IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

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Fukushima Daiichi nuclear accident

Contamination of the ground between the damaged reactors and the Pacific Ocean

This document is based on publicly available information on the situation of the Fukushima Daiichi nuclear power plant.

One of the major challenges faced by TEPCO following the Fukushima Daiichi accident has been dealing with the contaminated water[1] present on the site. In fact, cooling the cores of the damaged reactors requires the continuous injection of water into the reactors; this water then flows into the basements of the buildings, from where it is collected before being treated and reused for cooling the cores. **Influx of water into these building basements from the groundwater and from rainfall, which is in addition to the influx of cooling water, means that the amount of water that need to be recovered daily and then treated is very considerable (currently at least 700 m^3 a day).** In addition to this water present in the building basements, there is the water contained in certain services galleries of the site, in storage areas (before and after treatment), in treatment facilities, and in the connecting circuits between these various areas and equipment, the total length of which is nearly 4 kilometres.

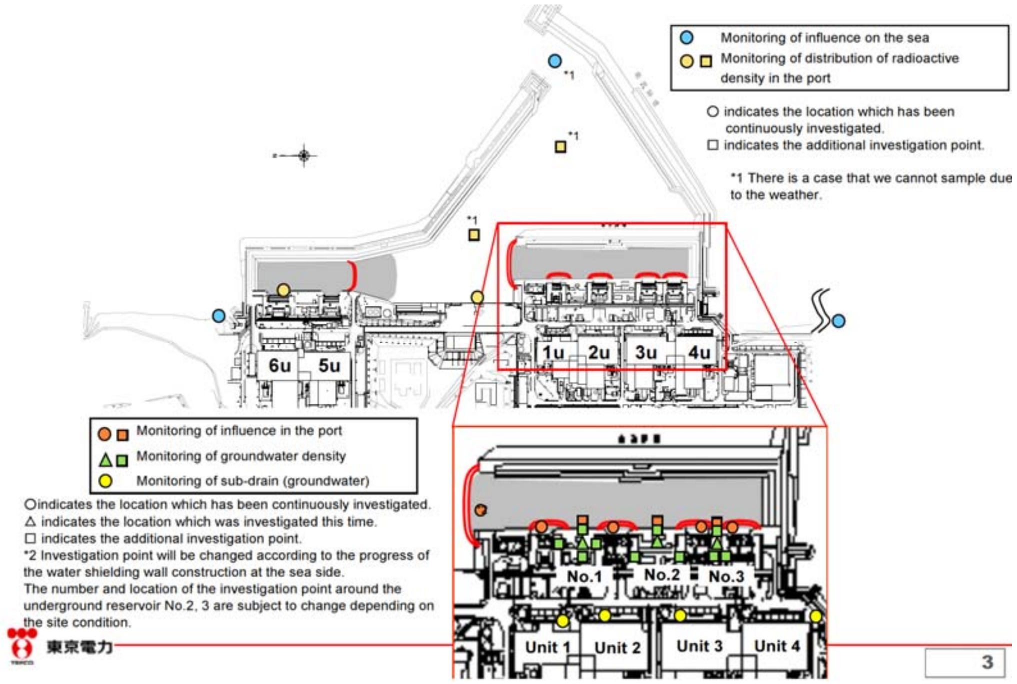
The amount of contaminated water on the site is currently estimated at several hundreds of thousands of m^3. **The considerable volume and number of zones and equipment concerned (the confinement characteristics of which are highly variable) mean there are high risks of leakage, as various events that have occurred in April 2013 have demonstrated.** Potential locations for leaks are thus highly diverse, ranging from the pipes and storage facilities that are dispersed on the site to service galleries and the buried parts of buildings. Whatever the case, while leakages from over ground pipes and tanks are relatively easy to detect, particularly visually, the detection of leakages from underground areas requires surveillance of the groundwater. Borings are also being sunk for this purpose.

In particular, the presence of contaminated water in the basements of the reactor buildings and their associated turbine buildings presents a risk of pollution of the groundwater. In order to limit the transfer of contamination into the groundwater, TEPCO is maintaining the water level in these buildings slightly below the groundwater level. In addition, it is verifying that this potential contamination does not reach the ocean; in particular, it is carrying out checks of radionuclide levels in ocean water immediately downstream of these buildings and on the groundwater in borings situated between the site buildings and the ocean.

Over the last few weeks, the presence of high activity levels (around 500 000 Bq/l in tritium and 1000 Bq/l in strontium) in a hole located between reactor 1 and reactor 2 has led TEPCO to sink additional borings to try to pinpoint the source of the leak, and to reinforce its ocean water controls. The figure below shows the control points, particularly the zone marked N°1, the southern part of which comprises two borings showing high radioactivity.

[1] For more information, see the note on the management of contaminated water from the reactors published jointly on IRSN's website.

TEPCO's main hypothesis is that the contaminated water was able to infiltrate into the ground in April 2011 when galleries located near to the aforementioned borings were flooded.

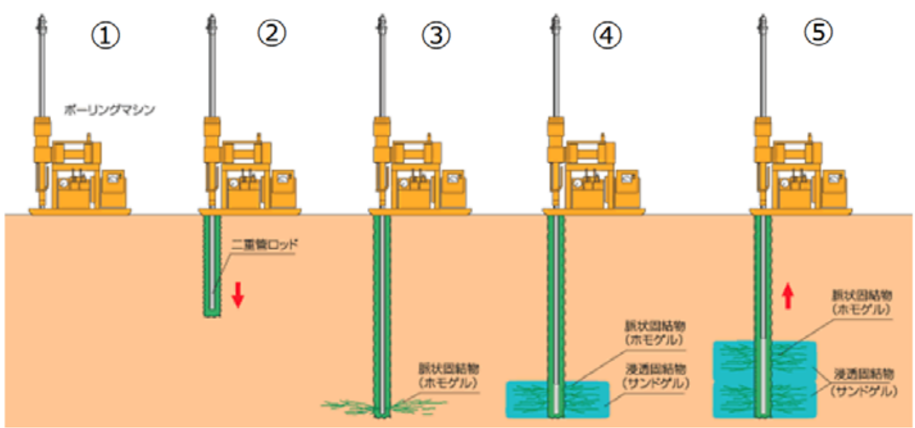


Source TEPCO – Surveillance points of the risk of contamination of the ocean

The controls carried out since the discovery of this increase in the radioactivity of the ground water did not highlight any significant evolution of the activity of water in the ocean.

On the other hand, **on the 9 July 2013, TEPCO measured caesium 134 and 137 levels of respectively 11,000 and 22,000 Bq/l in a boring in zone N°1, levels close to those measured the day beforehand but showing a very sharp increase compared to the first measurements made in this boring.**

Following these events, TEPCO has decided to undertake important work to reinforce the leak tightness of the ground in zone N°1 by the injection of sealing products along the bank situated between reactors 1 and 2. The works should start in early August 2013.



Source TEPCO – Schematic diagram of chemical injections into the ground

The origin of the significant rise in the radioactivity concentration measured in drilling on the edge of ocean

The origin of the increase in the radioactivity concentration **measured in the borings at the ocean's edge cannot be linked to a precise cause given the information currently available;** in fact, it could be explained by the event mentioned above, which occurred in April 2011. However, it could also be due to a leak that affected, in the early phase following the accident, the basements or galleries of the buildings, which were flooded by contaminated water. Depending on the nature of the ground, the migration of the groundwater contamination could have reached only recently the zone mentioned above. Nevertheless, since the migration of caesium in the ground is much slower than that of strontium or tritium, a multiple origin is also possible. The origin of the caesium pollution should however be close to the incriminated zone, given its slow migration speed; moreover, it is also possible that the origin of this pollution has now dried up. If this is the case, the contamination levels should increase, and then level off before decreasing again. TEPCO's investigations into this event should provide more precise information on this subject.

Whatever the case, the fact remains that the actions underway to create a first barrier between the ocean and the groundwater should be able only to limit contamination of the ocean. In this respect, **besides the sealing of the soils by injection as indicated above, the construction of a leak tight screen between the site facilities and the ocean is continuing (expected to be completed by mid-2014).** This type of screen does not however enable all risks of contamination of the ocean to be entirely averted if it is not complemented by pumping of the groundwater. In fact, leak tightness is never total and a risk exists of the screen being by-passed because of the continuous influx of groundwater. On the other hand, this pumping increases the need for water treatment and storage capacities, further increasing the complexity of the overall management of the contaminated water on the site.

In addition, it should be noted that the lessons learned from the Chernobyl accident show that, in the years following such an accident, a few thousandth of caesium deposited in the terrestrial environment migrate annually due to soil erosion and run-off, towards the ocean in the present case. Furthermore, it should be recalled that caesium 137 discharges into the atmosphere and the ocean due to the accident of March 2011 have been estimated respectively at around 60 and 27 PBq. Due to the leaching of deposits in the environment following the accident (deposits estimated at around 2 PBq), the ocean is still receiving important amounts of radioactivity (estimated at several TBq/year). **Given the values observed in the ground water, radioactive contamination of the ocean by the site should remain limited with regard to this overall terrestrial influx, in light of the measures taken, and the potential ecological impacts may remain localised to the immediate vicinity of the power plant due to the important dilution capacity of the ocean.**