the United States, which are typically filled with far more radioactive material, according to a study released on Tuesday by a nonprofit institute.
The report, from the Institute for Policy Studies, recommends that the United States transfer most of the nation's spent nuclear fuel from pools filled with cooling water to dry sealed steel casks to limit the risk of an accident resulting from an earthquake, terrorism or other event."

Safeguarding Spent Fuel Pools in the United States
Huffington Post Mar 2011
http://www.huffingtonpost.com/robert-alvarez/safeguarding-spent-fuel-p_b_838236.html
"A drained spent fuel pool in the U.S. could lead to a catastrophic fire that would result in long-term land contamination substantially worse than what the Chernobyl accident unleashed."

Do-or-Die at Yucca Mountain
WIRED Magazine Nov 2004
http://www.wired.com/wired/archive/11.04/yucca_pr.html
A summary of the incredible challenge to find an acceptable location for the disposal of nuclear waste...that will be safe for >10,000 years.

2. OVERVIEW OF FUKUSHIMA DAIICHI SITUATION

Fukushima Reactor 4 poses massive global risk
CTV News May 2012
http://www.ctvnews.ca/fukushima-reactor-4-poses-massive-global-risk-1.829254#ixzz1vSqYh9cR
"More than a year after a devastating earthquake and tsunami triggered a massive nuclear disaster, experts are warning that Japan isn't out of the woods yet and the worst nuclear storm the world has ever seen could be just one earthquake away from reality."

1 Year Later: A Fukushima Nuclear Disaster Timeline
Scientific American Mar 2012
http://www.scientificamerican.com/article.cfm?id=one-year-later-fukushima-nuclear-disaster

Fukushima Timeline
Greenpeace
http://www.greenpeace.org/international/Global/international/publications/nuclear/2012/Fukushima/Fact%20Sheets/Fukushima_Timeline.pdf
A good overview of the event, plus a critical analysis of public statements from Japanese/TEPCO officials as the disaster unfolded.

3. FUKUSHIMA DAIICHI SITE CONDITIONS AFTER INITIAL DISASTER

Cooling System Fixed at Fukushima's Plant 4 Fuel Pool

Japan Times July 2012

http://www.japantimes.co.jp/text/nn20120702a9.html#.T_NbTL-iHIq

"The cooling system for the No. 4 reactor's hazardous spent-fuel pool came back to life Sunday at the crippled Fukushima No. 1 power plant after emergency repairs succeeded, Tokyo Electric Power Co. said.
The cooling system automatically shut down on Saturday for unknown reasons, allowing the water in the pool to reach 42.9 degrees Sunday. The pool must stay filled to prevent the used rods from burning up. ... The same cooling system also was suspended on June 4."

Japan Reactor Building is Tilting but not a Risk, Operator Says

New York Times June 2012

http://www.nytimes.com/2012/06/27/world/asia/fukushima-daiichi-building-tilting-but-not-a-risk.html?src=twr

"The Tokyo Electric Power Company, or TEPCO, said in a report on Monday to Japanese nuclear regulators that at least two of the walls of the No. 4 reactor building are bulging outward at various points and that the building is tilting. The biggest bulge measured about 1.8 inches about a third of the way up the building, the report said."

Spent Fuel Rods Drive Growing Fear Over Plant in Japan

New York Times May 2012

http://www.nytimes.com/2012/05/27/world/asia/concerns-grow-about-spent-fuel-rods-at-damaged-nuclear-plant-in-japan.html?_r=4&pagewanted=all

"Fourteen months after the accident, a pool brimming with used fuel rods and filled with vast quantities of radioactive cesium still sits on the top floor of a heavily damaged reactor building, covered only with plastic. The public's fears about the pool have grown in recent months as some scientists have warned that it has the most potential for setting off a new catastrophe, now that the three nuclear reactors that suffered meltdowns are in a more stable state, and as frequent quakes continue to rattle the region. "

Fukushima Daiichi Site: Cesium-137 is 85 times greater than at Chernobyl Accident

Akio Matsumura April 2012

http://akiomatsumura.com/2012/04/682.html

"Japan's former Ambassador to Switzerland, Mr. Mitsuhei Murata, was invited to speak at the Public Hearing of the Budgetary Committee of the House of Councilors on March 22, 2012, on the Fukushima nuclear power plants accident. Before the Committee, Ambassador Murata strongly stated that if the crippled building of reactor unit 4—with 1,535 fuel assemblies in the spent fuel pool 100 feet (30 meters) above the ground—collapses, not only will it cause a shutdown of all six reactors but will also affect the common spent fuel pool containing 6,375 fuel assemblies, located some 50 meters from reactor 4. In both cases the radioactive assemblies are not protected by a containment vessel; dangerously, they are open to the air. This would certainly cause a global catastrophe like we have never before experienced."

After Tour of Fukushima Nuclear Power Station, Wyden Says Situation Worse than Reported

Senator Wyden's website Apr 2012

http://www.wyden.senate.gov/news/press-releases/after-tour-of-fukushima-nuclear-power-station-wyden-says-situation-worse-than-reported

www.wyden.senate.gov/download/letter-to-secretary-of-state-clinton-on-assistance-for-fukushima

"After an onsite tour of what remains of the Fukushima Daiichi nuclear facilities decimated by last year's earthquake and subsequent tsunami, U.S. Senator Ron Wyden (D-Ore.) a senior member of the U.S. Senate Committee on Energy and Natural Resources, sent a letter to Japanese Ambassador Ichiro Fujisaki looking for ways to advance and support cleanup and recovery efforts. Wyden's principal concern is the relocation of spent fuel rods currently being stored in unsound structures immediately adjacent to the ocean. He strongly urged the Ambassador to accept international help to prevent dangerous nuclear material from being released into the

environment."

Japan Nuclear Plant May Be Worse Off Than Thought
NY Times Mar 2012
http://www.nytimes.com/2012/03/30/world/asia/inquiry-suggests-worse-damage-at-japan-nuclear-plant.html?_r=2
"The damage to one of three stricken reactors at the Fukushima Daiichi plant could be worse than previously thought, a recent internal investigation has shown, raising new concerns over the plant's stability and complicating the post-disaster cleanup."

Fukushima: it's much worse than you think
Aljazeera Jun 2011
http://www.aljazeera.com/indepth/features/2011/06/201161664828302638.html
Although this article is a year old, it provides a good overview of the ongoing challenges at Fukushima.

4. JAPANESE NUCLEAR INDUSTRY & TEPCO

Japan to probe TEPCO radiation cover-up claim
BBC News Jul 2012
http://www.bbc.co.uk/news/world-asia-18936831
"The Japanese government says it will investigate a report that workers at the stricken Fukushima Daiichi nuclear power plant were urged to disguise their exposure to radiation."

Fukushima reactor meltdown was a man-made disaster, says official report
The Guardian Jul 2012
http://www.guardian.co.uk/environment/2012/jul/05/fukushima-meltdown-manmade-disaster?newsfeed=true
"Last year's accident at the Fukushima Daiichi nuclear power plant was a manmade disaster caused by poor regulation and collusion between the government, the operator and the industry's watchdog, a report has said... It accused TEPCO and regulators at the nuclear and industrial safety agency of failing to take adequate safety measures, despite evidence that the area was susceptible to powerful earthquakes and tsunamis. "The Fukushima nuclear power plant accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties," said the report, compiled by the Fukushima nuclear accident independent investigation commission."

Japan nuclear minister speeds up Fukushima cleanup
Reuters Jun 2012
http://uk.reuters.com/article/2012/06/21/uk-japan-nuclear-idUKBRE85K0JM20120621
"Workers at the crippled Fukushima nuclear plant will begin removing fuel rods from a damaged reactors a year ahead of schedule, a government minister said Thursday, a move to address concerns about the risk of a new quake that could cause a further accident and scatter more radioactive debris."

Nuclear Power in Japan
World Nuclear Association
http://world-nuclear.org/info/inf79.html
Extremely detailed overview of Japan's nuclear power history and current state, from a pro-nuclear association

5. SEISMIC RISK IN JAPAN

Tomography of the 2011 Iwaki earthquake (M 7.0) and Fukushima nuclear power plant area
Solid Earth, 3, 43-51, 2012
http://www.solid-earth.net/3/43/2012/se-3-43-2012.html
A peer-reviewed scientific paper discussing the risk of additional strong earthquakes in the Fukushima area. The risk is deemed to be high.

Nuclear Plant Siting and Earthquake Risk
MIT NSE Nuclear Information Hub May 2011
http://mitnse.com/2011/05/04/nuclear-plant-siting-and-earthquake-risk/
A map of all nuclear plants, and all earthquakes >7.0 magnitude that have occurred in the world since 1973. "an overwhelming majority of the world's nuclear plants are located quite far from regions in which large earthquakes typically occur. The main exception is eastern Asia and especially northern Japan."

Rebuilding seismology
Nature – International Weekly Journal of Science May 2011
http://www.nature.com/nature/journal/v473/n7346/full/473146a.html
"Two months on from the earthquake and tsunami that hit their country on 11 March, five Japanese seismologists reflect on what they have learned from it so far."

List of Earthquakes in Japan
Wikipedia
en.wikipedia.org/wiki/List_of_earthquakes_in_Japan

List of Historic Tsunamis
Wikipedia
http://en.wikipedia.org/wiki/List_of_historic_tsunamis

6. WATER, FOOD, & AIR CONTAMINATION DUE TO FUKUSHIMA

Worldwide health effects of the Fukushima Daiichi nuclear accident
Energy & Environmental Science Jul 2012
http://www.stanford.edu/group/efmh/jacobson/fukushima.html
"This study quantifies worldwide health effects of the Fukushima Daiichi nuclear accident on 11 March 2011. Effects are quantified with a 3-D global atmospheric model driven by emission estimates and evaluated against daily worldwide Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) measurements and observed deposition rates. Inhalation exposure, ground-level external exposure, and atmospheric external exposure pathways of radioactive iodine-131, cesium-137, and cesium-134 released from Fukushima are accounted for using a linear no-threshold (LNT) model of human exposure. Exposure due to ingestion of contaminated food and water is estimated by extrapolation. We estimate an additional 130 (15–1100) cancer-related mortalities and 180 (24–1800) cancer-related morbidities incorporating uncertainties associated with the exposure–dose and dose–response models used in the study. We also discuss the LNT model's uncertainty at low doses..."

Post-Fukushima, Japan's irradiated fish worry B.C. experts
Straight.com Jul 2012
http://www.straight.com/article-735051/vancouver/japans-irradiated-fish-worry-bc-experts

Are fish from the Pacific Ocean and Japanese coastal and inland waters safe to eat 16 months after the Fukushima nuclear disaster? Governments and many scientists say they are. But the largest collection of data on radiation in Japanese fish tells a very different story. In June, 56 percent of Japanese fish catches tested by the Japanese government were contaminated with ce-sium-137 and -134. (Both are human-made radioactive isotopes—produced through nuclear fission—of the element cesium.) And 9.3 percent of the catches exceeded Japan's official ceiling for cesium, which is 100 becquerels per kilogram (Bq/kg).

Fukushima radiation could reach US coast in five years

Environmental Research Web, Jul 2012

http://environmentalresearchweb.org/cws/article/news/50176

Radioactive water from the Fukushima nuclear reactors in Japan could reach the US West Coast in the next 5–6 years, doubling the radioactivity of US coastal waters, according to simulations carried out by German oceanographers.

Health Canada failed to reveal radioactivity in rainwater

Green Party Jan 2012

http://www.greenparty.ca/media-release/2012-01-18/health-canada-failed-reveal-radioactivity-rainwater

"Despite public concern over fallout from the nuclear disaster in Fukushima, Health Canada failed to report higher than normal radioactive iodine levels in rainwater. It has now been revealed that data were not released from a Calgary Health Canada monitoring station detecting levels of radioactive iodine in rainwater well above the Canadian guideline for drinking water. This isotope was known to be released by the nuclear accident and also showed up in tests in Vancouver, Winnipeg and Ottawa. Lower levels of contamination resulted in a don't-drink-rainwater advisory in Virginia".

Citizens' Testing Finds 20 Hot Spots Around Tokyo

New York Times Oct 2011

http://www.nytimes.com/2011/10/15/world/asia/radioactive-hot-spots-in-tokyo-point-to-wider-problems.html?_r=1&pagewanted=all

Japan's Fukushima catastrophe brings big radiation spikes to B.C.

Straight.com Apr 2011

http://www.straight.com/article-415211/vancouver/fukushima-brings-big-radiation-spikes-bc

"After Japan's Fukushima catastrophe, Canadian government officials reassured jittery Canadians that the radioactive plume billowing from the destroyed nuclear reactors posed zero health risks in this country. In fact, there was reason to worry. Health Canada detected large spikes in radioactive material from Fukushima in Canadian air in March and April at monitoring stations across the country."

Fukushima Radiation Survey

Greenpeace (Ongoing)

http://www.greenpeace.org/international/en/campaigns/nuclear/Fukushima-nuclear-disaster/Radiation-field-team/

"A Greenpeace team of radiation experts is monitoring locations around the evacuation area that surrounds the crisis-stricken Fukushima/Daiichi nuclear plant. They're there to independently assess the true extent of radiation risks that the local population may be facing". Data is provided through Dec 2011.

7. HEALTH IMPACTS OF EXPOSURE TO NUCLEAR RADIATION

Fukushima's uncertainty problem
Nature – International Weekly Journal of Science Jul 2012
http://www.nature.com/news/fukushima-s-uncertainty-problem-1.11031
"Science holds few definitive answers for those worried about radiation exposure, says Geoff Brumfiel."

Fukushima's doses tallied
Nature – International Weekly Journal of Science May 2012
http://www.nature.com/news/fukushima-s-doses-tallied-1.10686
"Studies indicate minimal health risks from radiation in the aftermath of Japan's nuclear disaster."

Background information for journalists -UNSCEAR assessment of the Fukushima-Daiichi accident
United Nations Scientific Committee on the Effects of Atomic Radiation May 2012
http://www.unis.unvienna.org/pdf/2012/UNSCEAR_Backgrounder.pdf
"At its annual meeting in May 2011, two months after the accident at the Fukushima-Daiichi Nuclear Power Station (FDNPS) in Japan, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) agreed to carry out a scientific assessment of the levels of radiation exposure and risks to health resulting from the accident". This document is an update on the status of that project.

Health Effects due to Radiation from the Chernobyl accident
United Nations Scientific Committee on the Effects of Atomic Radiation 2008
http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_D.pdf
The United Nations Scientific Committee on the Effects of Atomic Radiation was tasked with studying the effects of Chernobyl over a 25 year period with support from hundreds of highly qualified scientists and other professionals from all over the world. Their findings: "Among the residents of Belarus, the Russian Federation and Ukraine, there had been up to the year 2005 more than 6,000 cases of thyroid cancer reported in children and adolescents who were exposed at the time of the accident, and more cases can be expected during the next decades. Apart from this increase, there is no evidence of a major public health impact attributable to radiation exposure two decades after the accident. Although those most highly exposed individuals are at an increased risk of radiation-associated effects, the great majority of the population is not likely to experience serious health consequences as a result of radiation from the Chernobyl accident."(summary from: http://www.unscear.org/unscear/en/chernobyl.html)

Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2
National Research Council 2006
http://books.nap.edu/catalog.php?record_id=11340
"National Research Council study series on the effects of Low Level exposure to radiation, i.e. not for people at the site of a disaster, but who would receive exposure through dispersion or other low-level sources of radiation.

The mechanisms that lead to adverse health effects after exposure to ionizing radiation are not fully understood. Ionizing radiation has sufficient energy to change the structure of molecules, including DNA, within the cells of the human body. Some of these molecular changes are so complex that it may be difficult for the body's repair mechanisms to mend them correctly. However, the evidence is that only a very small fraction of such changes would be expected to result in cancer or other health effects...
The BEIR VII lifetime risk model predicts that approximately 1 person in 100 would be expected to develop cancer (solid cancer or leukemia) from a dose of 0.1 Sv above background, while approximately 42 of the 100 individuals would be expected to develop solid cancer or leukemia from other causes."