The Faustian Bargain

Environmental scientist Peter Strauss' notes for his talk at the Tri-Valley CAREs "State of Superfund" Cleanup Meeting 9/18/2014 in Livermore, CA

I probably don't need to describe the environmental toll from nuclear weapons development to this audience. It comes about from what I call a "Faustian Bargain" that the U.S made in the late 1930's and 1940's when it decided to pursue the development of a nuclear weapon. Faust was a mythical character that sold his soul to the devil in return for worldly goods and power.

In 1939, physicist Niels Bohr expressed deep doubt that a nuclear bomb could be made "unless you turn the United States into one huge factory". Others had provided similar warnings: warning Congress and the President of the possibility of vast expanses of land becoming sacrifice areas.

During the Second World War and the ensuing Cold War, the United States created a massive industrial complex to produce nuclear weapons for national defense: 134 distinct sites in 31 states and 1 territory, with a total area of more than 2 million acres. Weapons production activities at these sites produced large quantities of radioactive and hazardous wastes that resulted in widespread groundwater and soil contamination.

Hundreds of billions of dollars were spent to support nuclear material production, weapons assembly, and nuclear testing.

Most obvious are sites areas such as the Nevada Test Site, the Hanford Reservation and Rocky Flats. These areas are nearly uninhabitable; and must <u>be essentially guarded forever.</u>

Notwithstanding the moral dilemma weapons development poses, there is another problem that comes to fore. We have largely allowed the same people and agency that developed the nuclear weapons to safeguard the contamination left in place.

Not until 1970, did the US first become seriously involved in establishing a foundation of environmental protection, and not until 1980 did it embark upon assigning responsibility for cleaning up past contamination. This, too, was largely left in the hands of those who had created the problem; except that state and federal environmental regulators were brought in to look after the cleanup process.

However grateful I am for allowing these regulators a certain amount of oversight, I think it is incumbent upon communities near the contaminated lands to take a long-term view of the problems and be involved in the agencies' decision making. This responsibility not only lies with us who have grown up in the nuclear world, but it must be passed to generations to come.

So with this view in mind, Tri-Valley CAREs has asked me to prepare an annual review on the state of Superfund for the two contaminated sites that are the responsibility of the Lawrence Livermore National Laboratory (LLNL). Both are named to the National Priorities List, a list of the most contaminated sites in the nation. Being named to this list is no honor: and they are called Superfund sites.

These sites, what we call the Main Site, in Livermore, and Site 300, the testing facility east of Livermore and west of Tracy, are described in the handout (report).

Those two facilities dealt with the research, design and testing of nuclear components and have contaminated the air, drinking water and soil with a soup of chemical and radioactive contaminants. Chemicals include chlorinated volatile organic compounds, such as TCE and PCE (solvents); high explosive compounds; PCBs; and various metals. Radioactive substances that have escaped from both normal and abnormal events include plutonium, tritium and depleted uranium.

<u>I'll describe some of the near-term challenges we now face in cleanup</u>.

At the **<u>Main Site</u>**, the Lab has been operating soil and groundwater treatment facilities designed to contain and remove contaminant mass for 20 plus years. Releases of contaminants were mainly due inadequate procedures and failed mechanisms that were supposed to prevent releases, as well as accidental releases and just plain careless operations.

The Lab and its environmental staff have used a process known as pump and treat as the primary method of cleanup. That is, you pump contaminated groundwater to the surface, treat the water at the surface by removing the contaminants, and discharge the relatively clean water back to the environment.

At present, we face two new problems that has made cleanup more difficult, and potentially more expensive.

<u>The first is the problem of mixed waste – that is radioactive waste combined with chemical waste.</u> The Lab has radioactive tritium in the groundwater at the same location as chemicals. It was thought that they could keep the tritium in the ground while removing the chemicals, but they have been unable to do so. Instead, they have brought both radioactive tritium and chemicals to the surface, absorbed onto activated carbon – creating a mixed waste. Although relatively low-level, disposal costs are very expensive. For LLNL, rough estimates are somewhere between $6 -10 million.

The Lab prepared a feasibility study to address options for dealing with this problem, but left this in draft because of the experiments described in the second issue.

The second problem at the Main Site is a function of diminishing returns. After 20 years of active remediation under the Superfund law, the Lab has been able to remove much of the easily accessible contaminants. Now, because contaminants are more difficult to access, pump and treat is not very cost effective. Appropriately, the Lab's environmental staff has embarked on trying different approaches to get these hard to access chemicals cleaned up.

One approach is through injecting zero-valent iron, most commonly in the form of iron filings. These break the bonds of the chlorinated solvents and turn them into harmless products. Another is through enhancing the biological agents that break down the chlorinated solvents. Providing the bacteria with food so that a community can flourish in the subsurface does this. If there are not enough bacteria present in the subsurface to form a viable community, bacteria are augmented by bacteria that are grown in the laboratory. This is known as bioaugmentation.

A third technology is thermal heating of the subsurface that makes these contaminants more mobile and easier to capture. Each of these methods has been successfully tested at sites across the country. There is one very big problem. Because of dense soil and clay it is increasingly difficult to get the injected material into contact with the bacteria, and the contaminant it is targeting.

The Lab is testing an approach called pneumatic fracturing to enhance the injected substance's ability to reach its target. The pneumatic fracturing process involves injection of highly pressurized air into consolidated soils to create a network of fissures and channels. This fracture network is filled with sand or guar gum to hold it open.   So far, tests have been shallow, and away from structures and subsurface infrastructure. On one occasion, because a nearby well was not properly completed (the casing was not properly cemented to the surrounding soil), the sand and guar mixture came out of the well.

Although not as controversial as the "fracking" used for by industry to extract gas, there are some concerns, including: Damaging underground infrastructure, damaging foundations (and the sensitive structures and equipment in buildings), and spreading the contaminants in places that are undesirable. (Fracture propagation is still being studied.) Lastly there is some concern about fracturing close to the numerous earthquake faults in this area.

While Tri-Valley CAREs encourages experimentation of the new technologies, the Lab has put off completing the mixed waste issue until these experiments are complete. There is no timetable for completion and we think that these two issues should have a timetable and resolution.

At **Site 300** we are concentrating on two pressing issues:

The first is remediation of an open-air firing table (Building 812).

Site 300 was selected in part because of its complex geology and topography: it was thought to be a good location to conduct open-air tests because the steep canyons would contain many of the by-products of the explosions. But as you can imagine, cleaning these hillsides is a difficult and costly. Cleanup is starting at one of the last open-air firing tables that had been used often to detonate weapons experiments with Uranium-238. The area encompasses about 200 acres in the east-central part of the Site. The firing table is located almost directly over an earthquake fault. The hillsides, canyons and groundwater in this area are contaminated, as is a nearby spring.

In soil samples taken 5 feet below the firing table, total uranium has been measured at a concentration of 22,700 picocuries per gram. For comparison, a DOE report lists the proposed soil cleanup standard for uranium at Building 812 as 3.1 picocuries per gram.

LLNL recently has undertaken an extensive soil survey in the Building 812 area to determine the extent of the Uranium-238 contamination, and a soil and biotic sampling effort to determine the radioactive material's deposition depth and uptake in plants and animals. Grades were so steep that the Lab had to develop/utilize a robot that could take radiation measurements. The sampling has taken a long time, and there are many complications. A proposed remedy with a public hearing is likely to take place in the 2015 – 2016 time frame.

Tri-Valley CAREs supports efforts to better characterize and understand the contamination at the Building 812 area before publishing a proposed cleanup plan. However, we recommend that LLNL hold a public workshop on the Building-812 firing table and the contamination between now and the proposed plan (circa 2016).

The second issue is monitoring the migration of contaminants at the Pit 7 Complex The "Pit 7 Complex" of unlined dumpsites has leaked uranium, tritium (radioactive hydrogen) and other contaminants into the groundwater at high concentrations. A remedy has been selected at that area, but the remedy allows most of contaminants to be left in place, with others (e.g., uranium) being removed from groundwater. Tritium is being allowed to naturally decay, hopefully before it reaches the site boundary. A series of drains and other engineered features have been installed to prevent rainwater from entering the pits and further dispersing the pollutants. Continued vigilance is needed to ensure that the remedy works as intended and that the pollutants do not continue to leach into the groundwater and/or migrate further.

Let us take questions, and then turn this over to Marylia Kelley to discuss how the community can get involved and stay involved.

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