FUKUSHIMA 11

SIMPLYINFO.ORG
11TH ANNIVERSARY REPORT
MARCH 2023

CONTENTS

INTRODUCTION

As the aftermath of the disaster stretches into the 12th year, we have seen a drastic slowdown in activities at Daiichi. In previous years covid had caused some work to slow down. This year work appears to have shifted into a new phase of longer, slower work.

This does not mean that risks at the plant have changed. Aging structures bring new concerns as corrosion and degradation eat away at the damaged buildings and systems. TEPCO and the research entities tasked with responding to the disaster are aware of this and have these concerns in their long-term planning. Actual activities to mitigate these risks are not being aggressively implemented.

These efforts from the initial flurry of response in 2011 to the now long slog of cleaning up the disaster site have come with a high cost. To date, $82 billion USD has been spent on compensation and decommissioning activities at the disaster site. (1)

Work to remove the nuclear fuel debris has yet to begin and only unit 2 has a fuel removal plan.

As the disaster evolves into one that is less of an immediate response to one that is more of a historical event in people's minds, a new Netflix drama, similar to HBO's widely acclaimed Chernobyl mini-series is expected to be released in June of 2023. (2)

To find out more about our work since the 2011 disaster, please visit www.SimplyInfo.org

Cover art: This AI-generated artwork was created in Starry AI based on imagery of the destroyed reactor buildings

Back cover art: This AI-generated artwork was created in Starry AI based on imagery of the destroyed pedestal doorway inside Unit 1.

PLANT STATUS

The plant cleanup rolls into another decade, as hundreds of unmaintained systems at the plant site start to show decay. So far these have been trivial in nature, but they show the widespread degradation of the plant site. What is happening with these systems is likely also happening to systems that can have serious consequences when they fail. This corroded pipe (below) containing the oil for a power transformer near unit 3 began to leak oil. (3)

Image: TEPCO

Onsite spent fuel storage efforts have gradually moved what fuel can be to safer storage. 30.9% of the spent fuel remains in reactor buildings.

Units 3 and 4 have been completely emptied of spent fuel. Unit 6 only has 2.3% of the spent fuel removed from the unit's pool. Unit 5 has had none of the spent fuel removed from the unit's pool to date. The central spent fuel pool storage building is 97.7% full and the dry cask storage facility is at 54.8% of capacity.

The need to have storage casks manufactured is further slowing the transfer work. Moving spent fuel to safer storage has been a somewhat urgent effort as each pool poses the risk of a meltdown-type disaster out in the open with no containment.

Units 1 and 2 still contain all the spent fuel from before the disaster. (4)

New technologies continue to be developed to help deal with the extreme challenges of decommissioning the disaster site. JAEA has developed a new method of creating 3D renderings of radiation on-site at Daiichi.

This creates a more usable way to display radiation levels. A video of the unit 1-2 vent tower base radiation can be found in the link for the citation.(5)

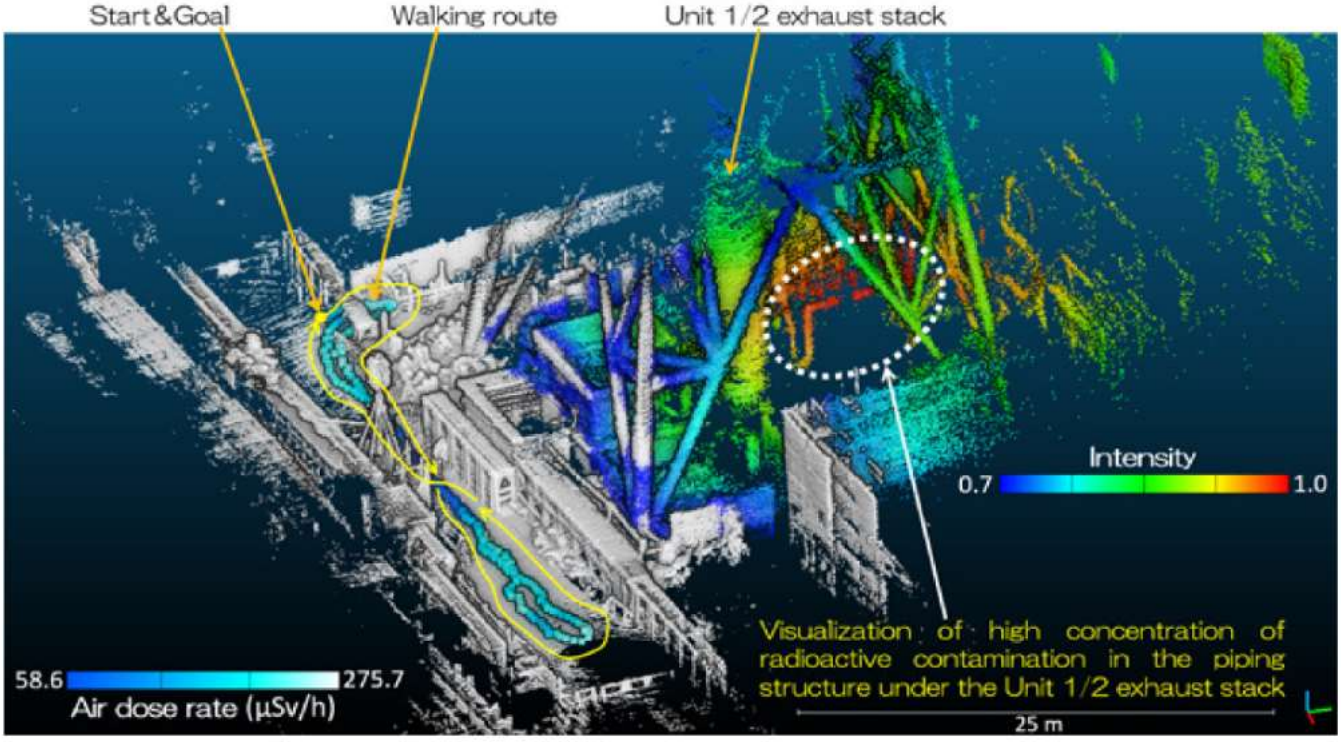


Image: JAEA

Work has continued in an attempt to add a sealed building and platform to the radwaste building. This would be used to extract, package, and remove highly radioactive sludge contained in the tanks of the building. (6) (right image)

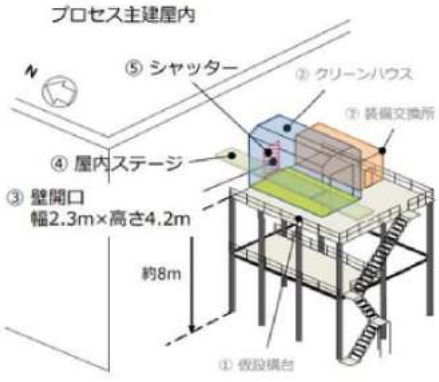


Image: TEPCO

Limited work around the plant has taken place in the last year except for this piece of significant work, the removal of the unit 1-2 Standby Gas Treatment System piping. This is to remove the vent piping from units 1 and 2 as it routes to the shared vent tower.

The area has been of concern due to the high radiation levels and the presence of small radioactive fuel particles in the pipes. Sections have been filled with expanding foam before being cut and removed. (7)

Image: JAEA

With the reduction of work at the disaster site, the number of worker injury incidents has decreased. This year there has been one reported incident where a worker felt unwell and was taken to the ER for observation.(8)

UNIT 1

The understanding and official admissions of what happened inside unit 1 have come full circle. Our early estimation soon after the initial disaster was that unit 1's failure was rapid and dire.

TEPCO dismissed such ideas, claiming the unit might have some fuel damage but surely hadn't melted down. Nuclear wonks from the US also insisted the damage to unit 1 was trivial. We now know with confidence that it was indeed a rapid and major meltdown.

Our initial assessment reported in the report Fukushima's First Hours showed that unit 1's failure was a matter of hours and likely a complete failure of the reactor and containment. (9)

Soon after the initial meltdowns, we documented fluctuations seen on containment radiation CAMS that showed radiation spikes whenever there was an aftershock.

This indicated there was a significant amount of corium (molten fuel) in containment and these aftershocks were disturbing it in a way that was causing brief radiation increases. (10)

By 2012 there was clear evidence that molten fuel had escaped containment into the torus room. Scope inspections found directional scorching on surfaces. (11)

By June of 2012 we had confirmed that some amount of molten fuel had collected on the torus room floor. This was based on both radiation readings and visual evidence from those scope inspections. (12)

TEPCO continued to deny this evidence, claiming a radiation sensor malfunctioned. (13)

Large chunks of concrete debris were found inside containment in 2012 when scope inspections took place. (14) Later containment inspections in 2012 showed heavily damaged structures that were subjected to high heat. (15)

Radiation levels in and around unit 1 were so high that the area was declared off-limits to workers early in the disaster. TEPCO abruptly threw a makeshift tent over unit 1 in 2011 indicating they knew fuel particles were escaping the reactor's containment early on. (16)

Another related event was the curious case of an unprotected worker taking readings at the base of the unit 1-2 vent tower and the mysterious death of a worker a few days later from what appeared to be radiation exposure.

TEPCO denied the two were connected. Later data confirmed the deadly levels of radiation at the base of the tower indicating one of the two units released a significant amount of fuel particles into the environment. (17)

You can read more about our past analysis of unit 1 on the Unit 1 Reactor page. (18)

Peter Melzer's excellent analysis of the reactor failures can be found in his paper Fukushima: Station Black Out & Delusion. (19)

Dean Wilke's Fukushima First Hours includes much of the data that underpins our estimations. (9)

More recent admissions from TEPCO and the parties working to inspect the failed reactors confirm what we already knew. In February of 2022, TEPCO released initial images from the unit 1 containment and pedestal inspections. These showed the concrete of the reactor pedestal base had been melted or otherwise destroyed leaving some warped rebar remaining.

The view inside the pedestal doorway showed a debris pile that appeared to be about 5 feet tall. Our initial estimates of the volume of fuel debris inside the pedestal did not account for all of the concrete and other materials the fuel debris consumed and added to the fuel debris pile in the pedestal. (20)

What TEPCO found on the inspection indicates a major series of destructive events took place beyond merely melting the reactor fuel. Layers of sediment and fuel debris were apparent on the containment floor and partway up the torus downcomer tubes, documenting the migration of the molten fuel out of the pedestal and out of the containment structure.

Image: Original Image TEPCO, image enhancement, SimplyInfo.org

Image: Original Image TEPCO, image enhancement, SimplyInfo.org

The two images above show the unit 1 pedestal doorway. Distinct visuals of the destroyed concrete and remaining rebar are evident. This damage goes up approximately 4 feet of the roughly 6-foot-high entryway into the pedestal.

Image: Original Images TEPCO, image enhancement, SimplyInfo.org

The top image shows the damaged entryway into the pedestal and a debris pile inside that exceeds the height of the doorway. The remaining images show solidified fuel debris reaching about 1/4 of the way up the jet deflectors of the downcomer tubes, confirming molten fuel flowed into the suppression chamber and out of containment.

These reports confirmed what we have stated for years. That the meltdown at unit 1 was a massively destructive event. All the fuel inside unit 1 has melted and a significant amount has escaped containment through various means. (21)

At the time, not knowing that the concrete pedestal had been destroyed, the source of these wasn't clear. It looked like a concrete aggregate but creating large amounts of that and distributing it to the containment

Image: Original Image TEPCO, image enhancement, SimplyInfo.org

In February 2023 TEPCO completed work to sample the fuel debris sediments on the containment floor of unit 1. The layered formerly molten strata can be seen in the photo above.

These sediment layers were initially a curiosity. TEPCO provided photos of what looked like deep layers of sand on the containment floor from some previous inspections.

floor would mean there was massive destruction of the pedestal, and potentially the concrete bio-shield.

TEPCO's newer inspections confirm that to be true. What isn't currently known is the condition of the pedestal further up from the containment floor. If there is damage further up it would confirm even more instability of the reactor vessel and internal containment structures.

In March of 2022, additional containment inspections inside unit 1's containment found solidified bulges or large bubbles in the cooled fuel debris on the floor. Each of these were found just outside of the perimeter of the pedestal. This appears to be a new not previously seen phenomenon. (22)

These "hollow shell" formations were also found in the corium debris bed. These were found near the pedestal door.
TEPCO speculated possibly something that fell from above caused them but at this point do not know what they are or what caused their formation.

Stitched-together photos of the layered corium inside unit 1 were included in the TEPCO report. This odd phenomenon shows two thin layers of solidified fuel debris with a clear gap between the layers. Trapped gases are known to bubble through molten corium. The extent of some of the findings like these two distant layers seems to defy the trapped gas theory.

significant portion of the pedestal base as seen in the inspection photos. (23) Engineers interviewed by Asahi Shimbun raised concerns about the stability of the reactor and related components with the pedestal so significantly damaged. (24)

Image: Original Image TEPCO, image enhancement, SimplyInfo.org

In 2022 Asahi Shimbun confirmed what we already knew but TEPCO had been avoiding stating. The concrete of the pedestal had melted away leaving just rebar around a

How to address this concerning instability has not been documented as a roadmap item and to date, there have been no public-facing efforts to research a solution.

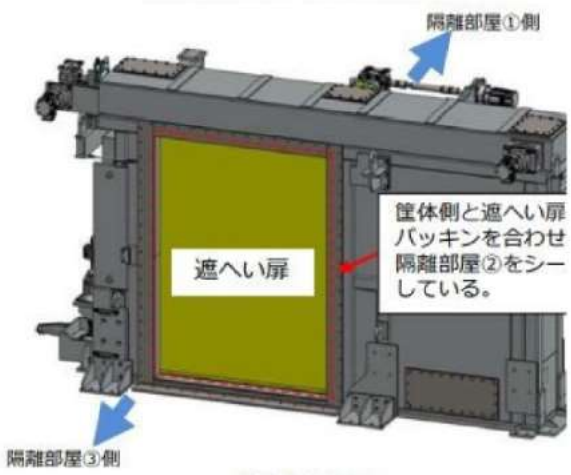
UNIT 2

Unit 2 has actionable plans to remove the fuel debris and the spent fuel. This unit has been designated as the fuel debris removal experiment that will then guide efforts at units 1 and 3. Researchers hope to learn from this process and any mistakes so they could avoid those in planning the removal process for the other units.

This means any effort to remove fuel debris from units 1 and 3 will be years off.

Workers have begun installing pieces of the hot cell structure needed to contain the fuel debris removal arm and remove canisters of collected fuel debris. (22)

<隔離部屋②運搬状況>



<隔離部屋②>

Image: TEPCO. Installation of the hot cell components and a diagram of the same for unit 2.

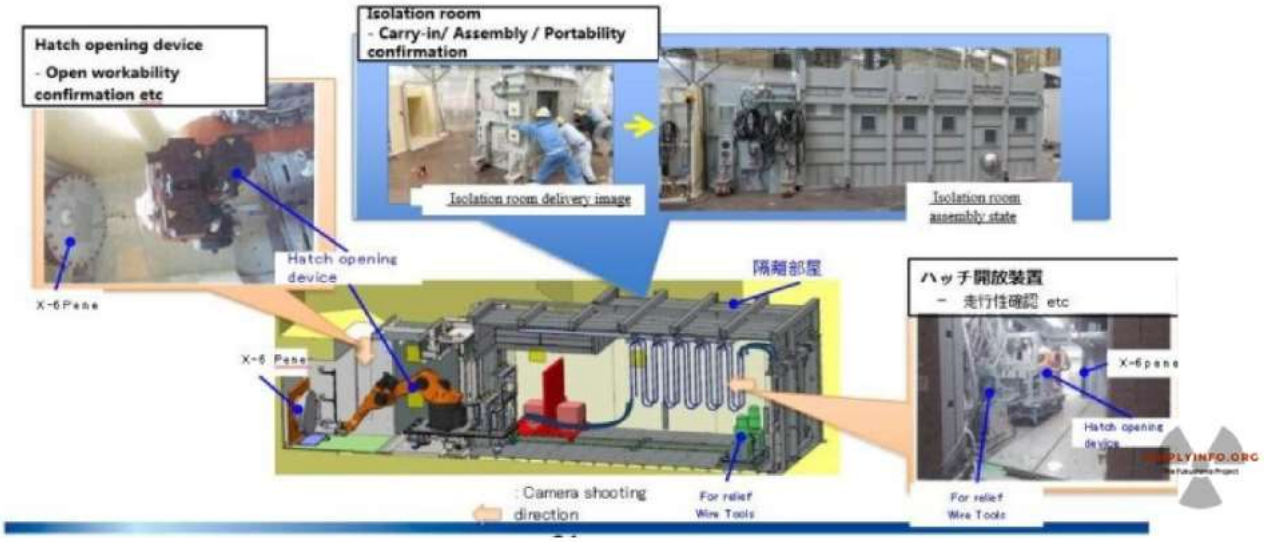


Image: Original Image TEPCO, image enhancement, SimplyInfo.org

Problems with the performance of the robotic arm for fuel debris removal have bumped the start of those efforts until fall of 2023 (25)

Image: IRID

Work has continued to prepare unit 2 for eventual spent fuel removal. Efforts to dismantle structures inside the refueling floor have been underway as has work to install the new building alongside unit 2 for removing spent fuel casks. (26)

Image: Original Image TEPCO, image enhancement, SimplyInfo.org

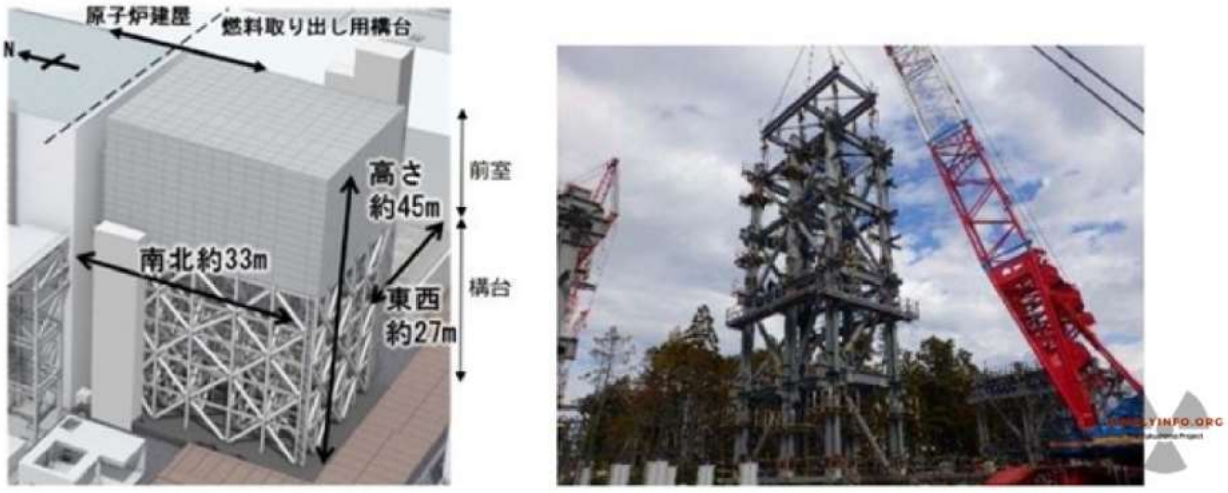


Image: Original Image TEPCO, image enhancement, SimplyInfo.org
Unit 2 external defueling building diagram and construction on site.

UNIT 3

TEPCO plans to begin removing the remaining high-level debris inside the unit 3 spent fuel pool. This includes old control rods and other pieces of equipment.

All of the spent fuel has been removed. Control rods, other highly radioactive reactor components, and the fuel racks remain in the pool. (27)

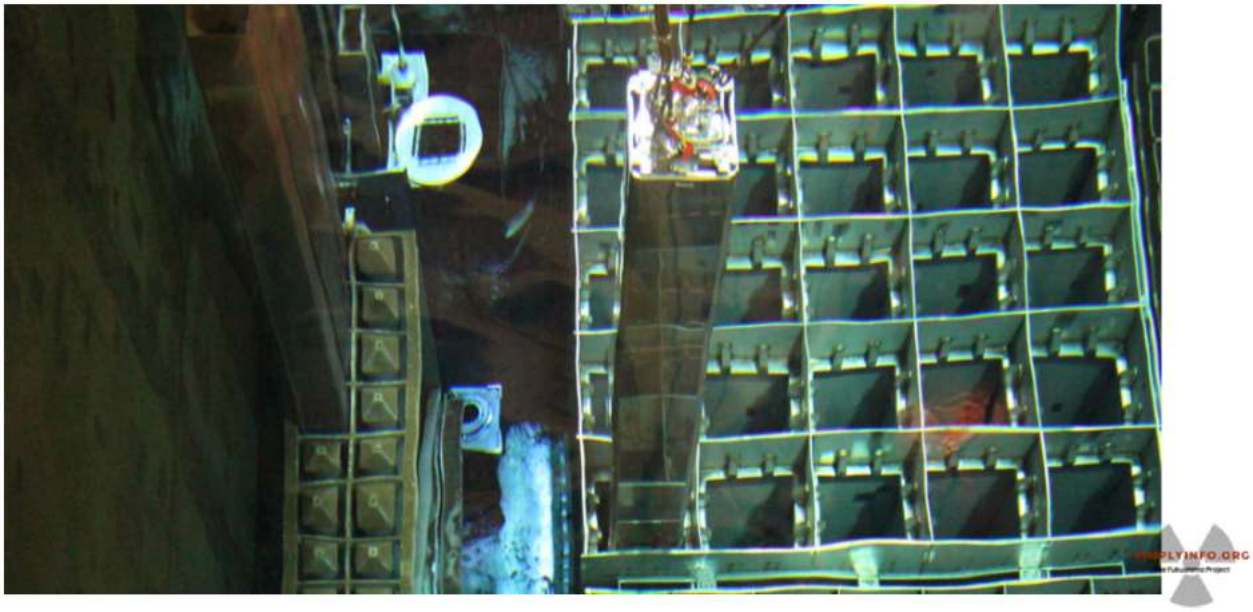


Image: Original Image TEPCO, image enhancement, SimplyInfo.org

Work is underway to lower the water level in containment by drawing water out of the suppression chamber via an RHR pipe. TEPCO plans to reduce the water level below the first floor citing seismic concerns.

The level above the first floor is also where the small but known leaks of water from containment have been found. (28)

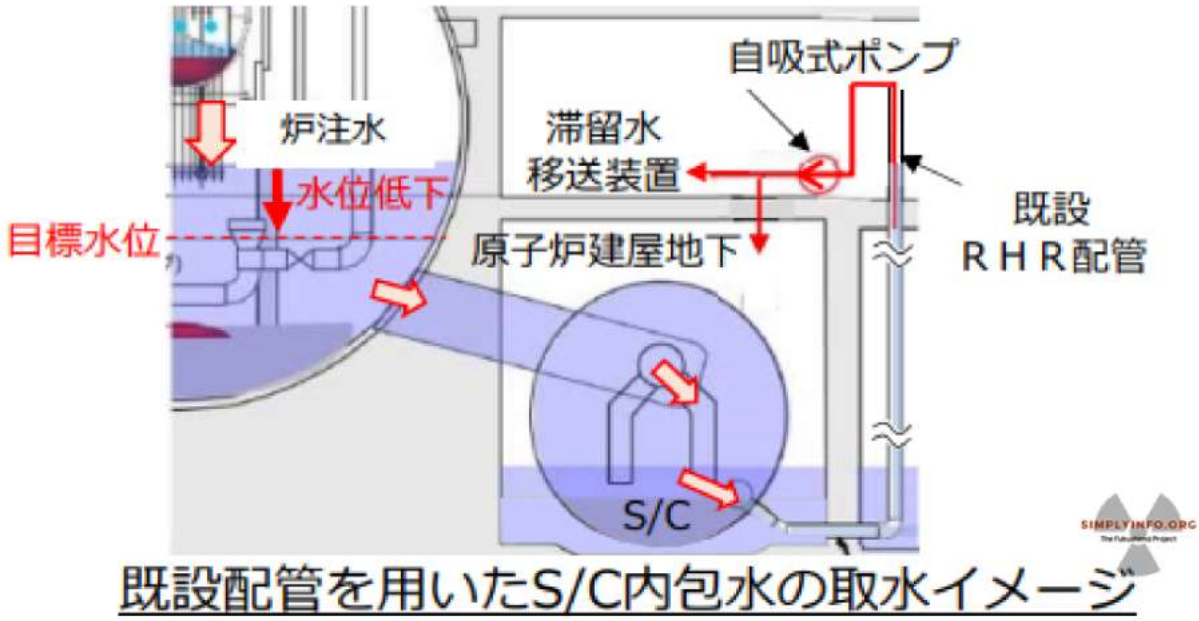


Image: Original Image TEPCO, image enhancement, SimplyInfo.org

UNITS 4, 5 & 6

Unit 4 remains in an empty state. During the initial disaster, the unit was under maintenance and all the fuel had been offloaded to the spent fuel pool. The spent fuel in the pool was removed to the central fuel pool facility and unit 6's spent fuel pool for safer storage. The condition of the spent fuel pool at unit 4 was a dire concern early in the disaster after it suffered significant damage from the hydrogen explosion at that unit.

TEPCO had not provided any recent updates to the structural status of the spent fuel pool or the remains of the building that suffered extensive damage.

Unit 5 remains a test bed for inspection teams to plan their work in units 1 – 3. The fuel assemblies in the reactor were removed to the spent fuel pool in 2015 where it remains with the rest of the unit's spent fuel. (29)

Image: Original Image TEPCO, image enhancement, SimplyInfo.org

Unit 6 sits in a similar state but is not used as a test bed due to being a different reactor design.

Units 4, 5, and 6 are decades away from any decommissioning effort due to the units that suffered meltdowns being the initial priority.

CONTAMINATED WATER

Contaminated water has been at the forefront this year as TEPCO plans to dump it into the Pacific rather than store it long-term. To accomplish this TEPCO constructed a new pipe out into the Pacific.

After repeated delays due to construction problems and opposition to the plan, they claim they will begin the releases this summer. (30)

As the debate about releasing the contaminated water continues it is worth noting exactly what is in this water. Most of the news reports cite it as containing tritium. It also contains significant amounts of Ruthenium 106, Iodine 129, and Technetium 99. (31)

Smaller amounts of Cobalt 60, Strontium 90, and Nickel 63 were found in post-ALPS sampling. There were also small but detectable levels of Cesium 137 found in this water.

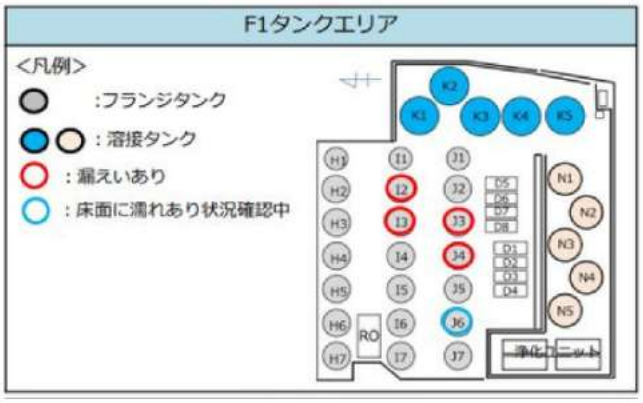
ALPS is the final step of contaminated water testing. Anything not removed would be in water slated for release into the ocean. (32)

These planned releases of contaminated water into the Pacific have significant opposition not just from the local fishing industry, but from Japan's Pacific neighbors. South Korea, Taiwan, and several pacific island nations have publicly opposed this plan. (33)

In response, TEPCO began a public-facing website to provide information about the contaminated water and planned water release. TEPCO, not impartial 3rd parties provide all the documentation and testing. (34)

One nuclear expert suggested releasing water to the deep layer of the ocean, not the surface layer, if at all. This might mitigate some of the migration of the contamination in surface currents, but it doesn't negate the added radioactive contamination itself. (35)

The bolt together tanks used to hold contaminated water as a stop-gap measure in 2011 are still in use at the plant site. TEPCO assured the public that they would drain and decommission all these tanks on site, yet many are still in use. These tanks had a 3–5-year life span before the gaskets between the tank sections were expected to fail and leak. 12 years later they are still in use. (36)



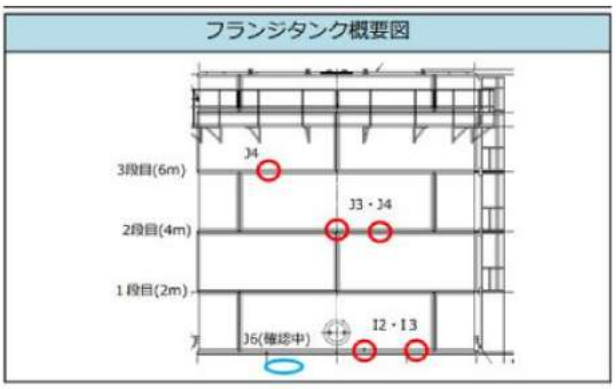


Image: Original Image TEPCO, image enhancement, SimplyInfo.org

ENVIRONMENT

A new research paper indicates that releases during the disaster may have been higher than official readings. By including all the known events during the initial disaster researchers concluded that Japan's WSPEEDI system underestimated the source term. This then distorts the contamination projections of WSPEEDI downward. The researchers' more accurate source term estimation shows that the total releases during the initial disaster were likely much higher than the official reports. (37)

Contaminated soil continues to be a persistent problem and will likely be one for decades and in some cases for generations. Little has been done to deal with the massive amounts of contaminated soil stored around Japan. The central government attempted to create designated sites to store the bags of radioactive soil. Local opposition has stopped that project.

Now government officials are considering redesignating some of the radioactive soil to no longer be considered radioactive waste if the contamination levels fall below 8,000 becquerels per kilogram. This would allow them to dispose of the soil as general trash. (38)

One of those plans includes reusing the contaminated soil in Tokyo. The government declared the soil "decontaminated" though nothing has been done besides allowing it to sit in bags for years. (39)
Official testing of this soil only includes gamma radiation focused on Cesium 137. No testing for Strontium 90 or alpha radiation is used when determining soil radiation levels.

Much of the Cesium 137 that fell on parts of Japan included microparticles of reactor fuel. These particles are hazardous as they are small enough to inhale but not soluble, meaning, they can remain lodged in the lungs long term causing significant internal radiation exposure to the unlucky recipient.

Experiments to "reuse" contaminated soil are already underway in Tokyo. (40)

PUBLIC HEALTH

The citizen-run radiation lab in Iwaki (Mother's Radiation Lab) has been a reliable food and environmental testing source in recent years. Tests found notable contamination in persimmons, wild boar, and soil samples around Iwaki, rice, sweet potatoes, and fish. In December 2022 the lab ran a series of soil tests from Okuma, Fukushima near the Fukushima Daiichi disaster site. These readings are a stark reminder that this disaster remains an active problem. (41)

Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	195920.0 Bq/kg dry	± 238.5 Bq/kg dry	200818.4	Cs137	40.8	Bq/kg dry
				Cs134	4898.4 Bq/kg dry	± 28.6 Bq/kg dry		Cs134	42.5	Bq/kg dry
Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	146820.0 Bq/kg dry	± 557.9 Bq/kg dry	150490.3	Cs137	98.1	Bq/kg dry
				Cs134	3670.3 Bq/kg dry	± 69.0 Bq/kg dry		Cs134	114.7	Bq/kg dry
Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	98814.0 Bq/kg dry	± 391.6 Bq/kg dry	101371.5	Cs137	70.5	Bq/kg dry
				Cs134	2557.5 Bq/kg dry	± 48.4 Bq/kg dry		Cs134	79.3	Bq/kg dry
Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	56065.0 Bq/kg dry	± 417.4 Bq/kg dry	57460.2	Cs137	79.7	Bq/kg dry
				Cs134	1395.2 Bq/kg dry	± 52.8 Bq/kg dry		Cs134	93.2	Bq/kg dry
Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	55235.0 Bq/kg dry	± 333.1 Bq/kg dry	56619.5	Cs137	61.2	Bq/kg dry
				Cs134	1384.5 Bq/kg dry	± 41.2 Bq/kg dry		Cs134	67.5	Bq/kg dry
Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	48322.0 Bq/kg dry	± 282.7 Bq/kg dry	49523.9	Cs137	50.5	Bq/kg dry
				Cs134	1201.9 Bq/kg dry	± 34.7 Bq/kg dry		Cs134	58.0	Bq/kg dry
Soil	Okuma, Futaba, Fukushima	Dec-22	CA	Cs137	46514.0 Bq/kg dry	± 263.7 Bq/kg dry	47710.0	Cs137	49.0	Bq/kg dry
				Cs134	1196.0 Bq/kg dry	± 32.6 Bq/kg dry		Cs134	53.6	Bq/kg dry

Cedar leaves from Okuma were found to continue to have high levels of cesium contamination, raising more speculation about the government claims that regional radiation levels near the disaster site are no longer problematic. (42)

Samples	Sampling Point	Sampling Month	Measurement Result		Uncertainty	Total Amount of Cesium	Minimum Limit of Detection	
Cedar leaves	Okuma, Futaba, Fukushima	Jun-22	Cs137	14219.4 Bq/kg raw	± 1202.0 Bq/kg raw	14502.0	Cs137	11.1 Bq/kg raw
			Cs134	282.6 Bq/kg raw	± 46.5 Bq/kg raw		Cs134	10.8 Bq/kg raw
Leaves (unknown)	Okuma, Futaba, Fukushima	Jun-22	Cs137	6110.0 Bq/kg raw	± 1220.0 Bq/kg raw	6303.0	Cs137	10.5 Bq/kg raw
			Cs134	193.0 Bq/kg raw	± 39.0 Bq/kg raw		Cs134	9.9 Bq/kg raw

High levels of soil contamination were found in Nihonmatsu, 72 km from the disaster site. (43)

Soil①	Nihonmatsu, Fukushima	May-22	CA	Cs137	23780.0	± 170.0	24497.2	Cs137	30.3	
				Cs134	717.2	± 22.6		Cs134	39.1	
Soil②	Nihonmatsu, Fukushima	May-22	CA	Cs137	17133.0	± 139.0	17641.1	Cs137	26.1	
				Cs134	508.1	± 18.3		Cs134	29.9	

The lab also found radioactive cicadas in Tokyo in November of 2022. (44)

Cicada's shell	Setagaya, Tokyo	Aug-20	OR	Cs137	4.4	± 1.3	4.4	Cs137	2.6	
				Cs134	—	± —		Cs134	5.6	
Cicada's shell	Katsushika, Tokyo	Nov-22	CA	Cs137	36.5	± 1.6	36.5	Cs137	2.5	
				Cs134	—	± —		Cs134	3.6	

Tests published in October of 2022 found tritium in the drinking water in Iwaki. (45)

Tap water	Yotsukura, Iwaki	Apr-22	T (free)	0.30	Bq/L	± 0.12 Bq/L	0.11 Bq/L
Tap water	Negishi, Tono, Iwaki	Apr-22	T (free)	0.39	Bq/L	± 0.12 Bq/L	0.11 Bq/L

Using more sensitive testing they were able to consistently detect low levels of cesium contamination across a wide variety of types of produce from the Tohoku region, mostly in Fukushima prefecture. This was repeated across the months of reporting we reviewed. While the levels were low, the notion of having all the food one might consume be contaminated raises concerns about the total exposure from these sources. (46)

Contaminated household dust has been another ongoing source of exposure. These readings from July 2022 collected in Tamura Fukushima showed cesium contamination. These are much lower than readings in previous years from Iwaki that were in the thousands. (47)

Vacuum cleaner dust	Miharu, Tamura, Fukushima	Jun-21	Cs137	130.5	± 13.8	130.5	Cs137	4.5	
			Cs134	—	± —		Cs134	3.4	
Vacuum cleaner dust	Miharu, Tamura, Fukushima	Jun-22	Cs137	106.4	± 11.6	106.4	Cs137	4.1	
			Cs134	—	± —		Cs134	3.2	
Vacuum cleaner dust	Funehiki, Tamura, Fukushima	Apr-22	Cs137	175.0	± 22.2	175.0	Cs137	7.8	
			Cs134	—	± —		Cs134	6.7	

The ongoing health risks to people exposed due to the disaster remain hard to quantify. Official sources admitted to the existence of thyroid cancer problems among children from the region. Any connection between people's exposures and subsequent cancers has been dismissed as "over-testing". There is no organized effort to track the long-term incidences of other cancers in the exposed populations. (48)

This year six thyroid cancer patients filed a lawsuit against TEPCO for their radiation exposure from the Fukushima disaster that led to their cancers. (49)

SOCIOECONOMIC

People impacted by the disaster have struggled to find true relief and compensation for their losses. Financial compensation has been limited. Evacuee support programs have gradually ended or have been reduced. More towns in the evacuation zone have reopened with minimal services, a lack of jobs, and questions about the radiation levels and overall safety.

A group of disaster victims appealed a high court ruling on TEPCO execs negligence. (50)

They later obtained a supreme court ruling that TEPCO should compensate them for their losses. The individuals were awarded only a little over $3000 USD each. (51)

While disaster victims have been largely left empty-handed in their efforts to hold TEPCO execs accountable, shareholders succeeded in extracting significant financial compensation out of the same.

TEPCO executives were ordered to pay $97 billion dollars to shareholders. (52)

More evacuation areas reopened last year like this one in Katsurao Village. As with others, few have any interest in returning. (53)

The first medical clinic has reopened in Futaba, one of the most contaminated areas near Fukushima Daiichi. As the government officially reopens evacuation zones these towns have struggled with basic services needed for residents to return. (54)

POLITICAL

With the war in Ukraine causing instability in oil and gas markets Japan's government is reconsidering their official stance on nuclear power.

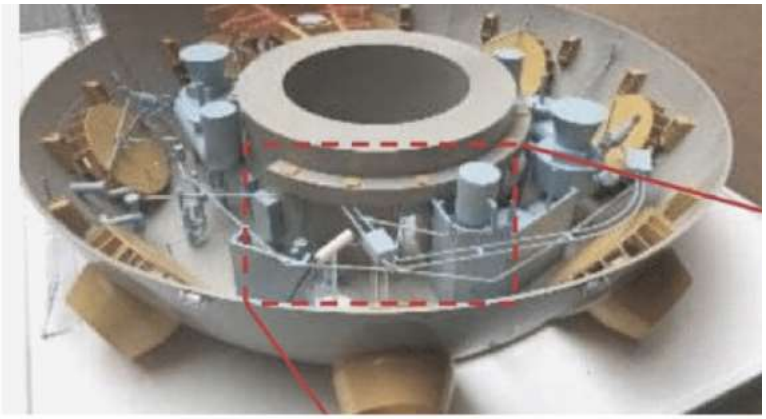
The Diet introduced a bill to extend nuclear reactor lifespans. (55) This bill to extend reactors beyond 60 years was formally adopted, allowing aging reactors to continue operating. (56)

The addiction to nuclear power extends beyond the politicians in Japan.

Many rural communities were offered large sums of money to allow nuclear power plants to be built in their towns. This money meant struggling towns were suddenly handed funding to do things and became dependent on this money.

Now residents near the Omha nuclear power plant that was under construction in 2011 are asking the government to resume construction. The MOX-fueled reactor project termination meant the loss of community subsidy money has made them "impoverished." (58)

Image: Omha Nuclear Power Plant



CONCLUSION

Decommissioning efforts have slowed. They don't necessarily have to. There is ample work that could take place related to units 4 and 6. Part of this delay may be related to a desire to let radiation levels on equipment reduce over time before beginning any removal process. This also likely relates to money, and a desire to spread the costs out over time. Storage is also an issue. There is currently no planned location to store all the debris from removing the plant.

Making sure the decommissioning of the disaster site doesn't meander off into nothing after the fuel debris is retrieved may be a larger challenge. This task is enormous and those in charge seem keen to kick it down the road past their retirement dates. The disaster has entered a new phase.

Forgetting comes with consequences. Demanding clear long-term decommissioning plans and what real recovery looks like for the people and the environment will be the real challenges over this next phase.

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