Chalk River's Forgotten Story

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The world's first major nuclear accident occurred in Ontario in 1952, followed by a second incident in 1958. Here's a look back at those episodes as the federal government prepares to compensate the surviving workers who cleaned up the mess.

George Kiely is at a loss for words.

On that July morning, I was calling him to get his reaction to the federal budget presented three months earlier. One measure had caught my attention: $22.3 million was allocated to the several hundred workers who decontaminated the Chalk River laboratories after two nuclear accidents in the 1950s. I had never heard of this history.

George Kiely knew it all too well. He and other retirees from Atomic Energy of Canada Limited (AECL) had been fighting for 13 years to get some form of recognition for the risks they faced during those events. At the time of my call, he still had not heard of the success of the process. I am as perplexed as he is!

After a long silence, he recalls his colleague and friend Al Donohue, who blew out his 92 candles this year. "I hope we live long enough to see the compensation," says the 89-year-old.

This story begins at the University of Montreal. During the Second World War, the institution hosted a secret laboratory resulting from an agreement between Canada, Great Britain and the United States. Several hundred researchers and technicians conducted nuclear research there.

"The Montreal laboratory had two objectives: to build reactors to provide electricity and to produce plutonium to eventually build a bomb," explains Gilles Sabourin, author of Montreal and the Bomb, published in 2020. They held experiments there and, most importantly, designed the NRX [National Research Experimental] reactor and a plutonium extraction plant." The plan was to build them at Chalk River, 180 km north of Ottawa

Then, in 1945, the world's first atomic bomb was tested in New Mexico. Two more were dropped on Japan a few weeks later. The war ended.

A month after the bombings, the Chalk River Laboratories (which were located close to the town of Deep River) opened. The public was told that they were conducting peaceful nuclear research. But military objectives remained: Canada supplied the United States with uranium [to be] enriched for military purposes for two decades after the war, as well as 252 kg of plutonium between 1959 and 1964.

NRX became operational in 1947. With a capacity of 20 megawatts (MW), it was "the most powerful research reactor in the world and the best for experiments," says James Ungrin, a retiree from the ‘physics of accelerators’ division. He takes me on a tour of the Canadian Nuclear Heritage Preservation Society's Deep River Museum, which is full of intriguing artifacts, including the red underwear worn by workers in the "active" zone, a color that helped to remind them to change their clothes completely before going home! "Overnight, AECL and Chalk River became internationally renowned. Certain experiments could only be conducted here, and nowhere else, so experts flocked to Chalk River." Many say they were completely blown away by the campus. "All the descriptions of the place from the 1950s revolve around nature, the beauty of the landscape," says Frances Reilly, a historian who has studied the influence of the atom on Canadian popular culture.

I can see why! The private consortium that has operated the site for AECL since 2014, Canadian Nuclear Laboratories (CNL), opened its doors to me. After a security check at the entrance to the 10,000-acre site, I drove a few kilometers on a winding road lined with trees and marshes. Then I arrived at the cluster of buildings set against the backdrop of the Ottawa River and the Quebec cliffs.

The NRX building, made of red brick with multiple high windows, is magnificent. A design like this is not seen any more; these types of facilities are now housed in concrete structures for safety reasons.

At the center of the brightly lit building sat the reactor, confined in a concrete enclosure topped by walkways, rails and a crane. At the time, it was a state-of-the-art facility, with automatic remote controlled systems. “There were mechanisms on top of the reactor that were used, among other things, to change the fuel,” says Gilles Sabourin. It was very science-fictionish!

The reactor core, located in a vessel called a "calandria," contained 175 long rods inserted vertically: 163 filled with fuel (uranium) and 12 others full of boron carbide, a material that absorbs neutrons and stops the fission chain reaction. If as few as 7 of these 12 so-called "control rods” were inserted into the reactor core, no fission could occur. Conversely, the control rods had to be removed to start the reactor.

One could also control the reactivity by adjusting the level of heavy water in the calandria. This water resembles ordinary water in every way, but its hydrogen atoms are heavier than normal hydrogen isotopes. In the reactor, the presence of heavy water slows down the neutrons so that they can participate more effectively in sustaining nuclear fission. Dumping the heavy water, on the other hand, meant the end of the chain reactions. In addition, ordinary water was circulated through those channels containing the fuel rods to remove the excess heat and keep everything at an acceptable temperature.

In its first year of operation, the National Film Board of Canada's documentary series Eye Witness visited the site. The narrator explained that safety is taken seriously. "Radioactive contamination is silent and deadly. A medical team monitors the workers constantly. And each worker tests himself before leaving the plant," he explained, adding that even the paint on the walls is re-applied after just a few months!

In the control room, four buttons were particularly important, recounts James Mahaffey in *Atomic Accidents : A History of Nuclear Meltdowns and Disasters*, published in 2014.

- Button 1: a batch of 4 control rods is withdrawn from the reactor.
- Button 2: the other 8 control rods are withdrawn from the reactor.
- Button 3: the current of the electromagnetic system holding the rods in place increases.
- Button 4: The 12 rods are inserted into the reactor using a compressed air system; if this system fails, the rods can fall back down by gravity alone.

Confusion over these buttons triggered Chalk River's "Black Friday".

On Friday, December 15, 1952, around 3:00 p.m., the last experiment of the day was about to begin. The configuration of the cooling system was changed for the occasion and the water flow was reduced, which did not worry anyone, since the experiment required little power.

While doing routine checks in the basement, an operator assessed that some valves in the compressed air system were in the wrong position. He replaced them. His actions caused three control rods to pop out of the reactor core. Red lights came on in the control room. A supervisor came downstairs and was shocked to see the mistake. He hurriedly lowered the rods under the effect of gravity. Unfortunately, only one of them entered the reactor completely; the others descended just far enough for the red lights to go out.

To make sure the rods were in the reactor, the supervisor picked up the phone and asked his assistant to press buttons 1 and 4. The assistant put down the handset to carry out the command and so did not hear his boss correct his order: he meant to say buttons 3 and 4 instead. Four more control rods were withdrawn out of the reactor, for a total of 7 out of 12. The power in the reactor started doubling every two seconds.

The warning lights came on again. The assistant tried to reinsert the batch of four rods. Only one goes in ... after a minute and a half! There is panic in the control room. "There wouldn't have been a problem if the cooling system hadn't been modified for the test that day," says Gilles Sabourin.

Ordinary water started to boil instead of circulating to get the heat out of the reactor. The instrument that measured the temperature could no longer keep up with the situation. The uranium rods eventually melted, contaminating the cooling water. Capable of handling up to 30 MW of heat, the reactor climbed to somewhere between 60 and 100 MW. The employees drained the heavy water into a tank to stop the fission, which worked. The loss of control lasted only 62 seconds.

Nevertheless, the staff was not out of the woods. The supervisor in the basement heard the sound of pistons being pushed by air pressure followed by a thud, according to *Nucleus: The History of Atomic Energy of Canada Limited*. It was an explosion caused by contact between the hydrogen that had formed in the reactor with the melting uranium and the air that managed to enter the reactor. Heavy water gushed out; the reactor was visibly leaking.

The accident was over, but the radioactivity was dispersed. The radioactivity contained in the 4.5 million liters of ordinary water that accumulated in the basement was equivalent to seven times the total world production of radium at the time, according to Canada's Nuclear Story, a book commissioned by AECL in the 1960s and written by journalist Wilfrid Eggleston. So it couldn't be sent to the river.

The air was also contaminated. The detectors sounded the alarm, not only in the building but also in adjacent buildings. Al Donohue was nearby, working on the foundation of a new reactor. As soon as the sirens sounded, he knew the situation was serious. "When I started working there, I had done some research to find out what I was getting into, so I knew that radiation was probably in the air. I immediately got my men out. We waited in buses outside the perimeter."

“This was the world's first case of a reactor core meltdown. This is a fairly serious accident," commented Gilles Sabourin. It is quite high on the international scale which, somewhat like earthquakes, ranks nuclear accidents according to their severity, from 1 to 7. The worst ever was Chernobyl: a 7. Chalk River, because the core melted, is a level 5.

A drama for AECL: was this the end of NRX? "They wondered if they were going to recover because no one had experienced this before," says James Ungrin.

The work to decontaminate and return the reactor to service took 14 months. A pipeline was built to dump the contaminated water into a sandy trench intended to filter it before it reached the river. Similarly for the calandria: "We buried it in a sandy area and that was it! It was quite rudimentary," recalls Mahdi Khelfaoui, a professor at the Université du Québec à Trois-Rivières and a specialist in Canadian nuclear history. It is said that drivers had to take turns driving the truck carrying it to avoid overexposure. The calandria was so contaminated that being just one meter away for less than an hour would have been enough for a worker to absorb a lethal dose....

In addition to 800 or so AECL employees, Canadian and American military personnel were also involved in the cleanup effort. "The Americans were starting to build nuclear-powered submarines and their submarine fuel was being tested at Chalk River," says James Ungrin.

The public also needed to be reassured, as rumours were beginning to circulate. For example, in Pembroke, 50 km away, there was talk of a police officer's coat buttons being tarnished by radiation! “This was AECL's first major public communication operation," says Khelfaoui. The corporation had just hired its first public relations professional.

Two days after the accident, a couple of journalists from the Ottawa Citizen visited the scene. The version of events they reported was astonishing! An official told them that the health of the trainees had never been in danger and that there was only a concern that the radiation might damage the equipment. The newspaper headline stated that the damage was negligible. “We were led to the reactor building where the leak occurred," they wrote. “Every minute it became more obvious that the stories of dangerous radiation were completely exaggerated. . . . We could not have been closer – and yet we were in less danger than a man crossing a street in Ottawa.”

The condition of the reactor was not yet known and this led to somewhat optimistic statements, according to a 1980 AECL scientific paper.

Chalk River Laboratories employees learned a lot from the event. “What exactly happened, how it could have happened, despite all the care taken to control and shut down the device, what the effects were, how to repair the damage, and how to ensure that such an accident does not happen again, are all questions that were thoroughly examined between Black Friday and the day the NRX returned to service 14 months later," writes Wilfrid Egbert.

The storage of radioactive waste has also been refined over the decades and has been the subject of much research at AECL. For the 1952 episode necessitated some improvisation. In 2005, specialists examined the place where the melted fuel rods had been buried. They found that the fuel rods were in direct contact with the ground, because the wooden boxes containing them had deteriorated over time. In addition, 32 pieces were found, while the archives listed 19, reports an AECL study. All of this was moved in 2007 to a more suitable storage area.

Once back on track, the NRX had a long life: it operated until 1993.

A more powerful research reactor, the 200 MW National Research Universal (NRU), began operation in 1957, a stone's throw from NRX.

On May 24, 1958, the NRU reactor was shut down: damaged fuel rods had to be removed from the reactor with a crane and a water-cooled transfer vessel and placed in a storage pool. When the second rod was taken out, the operators found that the transfer vessel contained no water," James Mahaffey recounts in his book. Danger!

The crane operator tried to put the damaged rod back into the reactor, but it got stuck without fully entering the core. Employees put on suits and masks and hosed it down with varying degrees of success. The crane then tried to remove the rod again, but only managed to get part of it ot, which caught fire. It was being moved by the crane to the pool when a 90 cm piece of burning uranium fuel broke off and landed in the maintenance pit.

"The radioactivity given off from the burning uranium was dispersed by the fumes as dust, contaminating the entire reactor room and other parts of the building. Since the radioactivity levels were high, the personnel were evacuated. No one could stay in the area for more than a short period of time: 2 minutes," wrote David A. Keys, general manager of the Chalk River facility, in a report cited by Wilfrid Eggleston. Employees, including an accountant, took turns pouring pails of wet sand onto the burning piece of uranium from the top of a walkway. Within 15 minutes, the fire was under control.

This time, Al Donohue had a front-row seat to the incident; he was working in operations at the NRU. He tells me he carried some sand garbage cans to an elevator, "probably the next day." "We knew our health was at risk. Every shift was torture," he says, sitting next to his friend George Kiely in his quaint house in Pembroke. He says he and his colleagues quickly exceeded the radiation dose limit considered acceptable. Afterwards, he was asked to prepare volunteers to enter the building for the cleanup operation.

George Kiely remembers being dressed by one of Al Donohue's men. He normally worked in the metallurgy building. He agreed to help with the cleanup without hesitation. Supervisors explained his mission: enter the darkened factory, locate a large vacuum hose and use it to pick up "fluorescent pellets" from the floor for 10 minutes. "It's one thing to hear that, but it's another to actually do it! The hose was very long, about 8 feet, and at the end there was an elbow that moved back and forth: it was tied with duct tape! By the time I figured out how to handle it, I was already being yelled at to get out. I only managed to clean up a 10 square foot section." Once again, more than 800 AECL employees took part in the operation, as well as 300 military personnel.

The 1958 accident was less serious than the previous one. It was not classified, but it would be potentially level 4 to 5. The reactor was closed only six months. It too had a long career: it was a major source of medical isotopes for the entire planet in the following decades before being officially shut down in 2018.

The events of 1952 and 1958 paved the way for the addition of an extra safety device when it came time to design reactors for electricity production, the famous CANDUs. "In Canada, in addition to the rods that go in by gravity or with a spring, we have another system, completely independent: a poison injection," notes Gilles Sabourin, "gadolinium, which absorbs neutrons."

Rosaura Ham-Su, CEO of the Reactor Sustainability Division at NLC, mentions that NRX and NRU, in the decades following the accidents, were used to simulate all sorts of catastrophic situations. "Both were used to test the fuel. This was done by bringing[the reactor up to the expected temperature, and even beyond at times to study the effects of the maneuver. In the NRU, for example, there was a place to expose the fuel used for the CANDU under steam conditions. This was like simulating an accident where the water vaporized to see what would happen. These tests were extremely important because they allowed us to design very safe reactors."

Despite their scientific importance, the two accidents have pretty much been forgotten. This is a pity, according to Mahdi Khelfaoui. "More attention should be paid to them, especially from the point of view of the workers who were exposed to radioactive doses during the cleanup work."

On the balcony of their home in Hampstead, a landlocked town on the island of Montreal, Gordon and Karen Edwards welcome me with bottled water. "After all these years of hearing

Gordon talk about the risks of nuclear power and the contamination entering waterways, among other things, I can't drink the river water," Karen says, with a laugh.

Gordon Edwards is co-founder of the Canadian Coalition for Nuclear Responsibility. In 1979, he received a call from representatives of Project Genesis, a Montreal community organization. "They said, ‘A former military man contacted us about a 1958 nuclear reactor accident at Chalk River. Have you ever heard of it? This man has multiple cancers and is trying to get a pension for the damage he suffered during his service.’"

Gordon Edwards agreed to help this man, Bjarnie Hannibal Paulson, who had undergone dozens of surgeries to treat basal cell carcinomas in his anal area, chest and face. Radioactive particles seem to have been lodged in his hair follicles. They would not have been detected on Mr. Paulson's body after his various passes through the danger zone and subsequent showers because they were alpha emitters, which are more difficult to detect than beta or gamma radiation because of their short range.

Corporal Paulson was posted at the St. John's Military base when he was sent to Chalk River to assist in the cleanup for two weeks. One of the jobs he did was to cut the long dangling hose off the legendary vacuum cleaner so that it could be lifted out by crane and buried.

In 1982, Gordon Edwards and McGill University epidemiology professor Duncan Thomas conducted a study on the health of the military personnel they managed to contact. "Sixty-five were located and 15 had developed cancer, which is four times the normal incidence of cancer in the general population," the epidemiologist told the Canadian Pension Commission, according to an article in Le Devoir.

That same year, the Department of Veterans Affairs asked researchers at the University of Ottawa to study the mortality of military personnel who cleaned up the mess at Chalk River or attended dangerous desert A-Bomb tests in the 1950s to train for nuclear war.

In their report published in 1984, the researchers specified that their study did not include all the military personnel involved, because a fire in the late 1950s at the Chalk River laboratories destroyed some of the documents listing the participants. The authors go on to report that they found no abnormal increase in deaths among the 1,000 military personnel studied. (A similar report was written about AECL workers and came to the same conclusions in 1986.) They point out, however, that this *mortality* study does not allow for a determination of *morbidity*, i.e., the diseases that could affect individuals exposed to radiation. “Especially cancers," they said. They proposed that a second study be carried out to clarify this point (which never took place).

In the six years since their meeting, Gordon Edwards and Bjarnie Hannibal Paulson appeared before the Canadian Pension Commission eight times, each time failing. The Federal Court of Appeal ordered that the case be re-examined and Mr. Paulson was finally awarded a pension.

What about Al Donohue and George Kiely? Donohue's voice breaks when he recounts the case of Raymond Paplinskie, the NRU crane operator. Because of sinus cancer, he underwent several surgeries that completely disfigured him. "I saw him at the grocery store one Sunday and he changed aisles because he didn't want to run into me. I went up to him anyway and told him my heart went out to him. That was the saddest thing I've ever seen." He died without getting any compensation, despite repeated requests. "Not a penny ..." laments Al Donohue.

That's why the two AECL retirees were shocked to learn in 2008 that military personnel involved in decontamination efforts at Chalk River Laboratories in the 1950s could claim compensation, while civilians like them could not. The $24,000 compensation was given as part of the "Atomic Veterans" Recognition Program (which also includes military personnel who attended the desert atomic bomb tests). The idea was not to recognize health damage, but rather to acknowledge the work done. For his part, Gordon Edwards feels that it is "really too little, and really too late" and he fears that light will never be shed on the true effects of the two accidents.

A few years later, Senator Céline Hervieux-Payette received a letter from former AECL workers, including Al Donohue and George Kiely. "I was in the Senate for 21 years and I answered every letter that was sent to me," the dapper retiree told me as she made herself a cup of tea.

This letter was no exception; the senator decided to help the group. "You have to remember that I'm a lawyer, I thought I had a good cause! They came to me twice." They told her what they had experienced and their sense of injustice. "I first made internal representations, to the government, but it didn't go very far. I decided to introduce a motion that passed the Senate without difficulty in 2016."

The issue still went nowhere until the 2021 budget. Civilian workers, or their descendants, will now be able to claim a token amount. Again, is it too little, too late? "As far as I'm concerned, it's never too late to right a wrong," says Céline Hervieux-Payette.

Natural Resources Canada has indicated that, over the next few months, “officials will be working to define the parameters of this new program. We will also be contacting former employees to ensure they are aware of the program.”

George Kiely and Al Donohue tell me that they will only believe it when the cheque arrives.
