PIPING, PUBLIC OUTREACH, AND SOIL ASSAYING AT THE NASA PLUM BROOK REACTOR FACILITY

Keith M. Peecook, PE
National Aeronautics and Space Administration
Sandusky, Ohio, USA

ABSTRACT

The National Aeronautics and Space Administration (NASA) is nearing the successful completion of its US $230 Million, 12 year effort to decommission the Plum Brook Reactor Facility (PBRF). This paper will consider several different key elements of the project, including cleaning and survey of embedded and buried piping, soil assaying, and community outreach.

1. BACKGROUND

The NASA Glenn Research Center's PBRF is located at Plum Brook Station near Sandusky, Ohio. It is halfway between Toledo and Cleveland, five kilometers south of Lake Erie. There are two US Nuclear Regulatory Commission (NRC) licensed reactors on site. The main reactor is a 60 MW pressurized water reactor and the Mock-Up Reactor (MUR) is a 100 kW swimming pool type. Both were used to perform neutron exposure testing on materials in support of the nuclear rocket program.

Figure 1. The NASA Plum Brook Reactor Facility – circa 2005

Construction started in 1958, with initial criticality in 1961. Full power operations began in 1963. The plant ran for 10 years, accumulating 98,000 MW days of run time. In 1973 it was shut down, all fuel was shipped offsite, and the balance of plant was placed in Safe, Dry Storage.

Pre-decommissioning began in 1999, and full decommissioning started in 2002 with the NRC's approval of the NASA PBRF Decommissioning Plan. NASA expects to submit its License Termination Request for both reactors to the NRC in early 2012.

1.1 Project goals and approach

NASA's goal for the project is to achieve unrestricted release from its two NRC licenses. It is performing the decommissioning to meet the requirements of NRC 10CFR20 Subpart E. Derived Concentration Guideline Levels (DCGLs), the clean up levels that tell us when we are done with decontamination, were developed using a pair of models. For residual soil contamination RESRAD Version 6.0 was used. This model has been formally accepted by the NRC for analysis of residential farmer scenarios. The dose model selected for analyzing residual building surface contamination, RESRAD-Build Version 3.22, is widely used in analyzing building reuse scenarios. These two site-specific models include all pathways and exposure modes included in the NRC generic screening.

The approach used has been to decontaminate the site to the DCGLs, and then to perform Final Status Survey (FSS) to demonstrate and document this was done. The Decommissioning Plan is written so as to allow NASA to demolish the structures either before or after License Termination. Buildings are to be demolished to one meter below grade, and the resulting hole is to be filled with Clean, Hard Fill. The final one meter will be backfilled with topsoil.

There are two other goals that have guided the decisions made by the project. The first, as directed by NASA Headquarters, was whether everything needed would be done to protect the safety of the public, the workers, and the environment. Second, where it made fiscal sense, work would be done so as to minimize the need to use offsite landfill space to dispose of waste.

2. BURIED AND EMBEDDED PIPING

NUREG 1757, "Consolidated Decommissioning Guidance", identifies and defines two classes of piping. Buried piping is buried in soil, while embedded piping is encased in concrete floors and walls. The PBRF Final Status Survey Plan further refines these definitions. Buried pipe is pipe buried in soil which is situated outside the structural foundation of a building, while embedded pipe is any pipe situated one meter below grade that is either directly encased in concrete or is below a building floor, and is all contained within the structural foundation of a building. The principal difference between the two types of pipe is that the only exposure pathway for embedded piping is direct dose from gamma emitting radionuclides. In addition there is a significant credit given for shielding provided by the layer of concrete over the pipe.

Pipe classification is based on the final condition of the pipe, not its original condition. In one case at PBRF this nuance was not initially recognized. Embedded pipe DCGLs were calculated for a set of pipes buried in the ground under a 30 cm thick concrete slab, and remediation was completed. A peer review of ongoing decommissioning activities determined that while the pipe was currently under a slab, that the ultimate plan for building demolition would remove the cover, meaning it would no longer be classed as embedded. New buried pipe DCGLs were calculated, resulting in the need for additional remediation.

2.1. Options for dealing with pipe

For the first three years of the decommissioning the focus was on removing the reactors and visible support equipment; little attention was given to the below grade piping systems. Once the project looked at the remaining piping, however, it quickly became apparent that this had been a significant oversight in planning – the scope of the task was massive. Systems involved included primary piping, process lines, floor drains, storm drains, and even a few sections of electrical conduit. Altogether there were over 7,000 m of plant piping. Some of it was just below the concrete floor, but other runs went deep, as much as 17 m below grade, under several meters of concrete. Piping diameter ranged from 2 cm to 0.8 m. There was another 1,200 m of storm drains, ranging from 20 cm to 1 m in diameter.

The first reaction was to take the conservative route and simply remove all piping from the site. It didn't take long to realize that this approach was not easy or cheap. It would have required very extensive excavations with the attendant significant safety and groundwater issues. An alternative approach was proposed – to clean and survey the pipes 'in-situ". The only pipe to be removed would be that which could not be cleaned to be below the DCGL, or where the removal and disposal of the pipe was the easier and cheaper option (such as for concrete and corrugated storm drain lines buried out in the yard).

A study examined three options – digging up and disposing of all pipe, cleaning and surveying the piping in place, or some combination. The best option turned out to be the combined approach. Digging up shallow piping buried in soil, such as the storm drains, was both cost effective and safe. In the case of pipes which were encased in concrete, cleaning and surveying in place was better. The net result was a projected US $10 M savings over full removal. Combined with the huge safety benefit the choice was obvious.

2.2. Cleaning the pipe

Babcock Services Incorporated (BSI) was hired for this job. They applied a combination of elegant engineering and brute force. Engineering involved designing or adapting tooling to clean and survey the pipe. This often called for customization and 'one of a kind' solutions developed in the field to deal with the in plant conditions (note- as-built drawings for piping systems, especially for things like floor drains, are not dependable). Brute force came in cleaning the pipe. In most cases the activity in the pipe was bound up in the rust and scale on the inside pipe walls. Remove that and you have a clean pipe.

The standard approach was to examine the drawings to identify a suitable length of pipe where access could be established to both ends. A cart with a TV camera and a radiation detector was then driven through the pipe to establish initial conditions. Figure 2 shows workers performing initial scans in a pipe while watching the video output real time on a monitor. Most pipes were dry, and suitable for mechanical cleaning.

To clean the pipe, access points were identified and opened at each end. Typical lengths of pipe handled were 12 m, though single lengths as great as 30 m were successfully cleaned. A large vacuum was applied to one end of the pipe while a mechanical or abrasive cleaning device was fed in from the other. Figure 3 shows a 'flail' type mechanical cleaner. The motor on the cart would spin at several hundred rpm, and the chain was sized so that the rapidly moving weighted brushes, or flails, just reached the wall of the pipe. As the cleaner advanced the rust and scale was knocked loose and pulled out by the vacuum, leaving a 'white metal' surface to survey. One pass was sufficient for about 90% of the piping to reach the DCGL.

Mechanical cleaning worked for 7,000 m of piping. 300 m of piping did require hydrolasing, which is cleaning with very high pressure water jets. Use of this approach was minimized due to the logistics and cost of dealing with the resulting waste water.

Finally there were about 100 m total of floor drain pipes that were found to be too corroded to clean. The fear was that the force of cleaning would break the pipe and send contamination into the surrounding soil. In these cases the concrete floor was cut out and the piping excavated.

Figure 2. Workers Cleaning Embedded Piping

Figures 3 and 4. A Pipe Cleaning 'Flail' and a Pipe Radiation Probe

Surveys were performed both before and after cleaning, using detectors mounted in custom carts that traveled down the pipe. A typical probe is shown in Figure 4, being tested in a dummy length of pipe. Such mock ups were made for the various diameter piping, and were used to check out the fit of carts for cleaners and detectors. The mock ups were also used to calibrate the instruments, with the use of a flexible flat plane source mounted to the interior pipe wall.

The specific DCGL applied to a piping system was dependent on the primary nuclide of concern and the specific nuclide distribution of the six gamma emitting nuclides evaluated as the dose contributors for grouted embedded piping (Cs-137, Co-60, Eu-154, Eu-152, Nb-94, Ag-108). The primary nuclides of concern were Cs-137 and Co-60. These nuclides were measureable by the detection equipment. The remaining nuclides were surrogated (scaled) to the primary nuclide to develop total activity loading for the pipe. These nuclide distributions were determined during a comprehensive sampling campaign in 2006. Samples analyzed included piping coupons and corrosion products collected from within the various piping systems. The final technical assessment developed eight different nuclide distributions for the various piping systems.

2.3 Hot Cell Conduit and Piping

One particular challenge was the cleaning of the conduit and pneumatic transfer piping associated with the hot cells. Hot Cell #1 alone had 366 m of piping to be cleaned and surveyed. Piping sizes were as small as 2 cm diameter. The hot cells are at grade, and are expected to be demolished and the debris used as backfill. Because of this the DCGL used for this piping was the same as for all building surfaces.

The same cleaning and surveying techniques were used, though the small size of much of the conduit required new tools yet again. Grit blasting, described in more detail in Reference [1], was also occasionally used. Figure 5 shows a selection of some of the abrasive tooling used.

Figure 5. Tooling used for Cleaning the Hot Cell Conduit

2.4. The results

Selective application of in-situ cleaning of embedded pipe worked out very well. Average prices seen were US $75 to $125 per foot of piping cleaned and surveyed. For piping which had to have concrete flooring cut out and the piping excavated and disposed of the costs averaged US $350 per foot. In the case of shallow buried pipe, such as storm drains, it was cheapest to simply dig it up and dispose of it.

The final survey of the pipe produced a detailed written record of the activity left in the pipe. These records were considered to be the FSS Record. They were grouped for a particular piping system and nuclide distribution group and sent to the NRC for review. Upon receipt of NRC approval, grout was pumped into approximately 2,500 m of the larger diameter piping systems. This grouting is a compliance criterion of the FSS Plan, and is required to be completed prior to license termination. The grout is required to meet a specific density and is integral to the dose modeling which drives the embedded pipe DCGLs.

3. SOIL ASSAYING

For the most part contaminated soil at PBRF contained Cs-137 and trace amounts of Sr-90 and Co-60. A surrogate DCGL of 0.54 Bq/g Cs-137 was established, with an action limit of 50% of the level, or 0.27 Bq/g Cs-137 set up to ensure clean up was accomplished the first time. In a few known on-site spill areas Co-60 was a more significant dose contributor, and a lower DCGL was applied.

Initial soil remediation efforts were of the 'hog and haul' variety. This means that soil above the action limit was dug up and packaged and shipped to the Energy Solutions site in Clive, Utah, for disposal. Contaminated soil was excavated out in 15 cm lifts, and the newly exposed soil was resurveyed until we met the action limit. Approximately 4,536 metric tons of soil was disposed of in this way.

3.1. A better way

Based on the cost and risk involved with long distance shipments of soil, as well as the potentially unnecessary use of landfill space, NASA considered a new approach to deal with the much larger volumes of soil left to be dealt with towards the end of the project. There was still

Figure 6. Soil Assay System

an estimated 42,600 metric tons of soil to be processed. Sources included the earthen diked Emergency Retention Basin, soil from Pentolite Ditch (the known normal discharge path during operations) and its banks (where spoils from dredging the ditch had been spread over the years), and soil from under the storm drain lines.

To handle this challenge NASA elected to employ soil assaying, using the MACTEC Orion Soil Sorting System. The system is shown in Figure 6. The soil to be assayed is passed through a trammel, which removes any rocks or other debris and places the soil evenly on a conveyor belt in a 15 cm thick layer. The belt carries the soil under a series of detectors. The soil then dumps onto a reversing belt. If the soil is within radiological limits then the reversing belt moves the soil towards the 'clean' pile. If it is above limits, or if the soil geometry is not within specs, the reversing belt immediately and automatically directs the soil to the 'dirty' pile. Once soil is back within limits the reversing belt changes directions again. With this system PBRF was able to process as much as 1,100 metric tons of soil during a 10 hour work day.

3.2. Application

The system had previously been used at other NRC regulated sites (the Saxton reactor site in Pennsylvania, and a thorium contaminated rail yard in Tulsa, Oklahoma), but PBRF's NRC inspectors had not seen it before and had several concerns. The main question had to do with blending – how was NASA going to insure that soil contaminated above the DCGL was not intentionally mixed with clean soil in the excavation, transport, and soil processing steps prior to assay so as to be diluted to be within standard and so left on site? This was resolved administratively by ensuring all areas to be excavated were scanned and segregated first. Any soil found by field instruments to be above the DCGL would be removed and placed in the shipping pile. Only soil believed to be less than the DCGL would go through the assay process.

Since the results of this system were treated as FSS results it was necessary to meet all applicable FSS QA/QC standards. This included the requirement that at least 5% of the samples be validated. To accomplish this 'clean' soil was collected at the end of the belt in 453 metric ton piles. This size pile roughly corresponded to the amount of soil in a standard MARSSIM open field survey unit, measuring 2,000 m^2 by six inches deep. Grab samples were collected from each pile and analyzed to provide the necessary check. Once the sample results were shown to be acceptable the individual pile was moved into the 'clean' pile.

3.3. Results

Approximately 9,072 metric tons of soil were excavated based on field instruments showing the soil as being above the DCGL. As had been agreed with the NRC, it was not run through the assay unit but was disposed of offsite. In most cases, due to overdigging and blending, final activity levels were low enough to send it to the Tennessee "Green is Clean" program as opposed to Utah, at less than 50% the cost.

This system was used for soil which, by field instruments, was found to be between 50% and 100% of the DCGL. Approximately 42,600 metric tons of soil was assayed and proven acceptable to be left on site. The assay units printed results and the NASA QA sampling procedure were considered by the project as being an FSS quality survey. The resulting soil pile will be used as backfill following demolition of the buildings.

4. COMMUNITY OUTREACH

NASA recognized early on that having the support of the community would be critical to a successful decommissioning. FOCUS GROUP, Inc, was hired to be the project's partner in this effort, to use risk communications to enable NASA to be seen as a credible source of information. To accomplish this it was important to 'get out early' with information about the decommissioning, before negative opinions could be formed. This had to be balanced with the potential for raising undue concern in a mostly unaware population.

4.1 Beginning steps

Stakeholder identification was used to define the needs and structure of the outreach program in 1998 – 1999, prior to the start of the decommissioning. Nearly 40 interviews were conducted with retired and former workers, local officials, and local residents. The interviews covered stakeholder awareness, perceptions, concerns and information needs and preferred channels. One point that came out loud and clear was that most of the public had no idea what went on "behind the fence" at NASA, and the very existence of a mothballed nuclear reactor came as a surprise. The results of the interviews were used to create a comprehensive Community Involvement Plan, which detailed a mix of communications vehicles.

4.2 Community Work Group

Another key outcome of the stakeholder interviews was that community members would trust information coming from respected neighbors and local leaders. At FOCUS GROUP's suggestion NASA decided to form a Community Work Group (CWG). While there is no regulatory requirement for such an effort this has proven to be our communication backbone, and has been time and money well spent. Figures 7 and 8 show two of the means of communication used during a typical meeting, formal oral presentation and story boards.

The CWG does not have approval authority over the decommissioning project's operations. Instead it is a means of providing two way communications between the project and the public. NASA provides information, including project status and plans. The CWG members are able to raise questions and concerns. The members in turn have carried this two way flow into the local community, carrying information to friends and neighbors while bringing the broader public's issues back to the workgroup.


Figures 7 and 8. Community Work Group Presentation and Display Boards

It is worth looking at an early example of how this worked out in practice. NASA made it known through the CWG that it planned on having waste shipments leave its facility through its south gate, which was closest to the turnpike and meant that trucks would not be passing through a residential area. The CWG responded with a concern for students at a vocational school located near the gate, and requested another route. Based on this request NASA put a gate on the east side of the property back into operation, which was a bit farther from the turnpike, but which avoided both residential areas and the school. By communicating intentions beforehand NASA gave the community time to absorb the information, and bring up their concerns. Since there was adequate lead time NASA was easily able to accommodate the neighbor's concerns. The public felt that they had some voice in the process, which increased their comfort with the project and improved their view of NASA's openness.

The CWG has typically had 10 members. These volunteers have been local residents including emergency responders, educators, health professionals, nearby neighbors, and members of environmental, religious, and minority communities. Many have been active in other community boards and associations, and are well known in the local community. There has been only a 50% turnover of the membership over nearly 11 years of meetings. One task given to FOCUS GROUP is to keep a list of potential CWG members so to help quickly fill any vacant position.

CWG meetings are open to the public and media, and are advertised in newspapers and on the radio. The location is rotated among local schools and churches, moving between different area cities to make it easy for all local citizens to attend. They were held quarterly until the last two years of the project where the decrease in the amount of new activities has allowed us to slow to three, then two annual meetings.

4.3. Project roll out and predecommissioning

The CWG is only one element of the decommissioning project's public outreach effort. While NASA knew that people feel less risk from something they are familiar with, we had also learned from the focus group results that the public didn't know what went on 'behind the fence'. At the same time the CWG effort was getting started NASA held a public introduction to the entire station. A 'Media Day' was put on for all branches of the local press, followed by a Plum Brook Station Public Open House. This included tours of the various test facilities, and a drive by of the reactor. Decommissioning was introduced as a part of this overall presentation. The key messages were emphasized throughout – NASA's priorities for the project were the safety of the public, the environment, and the workers. In addition, NASA was committed to communication with the public. Finally, while PBRF was being decommissioned there were four other non-nuclear test facilities that were to remain active, and care was taken to ensure the public knew the difference.

4.4. Other communication channels

Multiple channels are needed for getting a message out. People vary in how they most effectively receive information; some prefer verbal, some written, some a combination. Telling someone something once will likely have no lasting impression – the goal is for them to get the information at least three times. While the CWG was the real communications workhorse there were several other channels as well.

The project established a Community Information Bank at the library of a local community college. This contained all project plans, reports, and documents and was available to the public.

This bank has been kept up to date throughout the project. In this way a hard copy of all project documents was available to the public at all times, at an independent location.

"Fact Sheets", one page documents that addressed issues such as "Decontamination Technology", "Waste Shipments", and "FSS" have been produced whenever a new activity was taking place that NASA wanted to inform and educate the public on. These have been handed out at all public events, and have been mailed out upon request.

A project website, www.grc.nasa.gov/WWW/pbrf, was set up. Slide presentations from recent CWG meetings are posted on the site, as well as Fact Sheets, project description and summary, and certain project documents. People visiting the site also have the ability to send in questions or to get on the project mailing list. A note here on changing technology – this was all set up in the 2000 time frame. If we were starting today we would probably include Twitter and a Facebook page!

A Project Update phone line has been maintained. A two to three minute recording gave the status of the project. This was updated as events progressed with the decommissioning, typically every two to three weeks. There was also a menu selection for people to leave a question as a message, or to ask to be put on our mailing list.

Quarterly Newsletters were prepared giving regular updates for the project. These four page mailers have been very popular with local residents, government officials, and even with PBRF retirees living out of state who wanted to keep up with the project. Over 1,200 people are on the mailing list. Besides updates on the project there have been stories on the CWG members, updates from the other test facilities on station, even coverage of retiree activities.

Community Information Sessions have been held once a year. These were large "show and tell" type meetings with display boards, artifacts, and a project update presentation. These were very popular with local high school science teachers who assigned their classes to attend! For the first several years a "Media Day' was also held the morning of the CIS to get the information out to those members of the press not attending the meeting. A lot of positive coverage resulted from the effort, and NASA had a better chance to get its message out as part of the story.

4.5 The setup

All of this effort to keep the public informed and involved was intended to establish NASA as an open and honest source of information. We worked had to establish and earn the public's trust. The results of this effort were put to the test five years after we started the risk communication effort.

In August 2005 Cs-137 was found off of NASA property, in Plum Brook. The area impacted included a mixture of agricultural, residential, and recreational property. NASA had performed environmental monitoring over the operating and shutdown years and had not detected any contaminants that far from the plant. Characterization work with Final Status Survey sensitivity instruments told a different story.

During operations the permitted discharge path from the plant was out into Pentolite Ditch (an open road cut ditch) which flowed 1 km to Plum Brook, at the PBS fence line. From there the brook flowed 6 km to Lake Erie. The Cs-137 had built up over the years in the clay silt of Pentolite Ditch, and had slowly been eroding and redepositing down the ditch and into the brook as it worked its way through private property to Lake Erie. Detected levels were low (isolated spots in the 0.37 – 1.11 Bq/g range), but were definitely above background (0.02 Bq/g). NASA needed time to do a complete characterization, and to plan an appropriate remediation.

4.6 The payoff

This is when all the hard work in risk communication paid off. NASA immediately notified federal, state, and local regulators and officials. We also put out the information to the public through all its preexisting channels, including contacting CWG members, and updating the 800 number and the website. Letters explaining the situation were sent to the neighbors along Plum Brook. All of these gave the information we did have (isolated low level contamination on private property, but no public health risk existed), the plans for what we were going to do (additional sampling), how long it would take (several months), and the assurance that NASA would continue to provide information as it became available, and would do what was necessary to insure the public safety.

Without the prior work with the public the result could have been a publicity disaster for NASA, and might have resulted in calls for more stringent (and costly) than necessary sampling and remediation activities. Instead, the public viewed us a trustworthy source, and concurred that there was no public health risk. They did emphasize their desire to be kept informed, but overall they took us at our word that we would do what was necessary to protect them.

Because of this, NASA had the time to do a well developed and thought out characterization, to understand the situation properly and determine a reasonable remediation approach. The overall effort resulted in 2,400 samples over a 1 ½ year period. Regular updates of the results were given throughout that period, including written reports sent to all of the affected property owners.

In short, the pattern of isolated elevated pockets of Cs-137 continued down the length of the brook. Given an average concentration for the samples of 55.5 Bq/g, however, and a dose analysis that demonstrates less than 1 mrem/year additional above background to a resident living along the brook from the contamination NASA has been able to prove its initial judgment that no public health risk exists. Even so, in the summer of 2010 NASA conducted an ALARA cleanup effort in the brook, using a bucket and shovel brigade to dig up the few isolated elevated spots. This was in keeping with commitments made throughout the project to protect the safety of the public and the environment.

4.7 The Trust Bank

Think of this example as taking a withdrawal from the "trust bank". The trick is, you have to have made deposits in advance through early and consistent efforts to establish and maintain your openness and credibility. If you only communicate when there is already an issue it's too late, and you may be dealing with an angry and cynical public. If NASA had not earned the public's trust the result in this case might have been calls for more sampling and clean up than was actually needed. The financial cost may have been many times what was spent for our outreach efforts. The cost of damage to NASA's reputation may have been even higher.

5. SUMMARY

The NASA PBRF decommissioning project is nearing completion. While taking longer and costing more than originally estimated it has met its primary goals of protecting the safety of the public, the environment, and the workers. Nearly 1.9 million man hours have been worked with only 2 minor lost time accidents. Total worker dose has been 0.33 person Sv compared with the estimate in the D-Plan of 0.69 person Sv. There have been no detectable releases to the environment. The effective use of aggressive decontamination of concrete and piping and the assaying of soil were keys to reaching a secondary goal of minimizing radiological waste production. Finally, the proactive use of risk communications to earn public trust was an effort that helped NASA through some major challenges.

REFERENCE

[1]. Peecook, K.M., "An Overview of the Plum Brook Reactor Facility Decommissioning – Facilities", Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities, September 11-14, 2011, Toronto, Canada.