Attachment 4:

Affidavit of

Affidavit for

Who resides at:

Given on January 10, 2007

I went to work at site in 1966 to 1994. I started out as a Laborer, but eventually became a Labor Foreman. I primarily dug ditches around drilling rigs, buried butane and electrical lines, picked up trash from the drilling process, delivered drinking water, dug holes under the compressors and did whatever else that needed to be done to support the drillers. If there was a post-shot done on a test you can bet I was there. Even though I was a foreman I would be on location right next to my men.

The first several years I worked out at NTS they didn't have dosimeters, so who knows what my radiation levels were then. We just had film badges. I can't remember the exact date we finally got the dosimeters.

Some time in 1967 or so we were working on a post shot in Area 3. We had to hand shovel contaminated mud into 55 gallon drums. When the mud got hard enough we had to go the drilling sump and shovel it out into 55 gallon drums and then pour calseal on top and then put the metal lid on the drums. We only wore coveralls, rubber boots, gloves but nothing over the mouth or the nose.

In Area 18 they used visbestos, which was a mud additive. They told us all we needed was a paper mask to work around it. At the portable mud plant they would cut the sacks of the visbestos and put it in as a mud additive. We would take the empty sacks of visbestos and put it into a trash bin and stomp it down to make it efficiently packed. Leftover visbestos would be flying around in the air everywhere, and all we had for protection was a paper face respirator. My coworker (Teamster Foreman) and I were up there once stomping down the bags and we got covered in the stuff all over. I asked the guy in charge of the mud plant, if it was ok for us to wear only the paper masks and he said it was, but it just didn't seem right.

I was up at CP 6 (Control Point 6) when Baneberry went off late in December 1970. We were up there waiting for them to open up Area 3. When we finally went down the hill to Area 3 we could see the venting coming up. I saw a cloud of stuff coming out of where the detonation was. I didn't know if it was dirt or radiation. I was told not to change my work clothes because they wanted to make sure Baneberry wasn't leaking radiation. I can't remember how much time passed until we were finally told to evacuate Area 3 because Baneberry had in fact vented and was leaking radiation.

In about 1993 and 1994 when post-shot holes needed to be plugged I had to go in and clean out the holes with the Radsafe people. Radsafe would check to make sure the area was safe with no radiation. Once they gave the ok, I would go to the post shot cellar with a laborer to help him take out timbers, rope, wire cable, drill bits, etc. Radsafe would claim that the materials were ok to be around, but when the drilling personnel (operating engineers) would go back to the cellar to do a plug back they would wear anti-contamination clothes. They were wearing protective clothing, but when I was there I only had my coveralls on and I was told that was enough. This kind of thing happened all of the time.

What really gets me is that there were no recorded doses (internal or external) for any of the years I was there. Everything is zeroes. My NIOSH dose reconstruction report dated June 10, 2005 doesn't include me being at Baneberry. During my telephone interview (CATI) I was asked if I had been involved in any radiological accidents—I said no. At the time of the interview I didn't know Baneberry was considered to be a "radiological accident" so I didn't mention it. After getting denied I asked NIOSH for a copy of my full administrative record and sure enough there was a document in the file that showed me being at Baneberry (attached to this affidavit).

Just recently, I learned that NIOSH "assumes" in its site profile that I would volunteer to the interviewer during the CATI if I were in one of 8 particular vented tests which occurred since January 1, 1963 out of the hundreds of underground tests while I was employed. The NIOSH interviewer never asked me about these 8 tests, so I didn't tell him I was in it. It turns out the NIOSH site profile does not provide any methods for estimating internal or external radiation dose from the Baneberry test or any of the other 8 vented tests. So now I am left to wonder how can NIOSH can complete my dose reconstruction if they do not have methods for any of these 8 tests, including

Baneberry. If there is no way to estimate this dose, then my claim should have either been "pended" or NIOSH should have initiated an SEC Petition under 42 CFR 83.14. If my dose reconstruction omits a key vented release, how many others also have this basic omission? Given that 6 years have passed since EEOICPA was enacted and there is still no published method for estimating dose for workers Baneberry or any of these other vented tests, it is not "feasible" to estimate dose with sufficient accuracy.

I have read the above affidavit consisting of 3 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Name of Affiant

Executed on January 10, 2007, at the ~~Lloyd D. George Federal Building, 333 Las Vegas Boulevard South, Suite 8016,~~ Clark County Legal Services, Program 800 S. Eighth St., Las Vegas, Nevada 89101.

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC

STATE OF NEVADA)
COUNTY OF CLARK)

On January 10, 2007, before me, the undersigned Notary Public, personally appeared , personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that he executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

NOTARY PUBLIC
STATE OF NEVADA
County of Clark
A. ROSA NAJERA
No: 99-36092-01
My Appointment Expires April 7, 2007

A. Rosa Najera
Notary Public Signature

A. ROSA NAJERA
Notary Public Name

Attachment 5:

Affidavit of

Affidavit for

Who resides at:

Given on January 16, 2007

I worked at the Nevada Test Site as a Driller, Drill Supervisor and Project Manager of Drilling for REECo from from 1962 through 1991.

From 1962 until approximately 1965, myself and other drilling personnel smoked, ate food, and drank coffee and water on rig floors while sampling and drilling on post shot operations.

While Post Shot drilling on the Boyles Angle rig from 1963 to 1965, containment was nonexistent on the drill hole, casing, or drill pipe. It wasn't unusual while side wall sampling, for steam, rocks, and debris from Ground Zero (GZ), where we were taking samples, to come back up through the drill pipe and shoot in the air twenty to thirty feet. This would happen on just about every drill back. We drilled many holes without containment at this time.

From 1965 until I retired, the containment equipment became very sophisticated and was much more efficient. The Post Shot holes were drilled to retrieve radioactive samples from the cavity after a nuclear device had been detonated. After detonation, a rig was moved on location and a hole was drilled into GZ. With the drilling assembly in this area, a plug was pulled out of the assembly and a side wall sampler was lowered inside the drill pipe and out the side of the drilling assembly and into the wall of the drill hole. A tube at the bottom of the sampler collected a sample from the drill hole and was retrieved to the surface on a wire line. These samples were taken from the bottom of the cavity as soon after the shot as possible and therefore were highly radioactive. The drilling operation, collecting samples, and handling the drilling assemblies and drill pipe had a potential for workers to be exposed to radiation. I was involved in most of Post Shot drilling for LASL and some LANL post shot holes until my retirement in 1991.

I worked from 1962 through 1964 in tunnels and shafts as a Rotary Drill Operator (Union Classification). After a nuclear detonation in G Tunnel, I moved a core rig inside the tunnel near GZ and drilled through the sandstone formation towards GZ. The humidity and temperature was extreme. I believe we were approximately 100 feet from GZ. I worked three or four 8-hour shifts at that location.

I lived 7 days a week in Area 12 from June 8, 1962 through November 1962. From November 1962 through 1964, I lived in Area 12 but left the site on my days off. Furthermore, as a superintendent, I often lived on the drill-back site from the start of post-shot until completion of the drill-back, a period of time lasting between 3 days to 2 weeks. 24 hours a day was spent at the drill-back site, eating, sleeping, and working. This was common practice for all post-shot superintendents.

In 1963 or 1964.while drilling on a post shot hole in Area 3, my crew of three, a mechanic, a Rad Safe employee, and I were exposed to radiation. While performing work on the containment equipment in the cellar, we were contaminated. There was an inquiry with the REECo, Rad Safe, LASL, and DOE officials, questioning each of us separately to determine how we were contaminated. The investigation showed that the Rad Safe employee had been exposed to an equal amount of radiation as my crew and me. Because the Rad Safe employee's job was to stop us from going into a contaminated area, this proves that the Rad Safe employee either read the Geiger counter wrong or the Geiger counter had malfunctioned.

Some time after this incident, I can't remember how long after, the five of us who were exposed to radiation were instructed to report for testing on a Saturday in Las Vegas (I can't remember if the Rad Safe technician went with us or not). We were inspected one by one in a railroad car parked on a Spur by Nellis AFB. I was monitored and tested, in this very dark interior. I have no idea what tests they performed or what their results were. Aside from the men I was with, I have never talked to anyone who knew about this railroad car.

In approximately 1965-67 we used visbestos to make the drilling fluid for Post Shot holes. The drilling fluid resulted from the mixture of bentonite (clay), visbestos, and water. This drilling fluid was used on Post Shot holes to combat the very high temperatures encountered while drilling into GZ. At times this was mixed on location with a portable mud plant. The visbestos was in dry 50 lbs sacks and dumped by hand into hoppers, mixed with bentonite and water and pumped down holes as drilling fluid. When you poured the sacks of visbestos the powder would fly everywhere. Also, when using the fluid, the drill crews would come in contact with the visbestos mixture. The visbestos was mixed on location with a portable mud plant and also at the permanent mud plant.

I was on a drill back (post shot) in Area 7 the morning Baneberry vented in 1970. I saw the cloud and realized it had vented and we would be evacuated. I gathered up my paperwork and headed over to Mercury with the rest of my crew. A few hours later my crew and I were sent home.

I have read the above affidavit consisting of 3 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Executed on Jan 16, 2007, at Mesquite, Nevada.

Name of Affiant

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC
STATE OF NEVADA)
COUNTY OF CLARK)

On 1-16-, 2007, before me, the undersigned Notary Public, personally appeared personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that he executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

Notary Public - State of Nevada
County of Clark
DONNA R. PEAVY
My Appointment Expires
No: 04-92153-1 October 12, 2008

Donna R. Peavy
Notary Public Signature

DONNA R. Peavy
Notary Public Name

Attachment 6:

Affidavit of

Affidavit for

Who resides at:

Given on January 10, 2006

I worked for REECo at the Nevada Test Site from 1985 to 1989. I was a foreman/pipe-fitter/welder in Area 6. Area 6 was support for all areas on the test site, including the Tonopah test range. I have been in nearly every place in the test site. We floated in different areas when manpower was needed, or on reentry on tunnels or fixing air tool's lines. I remember working Areas 3, 5, 12, 19, 20, 22, 25, 26, 27, the original and the new Defense Assembly Facility (DAF) and the Tonopah Test Range. My supervisors were /and I worked in N Tunnel for General Foreman (he died of cancer), in P Tunnel for General Foreman (he also died of cancer) and I was the General Forman for X-Tunnel.

When I started work at the NTS working for REECo, I was issued a TLD badge. The first day I was welding in Area 6, the welding sparks damaged the badge so badly I was issued another badge the next day I had to go up to CP Hill to get a replacement badge. I can't remember the name of the person who told me, but I was told, don't damage the badge again or you can work someplace else. I asked what the big deal was and I was told it takes a lot of paper work and they didn't want to do it again. They would get angry if the badge was damaged, so I was told not to damage the badge and put it someplace safe so it would not get damaged again. From my second day of work on you will see that there are a small number of instances of dosimeter damage because I never wore a badge while welding. My superiors often told to put it in my truck, so I put it on the truck dash, in the lunch room, in my lunchbox, and a very small number of times in my back pocket in my wallet. That's why you will see "badge damaged" in my file and then the rest of my employment badges showed zero because I was told to put it away when welding, and that was all the time. All zeros because I was trying to keep my job. I was not the only one who was told to not to wear their TLD. Pretty much everyone I worked with was told not to wear a badge when welding so the sparks wouldn't damage it. Some guys would even put it in their tool buckets. It was practically protocol not to wear your badge when welding and they still have not solved the problem by getting badges that would not burn during welding to this day.

In Area 5 while working on the spill test project in the dry lake bed, badges were left in a lunch trailer or truck as usual. The Area had already been tested on so all of the dust blown by the wind that we breathed was crapped up with radiation from the previous tests. They shot X-Rays of the welds over here, and most of the time I was closer to the welds than the Holmes and Narver technician doing the shooting. I was present at 6000 to 7000 weld shots. That's a lot of dose with no monitoring. With all of the shots that were done, the safety practices were not what they should have been. We should have been in cold spots but often we working within an unsafe distance of the source to just get our job done.

In Area 25, I worked in X-Tunnel where they blew up M-1 Russian tanks with nuclear warheads shot into the tunnel. We put in the sprinkler systems and monitoring equipment. We went in the tunnel to more work that was needed without any monitoring. Again, I was told I was told to keep TLD badges outside and not damage it, so I put it in my lunch box or lunch trailer or truck my coworkers pretty much did the same. The Area was covered with camouflage nets so the satellites from above couldn't take pictures of what we were doing. Even if you felt sick from the explosion, you couldn't go out because of satellite flying over. If a satellite was over you had to stay under the net right by the tunnel portal because we weren't supposed to be seen. For four weeks after the shots and we were in their heavy. There was a mechanic that went into one of the tanks and got deathly ill. He came back just four days later. I can't remember his name but he was out of the Operator's Local. He was the only one that had left but the rest of stayed around even though we didn't feel all that great either. I had a sore throat and my lungs hurt, but the job went on.

I worked up on top of the mesa above N-Tunnel providing support for driller's water and mud lines. When they would drill a vent shaft and they vented the tunnel after a shot, the crapped up dirt and Freon would come up through the vent and radiate the drill rigs. The drill rigs had to be sent to Area 6 for decon and we were right there next to the drill rigs where the mud line and water lines were that we were in support of. The mud and water lines were crapped up with radiation and we would unhook them to move them on to the next project. Again no monitoring.

When a vent was drilled into T-Tunnel, the area around the drill rig got crapped up with radiation a lot. Badges were not worn again; same old thing just like in N-Tunnel, it was kept in the truck.

N and P Tunnel have contaminated water drainage coming out of them. They have a waste pond in Area 12 that catches the crapped up water. We had to put control devices that monitor the flow of water into the pond without protective clothing and no monitoring from Radsafe or anything. All we had on were leather boots and Levi's. If it got too bad I would just throw my clothes away because I didn't want to take it home to my family.

In Area 6, The Butler Building (decon) was inside, so you dressed down to go in (put on coveralls, booties, a hair net, and gloves) and self wanded when you left, but no badge was worn. It did not make a difference if the wand went off a little bit there was no body there from Radsafe to check you anyway. In my dose reconstruction report they said I had never dressed down. In my telephone interview they asked me if I was involved in any incidents. I said yes, when I was outside of the Butler Building. They asked if I had to wand or dress down out there and I said no. There were no written reports, because I was told to just go do my job. The interviewer never asked me if I had to dress down or wand to go into the building and they ended up doing my dose recon without taking into account all of the times I had to dress down! I always had to dress down to go into the Butler Building.

I also had to dressed down periodically in N-Tunnel, P-Tunnel, X-Tunnel and many times in other places in the field where a trailer was set up. They didn't account for that either in my dose reconstruction. They also don't list the white lead paint in N-Tunnel that they painted on the walls and the roof. We used to have to "walk fast" by it because it was so hot. I don't understand why we didn't have to dress down to go in there, but I just shut up and did my job.

When working outside of the Butler Building, my supervisors told me there was no need to dress down. So I never dressed down, but the crapped up toxic water still flowed in the pipes and on the ground outside of the building. Just because it was on the outside of the building doesn't change that it was crapped up with radiation. I was pissed and asked if the radiation got clean or if it was still "crapped up" when it goes outside of building. It is not like it automatically cleaned itself when it went from inside the building to the outside. I was told to do my job or find another place I would be happier working and if I wasn't sure about the safety, I needed to work someplace else. Again, I left my badge in the truck. It was a very bad Area with no control or monitoring. We never had to wand yourself outside of the building, only when you went in.

I have read the above affidavit consisting of 4 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

____
Name of Affiant

Executed on January 10, 2007, at the Lloyd D. George Federal Building, 333 Las Vegas Boulevard South, Suite 8016, Las Vegas, Nevada 89101.

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC
STATE OF NEVADA)
COUNTY OF CLARK)

On Jan 10th, 2007, before me, the undersigned Notary Public, personally appeared Mr. , personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that he executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

NOTARY PUBLIC
STATE OF NEVADA
County of Clark
DONNA A. LIEBMAN
No: 02-78700-1
My Appointment Expires Sept. 10, 2010

Donna A Liebman
Notary Public Signature

Donna A Liebman
Notary Public Name

Attachment 7:

Affidavit of

Affidavit for

Who resides at:

Given on January 29, 2007

I was hired in 1961 with Federal Services, Inc. In 1965 the contract was awarded to Wackenhut Services Inc. I worked with them until 1986 when I retired.

I was the union representing the officers for ten of my twenty-five years at NTS. I know first hand the fights we had trying to keep our members safe. I knew each one individually. Our force at the high point was about 315 persons.

Starting in about 1962 or 1963 when they started underground testing we would go into areas with big signs along the Mercury highway that said "Wind rows contain alpha contamination, Do Not Disturb." Well REECo would cut through the wind rows with road graders and bulldozers to clear an area for the drill rig and after they got the hole drilled they would clear an area for the cable and the trailers. This always kicked up dust. REECo Health and Safety people were supposed to come and water this dust down, but most of the time they would not come. We stood on the perimeter station, the dog station as we called it, to check the traffic to see if they had business in the area. The cars would also kick up the dust because it was a dirt road. Union members and I used to fight with REECo Health and Safety on a daily basis so we could get a water truck to stop the dust. It was pretty much a daily fight to get water and even after complaining about 50% of the time we could not get the water. For just one test you would be out for a month or two getting ready for the test.

Security was the last to leave all tunnel tests with the arming party. We were the first to reenter tunnels with the reentry teams (sometimes in full radix equipment) to protect classified materials. Reentry teams consisted of security, Rad Safe, miners, and laboratory personnel. When core samples were required, security was the first and last on scene with the samples under our control. The drillers would handle the samples but we would escort them to a compound. Security had to control the compound.

I was contaminated several times from blowouts. Once I was sent to CP2 (Control Point 2) Rad Safe to shower I don't remember when this happened, but it was early on, it had to be back in 1962 or early 1963. They took all my clothes: underwear, socks, pants, shirt, jacket, shoes, badge and hat. I took a shower but the radiation alarm sounded when I tried to leave. I had to take six showers before the alarm did not go off. They decontaminated my shoes, badge and gave me a new pair of coveralls to wear.

One time in Area 7 there was a shot that blew out, I can't remember the year, but I remember having to sweep the area because it hadn't been evacuated. I was in Area 3 about where the road goes to the Tweezer Facility and I saw a truck out in the field. I drove out to help and found out it was a Sergeant. I helped him dig his truck out and ended up getting mine stuck. He just told me to grab my weapon and go with him because we needed to get out of there. We came up to Station

300, which was a muster station, and they had lunches waiting for us there. I ate lunch and then went up to CP (Control Point) to be checked by Rad Safe and found out I was hotter then a fire cracker. The collar on my B-15 flight jacket I had on was so hot they took the jacket away.

We had a security station on the Tweezer compound with a guard station that was directly across the road from Plutonium Valley. The guard station had no monitors and when you worked there you had no special clothing. So when the wind blew from the direction of Plutonium Valley it blew right across where we were at. So the whole time they were doing the Tweezer tests security would have been exposed to the contaminated dust.

I worked in Area 25 and 26 on the Rover and Pluto Nuclear engines for rockets and airplanes when a NRDS reactor blew up. We secured the area while Rad Safe picked up radioactive graphite with tweezers and Geiger counters. The reactor that blew out was the one for the rocket engine that they were doing in Test Cell A if I remember correctly.

When Baneberry blew out they had a security officer, up there right near the edge on the Area 12 side. He was so hot that Rad Safe and Lieutenant would not let him move—he had to stay where he was right where the contamination was. About 19 or 20 other security officers were sent down somewhere near UNLV, maybe DRI, to be tested. Three of them were and

I was a Union officer so I knew all of this was going on.

The last three years I worked at NTS I had to go in to do a full body scan. A man that I know was before me and a man that I know was behind me and they were not called back. This happened all three times. I asked them what was going on the second and third times this happened and the lady insisted it was just a malfunction. This seems really odd that I would have a malfunction three years in a row.

I have read the above affidavit consisting of 4 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Executed on January 29, 2007, at Las Vegas, Nevada.

____
Name of Affiant

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC

STATE OF NEVADA)
COUNTY OF CLARK)

On Jan 29th, 2007, before me, the undersigned Notary Public, personally appeared personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that he executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

Notary Public - State of Nevada
County of Clark
SILVINA G. GIMENEZ
My Appointment Expires
No: 01-67269-1 May 3, 2009

Silvina
Notary Public Signature

Silvina Giménez
Notary Public Name

Attachment 8:

Email correspondence from regarding SC&As findings on the NTS Site Profile, dated February 23, 2006.

Rozner, Kathleen (Reid)

From:

Sent: Thursday, February 23, 2006 1:30 PM

To: Rozner, Kathleen (Reid)

Subject: S.C. & A. Findings

Attachments: Kathleen Rozner.doc

Kathleen: Attached are some comments on the S.C. & A Findings. Hope this helps. Any questions give me a call.

To: Kathleen M. Rozner
Regional Representative for
U.S. Senator Harry Reid

February 22, 2006

Re: S.C & A. Findings

Kathleen:

Per your request I have looked over the summary of findings and have managed to skim through a large portion of the full S.C.& A. report. A major problem with both the NIOSH ad S.C. & A. materials is that the events took place so many years ago that for them to try to accurately second guess what happened 40 or 50 years ago is not possible. A soldier or worker receiving an exposure in say 1955 would probably be 70 years or more old today. Remembering exactly where he was and what his exposure conditions were is very likely not possible. Even for regular NTS workers in the 1960s or1970s the same thing is true. Many of the Sandy Cohen comments, while technically correct, would likely add little improvement to the accuracy of the dose reconstruction but would require a lot more effort and time to address them. In my personal opinion, I seriously doubt that the dose reconstruction efforts will improve to any significant degree the existing dose values. They will, however, require a lot of effort, time, and money. It might be appropriate as a research effort but not as a way of determining whether cancer stricken patients get compensation. I believe that the money would be better spent on the remaining claimants who by now must be disappearing pretty fast. We are dealing with statistics on : 1. what dose it takes to produce a given effect on a given size individual, 2. what the accuracy of the particular measuring instruments might have been , 3. what the variability in time and space of the radionuclides producing the dose might have been, etc. When all the dose reconstruction is done there will still be a large plus or minus uncertainty on that dose. If the reconstructors do their job honestly it's still a large uncertainty. That uncertainty will never be reduced to zero. At some point someone has to decide whether you pay if the uncertainty is 10% but not 20% or 100%. As I mentioned the other day, I believe the VA has paid claims in the past on the assumption that a small dose may not have been large enough to cause the cancer but could have triggered a pre-existing condition. In other words its not the size of the dose but the fact that there was a dose.

With regard to the specific findings:

Finding 1. Radionuclide lists were classified for many years. The testing laboratories frequently had materials like unusual metals placed in the bombs that would be neutron activated by the bomb neutrons from the explosion. This could yield new or uncommon radionuclides beyond the ordinary fission and activation products. This would be of value in things like isotope production in the Plowshare program or in tracking and identifying debris.

Finding 2. The rocket propulsion test distributed hot, large particles out to some distance across the test site. Dose from these particles may have been important to more than just reentry personnel. Reentry personnel should have been suited up with masks and gloves.

Without seeing the assumptions in the TBD or the S.C.& A. I'm not sure why they consider G.I. tract and skin to be particularly important. I'm also not sure why they believe the doses would be dominated by large particles in the reentry area.

Finding 3. They seem to be assuming that reentry personnel are not suited up or masked. Since reentry teams were normally equipped with protective gear, it's not clear how they would be receiving internal exposures from inhalation. Internal exposures may have been more important for downwind workers elsewhere on the test site where they may have received exposure during plume passage.

Finding 4. See Finding 3 above.

Finding 5. I haven't seen the TBDs so I can't comment.

Finding 6. See Finding 5 above. No matter whether the dose reconstructor uses resuspension or dust loading the calculated dose is only a guess because of the number of variables. For instance, where was the worker with respect to the contaminated area, what was the wind speed and how was it changing, what was the wind direction and how was it changing, what was the soil type and composition, what was the distribution of radionuclides on the surface of the soil and with depth, what was the particle size distribution of the contamination and the soil moisture, was the surface desert pavement or disturbed surface, etc.

Finding 7. See Finding 5 above. For cases where the claimant wore film or TLD badges, the reported badge dose probably can not be improved for external exposures.

Finding 8. Radon exposure in tunnels is probably a trivial issue. It's a problem in uranium mines because of the radon production from uranium ore in the tunnel. Usually you keep it from being a problem with good ventilation. On tunnel reentries at NTS there might be a problem with noble gases, methane, or tritium but they tried to manage these problems with supplied air masks on reentry and with good ventilation otherwise. Where possible, tunnels were ventilated and the exhausted air filtered with activated charcoal before reentry. During normal mining and emplacement operations tunnels were well ventilated. Not sure why the concern over Gravel Gerties at NTS. My recollection says we built a few to use for safety tests. They were used for weapons storage facilities at some installations. The theory was that if you had an accidental detonation in the Gertie that the fission products would be scoured as the explosion tried to vent through the gravel, thereby minimizing offsite contamination. The NTS safety tests in the Gerties were to try and verify that theory. Basically they were gravel piles with a storage hole in the middle. As a gravel pile they should have been extremely porous to a gas like radon and there should not have been much radon buildup. Furthermore I don't recall them being used for weapons storage at NTS. Worker occupancy should have been very and probably limited to placing the bomb in it for the safety test.

Finding 9. Not having seen the description of the tests they're discussing, I'm not sure of the basis for the statement. Usually this is a fairly simple test and accuracy should be good.

Finding 10. The iodine/thyroid problem in the offsite areas was not really recognized as a major problem until near the end of atmospheric testing. Even in the offsite, the problem usually arises when someone drinks contaminated milk or eats contaminated food. I'm not sure that there is much iodine data for either monitored or non-monitored workers except perhaps for tunnel workers.

Finding 11. I would agree that this pathway as well as the Finding 10 pathway should be addressed in the TBDs but I doubt that the available information will be of much value in individual dose reconstruction.

Finding 12. See Finding 5 above. It may be true that assigning dose to workers on the basis of film or TLD badges may not capture some small increment of internal dose but the real question is whether that internal dose is large enough to add significantly to the worker's total exposure. In almost all NTS cases it probably does not.
Finding 13. Again see Finding 5 above. Fission product beta/gamma ratios as a function of time were developed very early in the testing program. Survey meter open window measurements have many problems, including the detector window composition and thickness, source to detector distance, time postshot, etc. I'm not sure why the authors feel neutron exposure is a problem, particularly after cessation of nuclear testing. The neutron dose from an explosion decreases more rapidly as a function of distance than does the prompt gamma dose. In other words if you're far enough from the explosion to have a safe occupational dose from the gamma flux you should have an even lower dose from the neutron flux. Neutron exposure may have been non-zero but was probably still a small portion of the prompt gamma dose for soldiers in early atmospheric testing who were located relatively close to the explosions. One would have to examine the yields, distances, soldier orientation toward the blast, shielding such as trenches, etc.
Finding 14. I'm not sure why medical exposures are an issue. My recollection says that regulations said medical exposures were not to be considered part of the occupational exposure. As medical exposures, I don't think they were ever (and I think are still not) considered part of the occupational exposure (and were not to be recorded or treated as such).

I hope this helps. If you have any questions please give me a call.

Attachment 9:

Anspaugh, Lynn. The Resuspension Pathway for Nevada Test Site Workers. Sanford Cohen & Associates. October 8, 2006 (Revision 3)

THE RESUSPENSION PATHWAY FOR NEVADA TEST SITE WORKERS

Lynn R. Anspaugh
SC&A
October 8, 2006 (Revision 3)

INTRODUCTION

I have been asked to review part of the Technical Basis Document (Rollins 2004) for the Nevada Test Site (NTSTBD). The NTSTBD is intended to provide the technical background and to present most of the procedures to be used to reconstruct doses to workers at the Nevada Test Site from 1951 through the present time. Such doses are being reconstructed in order to determine whether workers who have filed a claim have experienced a radiation dose sufficiently high to be eligible for compensation under the terms of the Energy Employees Occupational Illness Compensation Program Act (EEOICPA). The general intent of the dose-reconstruction procedures is to error, if necessary, in favor of the claimant, if there are uncertainties related to the dose reconstruction. All dose-reconstruction activities are being overseen and audited by members of the Advisory Board on Radiation and Worker Health (ABRWH), who are appointed by the President. The ABRWH has hired SC&A to assist in this process.

My assignment, within a larger review being carried out by other scientists from SC&A, was to examine how the intake of radionuclides by inhalation of resuspended radionuclides was treated within the NTSTBD, and whether such treatment might be judged to be claimant favorable or not. My judgment, for which the details are given below, is that the calculated inhalation of resuspended radionuclides can be grossly in error—and that this error could sometimes be claimant favorable, but under some conditions could be seriously unfavorable to the claimant. This issue was raised initially in the SC&A review (Makhijani 2005) of the NTSTBD and is amplified within the present report.

In general, it is very difficult to reconstruct doses to workers at the NTS, notably for some situations and some time periods. This has been acknowledged by the staff members of the National Institute of Occupational Safety and Health (NIOSH) in their evaluation report (Harrison-Maples et al. 2006), which recommended establishment of a Special Exposure Cohort (SEC) for "...Employees of the DOE or DOE contractors or subcontractors who were monitored or should have been monitored at the Nevada Test Site (NTS) for a number of work days aggregating at least 250 work days during the period from January 27, 1951, through December 31, 1962." This recommendation was based upon a conclusion that it was not feasible to reconstruct internal dose with sufficient accuracy for this class of employees; the final determination of this SEC became effective on July 26, 2006 (Howard 2006). NIOSH is still committed to perform dose reconstructions for persons who worked at the NTS for time periods beyond 1962—the testing of nuclear weapons at the NTS did not stop until 1992. This paper addresses resuspension issues in the 1951–1962 period, and this information should be useful for a future report from SC&A to address health-endangerment issues for employees who worked less than 250 days during that period. This report also covers resuspension issues from 1963 onward for workers not included in the SEC. This latter aspect is part of the resolution process following a critical review from SC&A (Makhijani 2005) on the NIOSH NTSTBD; this comment-resolution process is being undertaken by a Working Group, chaired by Robert Presley, of the ABRWH

One of the reasons that it is difficult to perform dose reconstructions is that the NTS was an outdoor and underground experimental laboratory. Many one-of-a-kind experiments were carried out under a variety of conditions. It was not unusual for these experiments to go awry. For example, some "safety shots," which were not supposed to have a nuclear yield did have small nuclear yields. Other tests were duds (in keeping with one-of-a-kind experiments) and resulted in less than planned nuclear yields, which produced contamination with not only fission products, but also unburned fissile materials. Over the years a total of 1021 detonations in 928 tests occurred at the NTS, of which 100 were atmospheric (DOE 2000).

In addition to the detonations of nuclear weapons, there were 31 tests of nuclear rocket engines (Hicks 1981i) and five tests of nuclear ramjets (Hicks 1981i). The nuclear ramjets were responsible for relatively minor releases [the largest was 680 Ci at release time plus 12 hours (H+12 h)], whereas the largest release from a nuclear ramjet was 240,000 Ci for the Phoebus-1B test on February 23, 1967 (Hicks 1981i).

Another unique feature of the NTS is that it is geographically huge—more than 1300 square miles—and it contains many areas contaminated with substantial amounts of radioactive materials. Many, if not most, of these areas were not actively controlled beyond the period of active experimentation. In addition to the NTS itself, adjacent areas of the Nellis Air Force Range (NAFR) were used for one "safety experiment" in 1957 and four "storage-transportation" experiments in 1963 (DOE 2000). These resulted in the dispersal of substantial amounts of plutonium (Friesen 1992).

Another set of four "safety experiments" took place in 1956 in Area 11. These tests resulted in the dispersal of substantial amounts of plutonium and uranium; the last test did result in a small nuclear yield, or an "unplanned criticality." The plutonium-contaminated sites in Area 11 cover nearly 5,000,000 m^2 (Friesen 1992). Other sources of plutonium on the NTS were so the so-called "hydrodynamic shots," which were non-nuclear and were designed to study the behavior of plutonium under conditions of explosive compression. In the GMX part of Area 5, 24 such experiments were carried out in 1954–1956, and these resulted in the contamination of about 125,000 m^2 (Friesen 1992).

Finally, mention should be made of the Plowshare experiments conducted at the NTS. The more spectacular of these were shots to produce craters with the ultimate goal to "dig" a new sea-level Panama Canal. These shots continued after the Limited Test Ban Treaty was signed in 1963 and were permitted, if the radioactive debris did not cross international boundaries. The last such test was Project Schooner on December 8, 1968. This test produced a much larger fallout cloud than expected, and debris was detected as far away as Finland (Anspaugh 1992); that was the end of the Plowshare cratering program.

Over the years there have been several programs to study the inventory and distribution of radionuclides on and off of the NTS. The earlier studies were focused on plutonium, and substantial efforts were made to determine the distribution and inventory of plutonium on the NTS and on the NAFR (Friesen 1992). Later efforts in the Radionuclide Inventory and Distribution Program (RIDP) were designed to develop an inventory and distribution of all man-made radionuclides in surface soil throughout the NTS (McArthur and Kordas 1983, 1985; McArthur and Mead 1987, 1988, 1989; McArthur 1989). The depositions of plutonium and ^{137}Cs were also evaluated in offsite soils in the NTS environs (Bliss and Jakubowski 1975) and throughout Nevada, Utah, Arizona, New Mexico and parts of Colorado, Wyoming, Idaho, Oregon, and California (McArthur and Miller 1989).

No efforts were made to contain fallout from the early tests at the NTS. The first tests were air drops, but it was preferred that explosions take place on towers (and later suspended from balloons) so that better diagnostics could be performed on device performance. Various detectors and measuring devices were placed around tests and rapid re-entry was typically made following the event in order to retrieve those measurement devices, some of which contained short-lived activation products as a result of radiations from the tests. This era ended on November 1, 1958, with a voluntary moratorium on testing. The moratorium was broken by the former Soviet Union on September 1, 1961, and testing resumed at NTS the same month. However, the NTS tests were either designed to be contained or were special effects tests or Plowshare related. Nevertheless, many tests produced unexpected ventings of varying magnitude. Schoengold et al. (1996) have published the recorded releases from tests after the moratorium was broken in September 1961. They report that 433 tests had effluent releases, and that effluents from 52 of these tests were designated as having had "off-site releases." Some of the larger unplanned releases are listed in Table 1. Because most of the radionuclides produced

Table 1. Some of the larger (>100,000 Ci at 12 hours after denotation) unplanned releases from tests conducted at the NTS after the moratorium on testing was broken in September 1961. From Hicks (1981i).

Event	Date	Release, Ci at H+12
Antler	Sep 15, 1961	2.1 10^{5}
Platte	Apr 14, 1962	1.9 10^{6}
Eel	May 19, 1962	1.9 10^{6}
Des Moines	Jun 13, 1962	1.1 10^{7}
Bandicoot	Oct 19, 1962	3.0 10^{6}
Pike	Mar 13, 1964	1.2 10^{5}
Parrott	Dec 16, 1964	2.3 10^{5}
Red Hot	Mar 5, 1966	1.0 10^{6}
Pin Stripe	Apr 25, 1966	2.2 10^{5}
Double Play	Jun 15, 1966	6.0 10^{5}
Door Mist	Aug 31, 1967	4.0 10^{5}
Hupmobile	Jan 18, 1968	1.2 10^{5}
Mint Leaf	May 5, 1970	4.0 10^{5}
Baneberry	Dec 18, 1970	6.7 $\cdot 10^{6}$

in a nuclear explosion have short half lives, it is standard practice to specify amounts at a time 12 hours after an event; this is typically noted as H+12. Baneberry produced a particularly difficult situation as the contamination was widespread and the effluent contaminated personnel who were in Area 12 at the time of the test.

The next sections of this report will consider how the NIOSH team is calculating resuspension for the NTS, as indicated in the NTSTBD (Rollins 2004), and then why I believe this procedure cannot be justified. (It is my understanding that NIOSH may be in the process of revising this procedure, so these comments apply only to the published procedure.)

METHOD USED BY THE NIOSH TEAM TO CALCULATE INTAKE VIA RESUSPENSION AT THE NTS

The method used by NIOSH to calculate dose from the inhalation of resuspended radionuclides on the NTS is given in chapter 4 of Rollins (2004). The method is very straightforward. First, estimates of the amounts of man-made radionuclides in surface soil at the NTS were based upon the results of the RIDP (McArthur and Kordas 1983, 1985; Kordas and Mead 1987, 1988, 1989; McArthur 1991). Inventory estimates by NTS Area were taken from table 5 of McArthur (1991) and are given in table 2-8 of Rollins (2004). Table 2-8 of Rollins contains one additional column, which is the geographic area within each "Area" that was actually surveyed or for which inventory values were inferred; these values are taken from McArthur's table A-2. The inventory value was then divided by the inventoried area to receive a value of deposition density (Bq m^{-2}). Such values are reported in Rollins' table 4.2.2-1.

The derived values of deposition density were then multiplied by a resuspension factor of $1.3 \quad 10^{-9}$ m^{-1}, which was stated to be the value from the time-dependent resuspension model of Anspaugh et al. (2002) at three years, to give values of concentration in air (Bq m^{-3}). Then, the assumption was made that an energy worker would inhale an average 2400 m^3 y^{-1}, and the result of the calculation is the annual intake (Bq) of radionuclides for an employee in a particular Area. The annual intake values for nine radionuclides are given in Rollins' table 4.2.2-2.

The data in Rollins' table 4.2.2-2 are suggested for situations when the employee worked outdoors within a given Area (or Areas) of the NTS. The values for the nine radionuclides in table 4.2.2-2 were averaged by Rollins, and the suggestion was made that such average values should be used if the employee's exact locations are not known. These average-intake values (averages of the areas within Areas, as described above) are given in Rollins' table 4.2.2-3. Also shown in table 4.2.2-3 are values of "Maximum intake;" these are the maximum values from table 4.2.2-2, but they have been multiplied by a factor of 10. No advice is given in Rollins on when or how these maximum values should be used.

In discussing uncertainty Rollins (2004) considers the time-dependent nature of the resuspension factor, and makes the statement that, "In addition, a claimant-favorable factor of 10 has been applied to the resuspension factor to minimize the likelihood that airborne concentrations would be underestimated." For the Area-specific values of intake shown in table 4.2.2-2 and the average intake values shown in table 4.2.2-3, this statement is not true. The statement is true only for the maximum-intake values, but no information is given on how such values might be used in a dose reconstruction.

Another interesting comment in Rollins (2004) is that, "Because the vast majority of radionuclides in surface soils were deposited as a result of atmospheric testing that stopped in 1962,...." This statement is not correct. Except for the radioisotopes of europium, all of the maximum values are associated with Area 30, and the only test conducted there was Buggy, a five-shot row-cratering event that took place on March 12, 1968. Many of the next higher values are associated with Area 20, and the only shots that occurred there were the cratering experiments Cabriolet on January 26, 1968, and Schooner on December 8, 1968. In terms of the largest amount of total activity, it appears that the champion was another cratering experiment in Area 10, the Sedan shot on July 6, 1962.

PROBLEMS WITH THE NIOSH METHOD OF CALCULATING INTAKE OF RADIONUCLIDES VIA RESUSPENSION

There are numerous problems with the method given in Rollins (2004) for calculating the intake via inhalation of resuspended radionuclides. These problems fall into three areas: the definition of the "source term" for resuspendible radionuclides, the method of calculating resuspension once the source term is defined, and the association of a person with the source term. The more serious is the issue of the source term.

Resuspension source term

Rollins (2004) depends entirely for the resuspension source term upon the results of the RIDP as summarized in McArthur (1991). The goal of the RIDP was to determine within a factor of two the distribution and inventory of man-made radionuclides in surface soil of the NTS. The values of radionuclide inventory given in McArthur (1991) are calculated to a common date of January 1, 1990. The goal of the RIDP was not to provide information for dose reconstruction, although the data can clearly be used for that purpose given that critical consideration is given to time dependencies of the source terms. A major issue with the Rollins source term is that it is assumed that the values measured and reported in McArthur (1991) were constant throughout the entire period from January 1951 through the current time. This assumption would be more appropriate for an environmental impact statement concerning future use of the NTS, but it is entirely inappropriate for dose-reconstruction purposes.

The list of the nine radionuclides included in Rollins (2004) is given in the upper half of Table 2 along with the values for their half lives. The first problem with the Rollins source term is immediately obvious: The half lives of several of these radionuclides are short compared to the period of interest. Therefore, assuming that these nine radionuclides were, in fact, the only important ones, half-life corrections must be made. For example, if the ^{155}Eu had been created in January 1951, the content at that time would have been about 300 times larger than it was in January 1990.

Table 2. Radionuclides for which Rollins (2004) calculated intakes from inhalation or resuspended material, and additional radionuclides for which inventories were reported by the RIDP (McArthur and Kordas 1983, 1985; McArthur and Mead 1987, 1988, 1989; McArthur 1991).

Radionuclide	Half life[a], years
Radionuclides for which inhalation via resuspension is calculated in Rollins.	
^{60}Co	5.27
^{90}Sr	28.90
^{137}Cs	30.03
^{152}Eu[b]	13.506
^{154}Eu[b]	8.590
^{155}Eu	4.753
^{238}Pu	87.7
^{239}Pu	24110
^{240}Pu	6561
^{241}Am	432.2
Radionuclides reported by the RIDP, which were not used by Rollins.	
^{54}Mn	0.855
^{106}Ru	1.023
^{101}Rh	3.3
^{102m}Rh	2.9
^{110m}Ag	0.684
^{125}Sb	2.7586
^{134}Cs	2.0652
^{133}Ba	10.52
^{144}Ce	0.780
^{174}Lu	3.31

[a] Values from Tuli (2005).
[b] Soil-activation product.

Another problem in the Rollins (2004) approach is the neglect of other radionuclides reported in the RIDP documents. These additional radionuclides are listed in the lower part of Table 2. These all have short half lives; if we correct the values back to their time of creation the relative importance of the short-lived radionuclides would be much greater.

The greatest problem of all is that the Rollins approach does not consider the many more radionuclides that were present at the time the fallout field was created. This type of reconstruction can only be done with proper use of the Hicks tables (1981a,b,c,d,e,f,g,h,i, 1982, 1984, 1990), which are reconstructions of the amounts of all device-related radionuclides present at time of creation up through 50 y after each event. Values are given for every atmospheric event, for cratering shots, for vents, and for tests of nuclear rockets and nuclear ramjet engines.

If, for example, we wanted to reconstruct the device-related radionuclide inventory 21 hours after the Sedan event, we can consult pages B-3 through B-7 of Hicks (1981h). Values are given for a total of 175 fission and activation products, but not including radionuclides of plutonium and americium. The key to being able to use Hicks (1981h) is that we have a measured value for ^{137}Cs. The amounts of the other 174 radionuclides can be computed by comparison to the time-corrected value for ^{137}Cs. However, the Hicks tables were derived for reconstructing radiation doses to off-site residents, and corrections were made for the observation that downwind concentrations of airborne radionuclides were enriched in volatile elements. This effect of enrichment was calculated by actually dropping a fraction of the refractory elements out of the source term. This dropped fraction of refractory elements would be expected to be on the NTS. For Sedan, the fraction of refractory elements present was 0.4; therefore for use in dose reconstruction for NTS workers the amounts of refractory elements [identified in Hicks (1982)] would have to be multiplied by four [$(1 + 0.6) \div 0.4$]. It may turn out that most of these radionuclides will not be of significant importance, but it is important that this be demonstrated. Some of the more prominent radionuclides at H+21 hours are indicated in Table 3 (but without the correction for refractory elements noted above). The radionuclide ^{137}Cs is shown for comparison, although it is not significant (in a relative sense) at 21 hours.

It should be noted that the Hicks tables do not contain values for ^{152}Eu and ^{154}Eu, as these radionuclides are not device related. These radionuclides are created through activation of ^{151}Eu and ^{153}Eu (Lederer and Shirley 1978), which are present in soil. Another isotope of europium, ^{155}Eu, is both a fission product and the result of activation of ^{154}Sm (followed by the decay of ^{155}Sm) in soil. Values for ^{155}Eu are given in Hicks' tables, but for purposes of dose reconstruction for persons on site, the values indicated in Hicks should be augmented to account for soil activation.

In many real situations a comparative pathway analysis can be helpful. For most radionuclides the external gamma-exposure pathway is more limiting than is resuspension (Anspaugh and Daniels 1996). Thus, if a person was wearing an external gamma dosimeter, it is possible to relate that measurement to limits on the amount of intake via resuspension. This is not true for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am, so possible exposure of NTS workers to plutonium and americium deposits can be critical and should be considered carefully.

Finally, there is one more problem with the definition of the source term as given in Rollins (2004). This is that no consideration has been made of clean ups between the times of the source deposition and the time of the RIDP. Clean ups have been an ongoing activity from the very early days of the NTS, so it is not reasonable to assume that the source term in 1990 represents that to which a person might have been exposed during an earlier time. McArthur and Mead (1989) specifically mention that much of the Nuclear Rocket Development Station in Area 25 had been cleaned up before the RIDP measurements were started in February 1984.

Table 3. Device-related radionuclides of relatively greater prominence at 21 hours after the Sedan event. The first eight radionuclides are activation products. The remainder are fission products.

Radionuclide	Half life[a]	Calculated deposition density,[b] µCi m^{-2} at H+21 h
^{24}Na	14.951 h	0.133
^{181}W	121.2 d	2.68
^{185}W	75.1 d	6.15
^{187}W	23.72 h	58.7
^{198}Au[c]	2.6956 d	0.185
^{203}Pb[c]	51.92 h	0.273
^{237}U[c]	6.75 d	0.170
^{239}Np	2.356 d	0.478
^{91}Sr	9.63 h	0.962
^{92}Y	3.54 h	0.310
^{93}Y	10.18 h	0.659
^{97}Zr	16.744 h	0.888
^{99}Mo	2.7489 d	0.527
^{99m}Tc	6.0058 h	0.448
^{103}Ru	39.26 d	0.124
^{105}Ru	4.44 h	0.803
^{105}Rh	35.36 h	1.89
^{109}Pd	13.7012 h	0.403
^{111m}Pd	5.5 h	0.122
^{112}Pd	21.03 h	0.197
^{112}Ag	3.130 h	0.228
^{121}Sn	27.03 h	0.121
^{127}Sb	3.85 d	0.129
^{128}Sb	9.01 h	0.140
^{129}Sb	4.40 h	0.259
^{131m}Te	30 h	0.202
^{131}I	8.02070 d	0.386
^{132}Te	3.204 d	0.931
^{132}I	2.295 h	0.962
^{133}I	20.8 h	2.99
^{135}I	6.57 h	1.72
^{137}Cs	30.03 y	0.000427
^{140}Ba	12.752 d	0.227
^{141}La	3.92 h	0.344
^{143}Ce	33.039 h	0.583
^{145}Pr	5.984 h	0.324
^{149}Pm	53.08 h	0.147
^{151}Pm	28.40 h	0.131

[a] Values from Tuli (2005).
[b] Values from Hicks (1981h), normalized to an external gamma-exposure rate of 1 mR h^{-1} at H+12 h.
[c] Stated by Hicks (1981h) to be estimates.

Resuspension model

As mentioned above, it can be quite inappropriate to use a single value of a resuspension factor with the accompanying assumption that the source term had been laid down more than three years previously. Thus, a worker in early 1951 would not have been exposed to any resuspended material, but a worker in Area 20 near the Schooner crater in late 1968 could have been exposed to very high levels of resuspended material.

Resuspension cannot be reconstructed accurately without knowledge of when a worker was on the NTS and where on the site s/he was. A worker who never left Mercury would not be exposed to any significant amount of resuspended material, whereas a person in Area 11 in 1956 could have been exposed to substantial amounts of resuspended plutonium. However, such a worker might well have been provided with respiratory and other protection, and these details must be considered as well.

I would prefer that a time-dependent resuspension-factor model be used to model resuspension for a source within two years of its having been deposited. This can be complicated, as some areas have had depositions from multiple events.

For times beyond two years it is my opinion that a mass-loading model is more credible. And it is necessary to consider whether the resuspension is occurring due to normal, undisturbed conditions, or whether it is due to soil disturbances, such as vehicle traffic.

Association of a person with the source term

The only way that a person can be exposed to resuspended material is if s/he is present or near a source of resuspendible radionuclides. Thus, it is critical to associate a person with a source of interest in both space and time. It appears that this would require substantially more time and effort than is currently being devoted to this topic. Given the present method of calculating exposure to resuspended radionuclides, the doses could be vastly overestimated or vastly underestimated. The current method can be very biased against a claimant; the two examples given above (Schooner in Area 20 in late 1968 and Plutonium Valley in Area 11 (in 1956) illustrate this. Of course, further information is also required in order to evaluate the effectiveness of respiratory protection.

One of the comments made in Rollins (2004) was that the resuspension pathway would not apply to workers in tunnels. This is not true. The main tunnel areas were used typically for many more than just one shot. In some (most?) cases there were some failures in the containment of the shots fired in drifts off the main tunnel. This resulted in a potential exposure to resuspended radioactive materials in the tunnels. The RIDP did not have the goal of defining radionuclide levels inside the tunnels. However, McArthur and Mead (1989) reported a number of areas with contaminated soil near the tunnel portals, which further supports the concept that the tunnels contained elevated levels of radionuclides. These enhanced values near the tunnels were not used in the final results reported in McArthur (1991) and used by Rollins (2004).

Blast-wave or shock-wave effects.

This is a combination of the two items directly above. A nuclear explosion is a violent event, and its first effect is a shock wave. This wave can be propagated through air and/or the ground (a bunker buster works through the destructive nature of the shock wave). It has been stated that winds of hundreds of miles per hour can be associated with the shock wave. This creates a special, localized source of resuspended material. Concern for shock-wave related effects on military personnel participating in NTS tests has been discussed extensively in NAS/NRC (2003). It is highly likely that civilian radiation monitors from the NTS would have been with the military personnel participating in such tests.

This issue has not been considered in Rollins (2004). Brady [in attachment 5 of Makhijani 2005)] also draws attention to shock waves as being important sources of resuspended material for persons within the vicinity of recent tests.

OTHER COMMENTS

Although I was not tasked to provide a complete review of Rollins (2004), I did read the entire document. The following are a few observations noted in passing.

Lack of consideration of the incidental ingestion of soil

I was quite surprised that there was no consideration of the incidental ingestion of soil, as this is a well-known pathway. For a typical mixture of NTS radionuclides at late time periods Anspaugh and Daniels (1996) identified soil ingestion as the critical pathway for $^{90}Sr/^{90}Y$.

List of radionuclides to be considered

I trust it is obvious from the above that the lists of radionuclides considered in Rollins (2004) are quite incomplete. The Hicks tables should be used, but with the corrections and additions noted above.

Unplanned criticality

The site description does mention an unplanned criticality, but the staff of NIOSH seems to be informing the members of the Advisory Board that such unplanned criticalities never occurred (ABRWH 2006). They did; and so did unplanned incomplete criticalities. In the NTS example (the fourth shot of Project 56) the unplanned criticality did not result in exposure of personnel to neutrons. Rather, a team rushed to the device to retrieve measurement devices, and they were exposed to external gamma exposure from the unexpected presence of fresh fission products. The main point, as made in attachment 4 of Makhijani (2005), is that episodic exposures did occur at the NTS. There were surprises with one-of-a-kind experiments; such surprises did not happen often and became less frequent with time.

"Natural plutonium" in soils in Nevada and Utah

The site description indicates that, "...the natural plutonium in Nevada and Utah soils comes from worldwide fallout." This is clearly not true. See Bliss and Jakubowski (1975) and McArthur and Miller (1989). Also, the term "natural plutonium" is quite peculiar.

Greatest surface disturbances from air-dropped weapons

The statement is made that, "The greatest disturbances typically occurred when an air-dropped weapon penetrated the ground surface to a shallow depth (about 15 m [50 ft.]) before detonation." To the best of my knowledge no such test ever occurred at the NTS. The NIOSH should provide a definitive reference for this (not an environmental impact statement) or delete the comment.

Project 57 was not Double Tracks

Project 57 and Double Tracks were two separate tests that occurred six years apart.

The description of the problem with Baneberry is faulty

The implication is given that the "containment structure" failed. I believe the conventional wisdom is that the vent occurred through ground faults.

There are major discrepancies concerning the number of vents, seeps, etc.

I refer Rollins and others to Schoengold et al. (1996), which was published by the Nevada Operations Office. As mentioned above, they state that 433 tests had effluent releases with effluents from 52 tests being detected offsite.

Error in Equation 4.1

Eq (4-1) is slightly incorrect. The value corresponding to the 95th percentile is 1.645, not 1.65585.

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Attachment 10:

Affidavit of

Affidavit for

Who resides at:

My late husband, was a systems test engineer for radiation effects for Lockheed's Nuclear Weapons Effects Group. He worked at the Nevada Test Site from /64 through /64 at the Nuclear Rocket Development Station and from 1967 through /1968. His SS # is

Attached to this affidavit is a letter that wrote to our family doctor on July 5, 1989, which described an accident at the Nevada Test Site and stated why he believed it caused his cancer. I can attest that he wrote and signed the attached letter, Attachment (1). The original was sent to Dr. who no longer practices medicine in California, so I was unable to get you a copy of the original document.

The description of the incident which is in the letter reminds me of the phone call that made to me after problems developed during a test. I was living in Sunnyvale, California, and was anxious for the project to end so that could come home for more than weekends. He never talked about his work except to tell me that once a big test was concluded his work on the project would be done. He was dejected and angry when he called to say that the test was completed but there had been big problems. Things had not gone as planned. I remember trying to be light hearted and saying something like, "You mean after all that work and time away from home, you can't even say that things went well?" He did not appreciate my attempt at humor. He said that there had been some particles released that had gotten into his protective clothing. Then he stopped himself from saying more except to assure me that he was fine, that I shouldn't worry and that they had gotten at least some of the information they had sought. He never spoke of the incident again until the later stages of his illness.

A summary of the Request for Personnel Exposure records under the Energy Employees Occupational Illness Compensation which was prepared by Martha DeMarre, Health Physicist, DOE Nevada Operations Office dated 7/23/03 regarding my husband's radiation exposure history at the Nevada Test Site indicates that the following was provided to NIOSH: External Dosimetry Records (Provided), Internal Dosimetry Records (Does not exist), Diagnostic Dose Records (Not readily available), Incident Investigation Reports (Does not exist) and Other Monitoring Results (Provided). A copy of this data availability document is attached as Attachment (2)

Attachment (3) contains a document stating there are "no internal dosimetry data, bioassay data or whole body counts" for my husband.

Attachment (4) states: "There are no records of any investigations or incidents for this individual" (referring to my husband).

NIOSH has admitted, as part of the audit of the Site Profile for the NTS, that it lacks beta monitoring data, internal dosimetry monitoring or neutron monitoring during the time vas employed at the Nevada Test Site between 1964-1967.

NIOSH has not demonstrated that it can estimate a bounding dose estimate for plutonium, as it does not know the solubility of the plutonium. It cannot bound the dose estimate for other internally deposited radionuclides, as NIOSH has conceded to the Advisory Board on Radiation and Worker Health that it does not have a published method for internal dose at the NTS prior to 1967 in its site profile. NIOSH lacks neutron dose monitoring for my husband's employment at the Rocket Development Station. Despite the lack of a published method for estimating internal dose prior to 1967, or neutron dose data for 1964, NIOSH sought to complete a dose reconstruction for Proceeding to conduct dose reconstruction under these circumstances also raises questions about the adequacy of NIOSH's quality control.

I have read the above affidavit consisting of 2 pages, including this one, and the four attachments to this affidavit. The information contained therein is true and accurate to the best of my knowledge and belief.

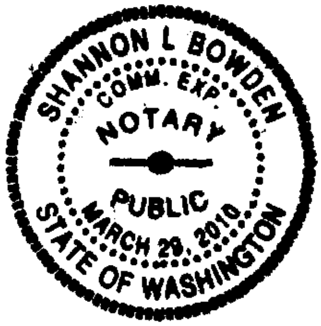
Executed on January 18, 2007, at Richland, Washington.

Name of Affiant

CERTIFICATE OF ACKNOWLEDGMENT OF NOTARY PUBLIC
STATE OF WASHINGTON)
COUNTY OF BENTON)

On January 18, 2007, before me, the undersigned Notary Public, personally appeare personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that she executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal,



Shannon L Bowden
Notary Public Signature

Shannon L. Bowden
Notary Public Name

Attachment # 1 (a)

5 July 1989

Subject: Occupational Injury or Illness

Dear Dr.

This is the letter you requested explaining an exposure I had to airborne plutonium particles.

Please find enclosed the California form on the subject with my redlined input for your consideration. My thanks to for sending it so promptly.

As our family doctor, you have been aware of my lymphoma since its discovery with Dr. first biopsy back in 1979. But, until now, I have not mentioned to you that I'd been exposed to airborne plutonium particles, as I didn't see the connection between that exposure and the disease. I suppose I've also been more occupied with working toward a cure than looking for the cause. As a nuclear engineer, I've often wondered about such a connection. I have discussed the possibility with others (friends, family, and other professionals) but, though often encouraged to pursue it, I was too busy earning a living and fighting the disease.

I've recently become personally convinced (primarily from press reports of radiation induced cancers) that the plutonium exposure led to the lymphoma and hence the enclosure.

As to the exposure incident, I recall the following: I was about 2 years out of college with a physics degree when I went to work for Lockheed as an engineer and "test conductor" in the Nuclear Weapons Effects group. We installed test items and instrumentation for an underground nuclear test that was conducted at the Nevada Test site during 1967-68. Some hours after the detonation, we were told that a Los Alamos researcher had erred in placing a plutonium sample in the test and that oversight personnel had overlooked it too. When the weapon detonated, that sample vaporized into atomic-sized particles that contaminated the test tunnel and its atmosphere. One of my tasks was to lead a reentry crew back into the tunnel to quickly recover our test specimens so that any effects could be assessed in the laboratory. This was planned as a fairly routine and "clean" task, but the unexpected plutonium contamination was severe. As a consequence, we "suited up" for the reentry. This included double cloth overalls, boots, lots of tape, and a breathing apparatus. It was very hot in the tunnel. The work was physically difficult and significantly complicated by the

Attachment #1 (b)

heavy bulky "suits". The result was lots of perspiration and labored movements that led to leakage of the breathing apparatus. It slipped about and often banged against things in the dark, debris filled, and partially caved-in tunnel. I know there was leakage, because a chemical was placed in the tunnel to make us aware of leakage (you got a strong banana odor when your breathing apparatus leaked). We tried to stop the leaks, but they were so frequent that it was impractical and the health physics persons who helped us to "suit up" were too far from the actual work site to be of immediate assistance. Anyway, we got the specimens out on time and I think it only took a few days. The airborne plutonium seemed of no special concern at the time. You could not see, taste, or sense it in any way. Today, I realize it was something we should have been a lot more concerned about.

I called Lockheed on 29 June 89 to seek their advice on this matter. Their Mr. confirmed my dates of employment and that Ms. handled their Worker's Comp. She was out, but Ms. who works for Ms. volunteered that "a 10-20 year latency period is normal for such exposures". There must be a pattern of cause/effect that leads to such a conclusion and that further persuades me that it is appropriate to pursue this matter even though more than 20 years have passed since the test. advised me to ask for the "5021" from your office and help complete it by redlining it for you. I also checked with the state of Nevada who said this was a California matter (just as had also thought).

That is about it. I didn't tell you earlier as I didn't see the linkage between the exposure and my cancer. Now, I do. Would you please send me a copy of the "5021" when you complete it and send it out? Thank you.

Sincerely,

Enclosure: Redlined "5021"; one page.

cc: Doctors

Attachment #2

Request for Personnel Exposure
Under the Energy Employees Occupational Illness Compensation

Information Requested

Individual records for each of the following are requested. Please indicate record status in the check boxes below.

External Dosimetry Records:
1) Includes individual readings from TLDs, film badges, neutron dosimeters, pocket ionization chambers, etc. (Summations that report annual dose only are not acceptable.) and 2) The manufacturer and model of equipment used

External Dosimetry Records Status (DOE Response Required):

- [X] Provided
- [ ] Not Readily Available Date Available:____________
- [ ] Does Not Exit

Internal Dosimetry Records:
1) Analytical results from urinalysis, fecal analysis, whole body counts, breath analysis, etc. (Derived quantities such as annual or committed effective dose equivalent or percentage of the maximum permissible body burden not acceptable.) 2) Type of analysis performed (i.e., chemical or spectroscopic analysis), and 3) Chemical and physical form of contaminant

Internal Dosimetry Records Status (DOE Response Required):

- [ ] Provided
- [ ] Not Readily Available Date Available:____________
- [X] Does Not Exit

Diagnostic Dose Records:
1) Includes any X-Rays required as condition of employment

Diagnostic Dose Records Status (DOE Response Required):

Not retrieved

- [ ] Provided
- [X] Not Readily Available Date Available:____________
- [ ] Does Not Exit

Incident Investigation Reports:
1)Includes reports related to the investigation of external or internal exposure due to incidents in the workplace

Incident Investigation Reports Status (DOE Response Required:

- [ ] Provided
- [ ] Not Readily Available Date Available:____________
- [X] Does Not Exit

Other monitoring results:
1)Includes analytical results of breathing zone or lapel samples taken (summations such as MPC-hours or DAC-hours are not acceptable) and 2) Whether or not protection factors for respirators are included in exposure determination

Other Monitoring Results Status (DOE Response Required:

- [X] Provided
- [ ] Not Readily Available Date Available:____________
- [ ] Does Not Exit

Department of Energy Representative Signature

Print Name: Darwin Morgan
Agency Address: Department of Energy
National Nuclear Security Administration
Nevada Operations Office
P.O. Box 98518
Las Vegas, NV 89193-8518
Telephone: (702) 295-1755
Signature [signature] Date: 7/23/03

This Form Contains Information Covered by the Privacy Act

OCAS-INT-004 Rev.1 09/26/2002

Attachment #3

SSN:

Internal Dosimetry Statement:

There are no internal dosimetry data, bioassay data or whole-body counts for this individual.

Attachment # 4

SSN:

Investigations Statement:

There are no records of any investigations or incidents for this individual.

Attachment 11:

Affidavit of

Affidavit for

Who resides at:

I worked at the Nevada Test Site as a carpenter's apprentice for REECo off and on from 1966 until 1968. Later in 1968 I came back to the Nevada Test Site to work for REECO as a carpenter and welder off and on until 1970. From of 1970 to 1972, 1973 to 1973, 1974 to 1975, and 1975 to 1976, I worked for REECo as a welder. I was employed by REECo again in 1976 until I left in 1995.

The whole time I worked at NTS I never had a fill body scan or a bioassay. The only urine tests I had were during my annual physicals and these were not associated with radiation exposures.

When I first worked at NTS as a carpenter's apprentice from 1966 to 1968, I worked in Areas 2, 4, 8, 9, and 10, most of which, if not all, were sites of above ground tests prior to 1963. They could put all the yellow rope they wanted to around the contaminated areas but it could not stop the contaminated dust from blowing all over the place. We were constantly breathing contaminated dust.

I first worked underground in the tunnels in Areas 12 and 16 when I returned to NTS late in 1968. Between 1968 and 1976 I worked in every active tunnel in Area 12 (E-Tunnel, G-Tunnel, N-Tunnel, and T-Tunnel) including the last event to be conducted in 16-Tunnel. The first tunnel I worked in was N-Tunnel. I believe there was at least one nuclear test in N-Tunnel prior to my arrival. The supervisors told us not to cross any yellow rope and to stay out of the water that was flowing in the small open ditches that were dug next to the "rib" or side of the drift. These ditches were used to pump the water out of the different drifts, including the drifts where they had previous tests that were contaminated. The water was then pumped from the "portal" or front of the tunnel to settling ponds down away from the work areas. These ponds all had radiation hazard warning signs attached to yellow rope that made a fence all around of the ponds. Every Tunnel I worked used this same system for removing the water from contaminated and non-contaminated areas. They told you to keep away from the contaminated water, but it was almost impossible when you had to work around it every day. The humidity was intense. I always kept my badge in my pocket so it wouldn't get burned when welding. On vertical welds we would wear leather to keep from getting burned. My badge would be under the leather.

In 1970 I was a carpenter/welder working on swing shift at E-Tunnel on December 18 when Baneberry vented. We didn't know it had leaked, so we reported for work on swing shift at the 100 gate (Main gate). The Security Guards told us to report to building 112 for job assignment. When you went to Building 112 they told us to go back home and they would call us back when we could get in to work.

About the middle of   1971 they called me back to work because our tunnel was a priority. They wouldn't let us take our vehicles past the 200 Gate (access to the forward Areas) because of contamination to the forward Areas from Baneberry. We had to get on school type buses in Mercury and ride the buses about 20 miles into Area 1 on Orange Road just past CP-6 to a Rad Safe station. We got out of that bus and went in and suited up in cotton anti-Cs (coveralls), gloves, rubber boots then got on another bus past the Rad Safe station where it was contaminated and rode that bus up to E-Tunnel portal and went underground in to the tunnel. I almost positive that it was E-Tunnel, but it could have been G-Tunnel. We had to keep the anti-Cs on in the tunnel while we worked because when Baneberry vented, the radiation cloud went up into Area 12 and they didn't shut off the tunnel ventilation systems, so it sucked the radiation into the tunnels contaminating them. The steel we were welding on was obviously contaminated like everything else, but they never issued us any masks or respirators. After a week or so, Rad Safe told us (welders) we weren't to be issued the coveralls because at the end of each shift our coveralls were all burned full of holes from welding. From then on it was declared safe and none of us wore the anti-C's, only the clothes we wore everyday to work and took home to our families to be washed! So it seemed management was more concerned about their coveralls than they were about ensuring we did not take contaminated clothes home to our families.

All the tunnels I worked in had had previous nuclear explosions in them except for T-Tunnel because it was brand new at the time I first worked there. The only thing that was contaminated when we first started working at T-Tunnel was the area below where we built a building and yard for the electricians. This area was badly contaminated because I-J-K Tunnels had blown out spewing radiation and debris over ½ - ¾ of a mile distance across a small valley, but Rad Safe had roped off an area that was supposedly ok to be in. T-Tunnel was located about ¼ to ½ mile west of I-J-K Tunnels on the same face of the mountain. We were never required to wear special clothing or face masks in this area.

T-Tunnel was an extremely wet tunnel. I can't recall how much water was pumped out hourly but it was a lot. Much of the tunnel we worked in was like being in a rain forest because the water was constantly dripping off the rock. This ended up causing a big problem when the nuclear device was detonated because of the pressure created by the super-heated steam from the water. I was told by a friend that worked at Holmes & Narver (H&N) that the gas seal door had leaked and almost ruptured. This is the last plug and access door in the main drift. The only thing keeping everything from coming out of the mouth of the tunnel like I-J-K did. Of course everything from the gas seal door back was contaminated. This was all supposedly cleaned up before we went back in to work on the new drift door behind the gas seal door. When we went back into the tunnel we did not wear protective clothing or respirators. The air was humid and we could not avoid the contaminated water in the ditches. For the next event in T-Tunnel, we built a thick plug in the tunnel drift between the gas seal door and the other drifts to help ensure the integrity of the gas seal door. This plug was called the hasty plug. I believe they called it that because it was a last minute decision because they were afraid of a repeat of the first event and that the gas seal door wouldn't hold this time.

Every tunnel we worked in was contaminated to one degree or another, but E-Tunnel was probably the worst. The main drift for the first event there was so contaminated with radiation that they had to abandon it and dig a new drift for it about 300 or 400 feet to the west of the old one. We had to use the bypass and old drift for egress on several occasions. I can't remember exactly how many times but it was at least two or three times. There was a period of approximately three or four weeks we were working back in an area in E-Tunnel where they had previously had a nuclear detonation. We were building bulkheads (concrete forms) that were around 6 to 10 feet. thick and pouring concrete to seal off the crosscuts and bypass drifts that led to the contaminated areas. We were close enough to ground zero that some of the steel sets were deformed and the rough cut 3 x 12 inch wood lagging was burned and charred. The steel sets and lagging are like a half oval that goes from the floor up the rib (side) of the tunnel and over the top to form a wall and ceiling barrier for loose rock. We welded wood and steel braces to the steel sets since they were so stable and then would use these braces to install our kickers to reinforce the concrete forms. All of the steel we were welding was contaminated with radiation from the previous, as was everything else, yet we weren't provided with masks or respirators. Again our badges and dosimeters were in our pockets. During this time period, Rad Safe would change the film in our badges every day because the area was so contaminated. Most of my exposure records came back zeros.

I was working for Foreman, when we welded casks full of D-38 (depleted uranium) and lead in 1987. The dust full of uranium and lead flew everywhere, but we were not required to wear respirators or protective clothing.

I have read the above affidavit consisting of 4 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Executed on January 31, 2007, at Chattaroy, Washington.

Signature of Affiant

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC

STATE OF WASHINGTON)
COUNTY OF SPOKANE)

On 1/31, 2007, before me, the undersigned Notary Public, personally appeared personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that he executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

Notary Public Signature

Pamela A Wise
Notary Public Name

PAMELA A. WISE
NOTARY PUBLIC
COMMISSION EXPIRES 6-6-08
STATE OF WASHINGTON

Attachment 12:

Affidavit of

Affidavit for

Given on January 31, 2007

I worked as a driller at the Nevada Test Site (NTS) for Moran Brothers and Signal Drilling on and off from 1963 to 1967. and were my supervisors at Moran Brothers. 'was my supervisor at Signal Drilling. I was employed by REECo for 10 years between 1969 and 1978—5 years as a miner and 5 years as a core driller. was my supervisor this whole time. In 1980 I returned to the NTS to work for REECo as a driller (operating engineers). In 1981 I was sent to work in what we referred to as Area "49 plus 2" or the "forward area", but is otherwise known as Area 51. I worked out there until I retired in 2004. was my supervisor while I was with REECo.

The whole time I worked at NTS I was issued a film badge, but I did not always wear it. When I was a driller from 1963 to 1967 I never wore my badge while I worked up in Rainier Mesa. We only wore our badges when we went to the job site and then we would put them away in our lunch pails. We would put them back on when we left the job site. We did this because we would get in trouble if they got too dirty or if we lost them and it was easy to get them dirty and lose them with the work that we were doing. The times I did wear my badge I had kept in my pocket. When I was a miner and a core driller from 1969 to 1978 we either covered our badges in plastic, so as not to get them dirty, or we would leave them in our lunch pails.

From 1969 to 1974 I was mining in the tunnels. One time in 1968 in N or E-Tunnel, we were sent in as re-entry workers in order to wash down after a test. We were supposed to read our dosimeters ourselves and get out when we had reached the maximum of 5,000 MR. If I remember correctly we our maximum for a quarter of the year was 5,000 MR. I reach 5,000 MR in about 5 minutes while working in that tunnel. NIOSH only has my dose for the whole year as 0.537 R.

I was on a bus in Area 12 getting ready to go to E or N-Tunnel (I can't remember which one) to work the day that Baneberry vented. While on the bus I saw the explosion, it was big a mushroom cloud. After we saw that it had vented our supervisors took us over to the tunnels. After about 2 hours or so in the tunnel, the supervisors decided we needed to leave because they had shut the fans off while we were in the tunnel. So we were brought back out, loaded us up in buses and taken to Area 12. Then we went up to the Rainier Mesa. From Rainier Mesa we went up toward CP Hill where we were wanded and then sent home in the clothes we wore to work that day.

Starting in 1981 when I worked in Area "49 plus 2" as an operating engineer I had to get special clearance through REECo. From 1981 to 1995 I worked for REECo. In 1995 it changed over to EG&G and then it changed again. I became a Foreman and then General Foreman. From 1981 till I retired I lived in housing located in Area "49 plus 2" about 50% of the time. In the first 5 years I worked there it was about 75% of the time that I would sleep out there. The whole time I worked out there I don't remember ever wearing a dosimeter yet my NIOSH Report of Dose Reconstruction dated March 22, 2006 states that there was dosimetry data for me during this time period. I did wear a Class B respirator when I worked in contaminated pit areas. I worked in areas that were contaminated, but I don't know what they were contaminated with.

I was diagnosed with thyroid cancer for the first time on November 20, 1968 (left side) and then again on December 30, 2002 (right side). I worked on almost every shot between 1963 and 1978 including Baneberry (1970). I was onsite in Area 49 plus 2 from 1981 to 1993 for almost every test including Mighty Oak (1986).

According to the Sanford Cohen and Associates audit on the NIOSH site profile, "from 1963 onwards there were many cratering and underground tests that resulted in the release of 131." The SC&A report (Table 6) documents 33 underground tests which released I-131 after January 1, 1963.

In NIOSH's response to comments by Sanford Cohen and Associates, Gene Rollins states, "There were 10 underground tests that resulted in loss of containment and unanticipated significant atmospheric releases after August of 1963. These are documented in Chapter 2 and in the limitations that precede Chapter 6, Rev. 00. To date, no analysis of radioiodine releases that occurred after 1962 has been performed."

NIOSH has no published method to reconstruct I-131 dose for unmonitored workers after January 1, 1963, and, as a result, it is not feasible to estimate such dose with sufficient accuracy. It is imperative to be able to reconstruct this dose, inasmuch as I-131 is known to cause thyroid cancer.

Since I worked on almost every shot between 1963 and 1978 and I was onsite or in very close proximity (in Area "49 plus 2") to almost every shot between 1981 and 1993, I was involved in tests which vented I-131.

Given the absence of a method for reconstructing I-131 for unmonitored workers, NIOSH cannot reconstruct dose to the thyroid.

I have read the above affidavit consisting of 3 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Executed on 01/31/07, 2007, at Las Vegas, Nevada.

Name of Affiant

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC

STATE OF NEVADA)
COUNTY OF CLARK)

On January 31 2007, before me, the undersigned Notary Public, personally appeared personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that he executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

State of Nevada

Notary Public - State of Nevada
County of Clark
ESPERANZA ANTONIA VIERA
My Appointment Expires
No: 06-103913-1 December 8, 2009

Esperanza Antonia Viera
Notary Public Signature

ESPERANZA ANTONIA VIERA
Notary Public Name

N.T.V.

Attachment 13:

Affidavit of

Affidavit for

Given on January 26, 2007

My father, was driller at the Nevada Test Site from 1962 thru 1970 during the cold war. He often worked over-time and on weekends.

During my father's *employment*, he *was involved in numerous nuclear* tests. These included blasts from Operation Nougat, Plowshare (Sedan) and the Dominic II series.

When I was very little in the early 1960s, I remember my father came home from work and he had little red cheerios on the right side of his face. My brothers and I were saying, "Did you see dad's face? He has cheerios on the side of his face!" Little did we know that they were caused by deadly radiation. He had been vented on earlier that day.

According to my father's supervisor, my dad had been vented on at the mud pumps in Area 3 during a drilling operation after the crater had sunk down. The supervisor called for the medical crew, but they never responded. They sent him home in his contaminated work clothes.

Also according to my father worked in Area 9 on the rig Baker & Taylor. The water they were using was being hauled in from another area and when it was pumped thru the drilling swivel, the swivel leaked and radiated the whole crew. They took the whole crew up to CP hill and washed everybody down and took their clothes. Then next day they took the whole crew to area 400 and ran tests and said everyone was ok. They never said what the RM readings were.

In Niosh's dose reconstruction report for my father dated October, 13, 2005, they have dosimeter readings for him until 1975. He quit the Nevada Test Site on 1970 and he passed away , 1975. He was not employed with the Nevada Test Site during this time. Their records are not correct.

I have read the above affidavit consisting of 2 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Executed on January 29, 2007 in Las Vegas, Nevada

Name of Affiant

CERTIFICATE OF ACKNOWLEDGEMENT OF NOTARY PUBLIC

STATE OF NEVADA)
COUNTY OF CLARK)

On Jan. 29, 2007, before me, the undersigned Notary Public, personally appeared , personally known to me (or proved to me on the basis of satisfactory evidence) to be the person whose name is subscribed to this instrument, and acknowledged that she executed it. I declare under penalty of perjury that the person whose name is subscribed to this instrument appears to be of sound mind and under no duress, fraud or undue influence.

WITNESS my hand and official seal.

Notary Public Signature

Sally M. Barto
Notary Public Name

Notary Public-State of Nevada
COUNTY OF CLARK
SALLY M. BARTO
My appt. Expires JAN. 1, 2009
NO: 01-688-1

Attachment 14:

Statement of

Statement of

Given on January 30, 2007

My father, was employed by REECo as a construction worker at the Nevada Test Site (NTS) from 1960 through 1960. From 1964 to 1964 he worked for REECo as a custodian. From 1964 and 1964 and then again from 1964 to 1969 my father was a construction worker for REECo. My father worked at the Nuclear Rocket Development Station (NRDS) from 1964 to 1966.

I find it very interesting that NIOSH's Report of Dose Reconstruction dated May 27, 2005shows there were no recorded doses (external or internal) for my father during his entire tenure at NTS. This is especially remarkable since he worked at NRDS for three years. In addition, NIOSH erroneously assumes that since there are no records of bioassay monitoring for my father that it is unlikely that he would have been exposed to radiation from internally-deposited radioactive material. Just because he was not given a bioassay test does not mean that he was never internally exposed to radiation. Finally, the fact that my father received chelation therapy while he was working at NTS was brought up in our telephone interview (CATI). NIOSH's Report states, "There is no record of any radiological incidents in the DOE dosimetry record and application of chelation therapy related to an intake of radionuclides would almost assuredly have been extensively documented in his records." Just because they could not find that he had been administered chelation therapy as a result of a radiological accident in his records does not mean that it did not happen.

My mother, , recalls my father's job being extremely secretive. Even though my father would not tell my mother about the work he did at the Nevada Test Site, he could not hide the rashes, vomiting and stomach pain that he brought home with him. One time she remembers him coming home from work and he had large, circular red spots on the middle of his back and he was vomiting. She tried to ask him what was wrong but the top secret silence of NTS kept him from telling her what had happed to him. My father did not start having stomach problems until he started to work at the Nevada Test Site. In April 1964 he was even hospitalized for stomach pain. Considering my father ended up dying from stomach and esophageal cancer, it is no coincidence that his stomach pain started when he worked at NTS.

According to the NIOSH Site Profile Audit done by Sanford Cohen and Associates there are no individual beta doses prior to 1975; there are no neutron dose data until 1966; radiation dosimetry badge dosing is unreliable due to worker misuse; ingestion of large particles due to oro-nasal breathing may increase GI-tract doses to workers who re-entered weapons and reactor testing areas shortly after the tests; the Nuclear Rocket Developmental Station (NRDS), where my father worked, had no method for addressing hot particle doses; and there are gaps in environmental data. It is known, even by the DOE, that the level of monitoring was inconsistent, irregular, and overall untrustworthy.

Therefore, it is not feasible to estimate dose with "sufficient" accuracy.

I have read the above affidavit consisting of 2 pages, including this one. The information contained therein is true and accurate to the best of my knowledge and belief.

Attachment 15:

Statement of

Statement of

Given on January 31, 2007

I was a welder for REECo at the Nevada Test Site (NTS) from 1968 to 1971. I worked for Camay Drilling in Area 19 from 1971. In returned to work for REECo in the Area 12 machine shop until 1973. In 1974 I came back to NTS to work as an Operating Engineer for REECo. I was promoted to , 1974 and remained a until I was terminated due to my poor health in 1992.

When I was first hired on 1968, I was assigned to work at Well 3 which is right below CP hill. vas the Department Manager for Drilling Support, was the Superintendent and was my Foreman. We worked in the casing yard fabricating casing strings of different lengths for each nuclear test hole. We were also on call by radio to support the Drilling Department in all areas of the test site. The majority of the shift was spent chasing drilling rigs, doing different jobs cutting and welding, pouring rope sockets, running casing to rig repair, post shots, plug backs, and whatever else it took to get the job done. Sometimes we worked double shifts or around the clock. We were told we had to work when asked due to National Security—we could not turn down overtime. We were told to not to ask questions and to do our jobs or else we could find a job somewhere else.

I was present at NTS for over 500 nuclear below ground tests including Baneberry, which leaked, and several post slots that leaked as well. I worked in every area of the test site including Area 51, Plutonium Valley, the North Las Vegas Bomb Assembly Building, and in the N and T-Tunnels. The whole time I was there, I never received a whole body count test. I even asked for a whole body count in about 1990 or 1991 right before I left and REECo personnel told me I could not have one. I do not remember ever being given a bioassay (urine or fecal) the whole time I worked at NTS.

From 1968 to 1971 I worked on a lot of plug-backs. We always did plug backs on swing or graveyard shifts because Rad Safe worked during the day. Drilling managers knew that if we did the plug backs during the day when Rad Safe was there we would have to stop working so they could check for radiation. Therefore, we always did plug backs at night so we wouldn't be bothered by Rad Safe. I remember was a Drilling Department Manager back then. Most of the time, I would leave my badge in my truck anyway because I didn't want to damage it. We always got in trouble for damaging our badges so we simply stopped wearing them while we welded. This resulted in a lot of radiation exposure that was never recorded.

After each test, a post shot sample was obtained by drilling into the underground cavity on a 45 degree angle to obtain core samples that were then sent to a laboratory to be analyzed to see if the test was successful. Whenever a drill back was done, we would weld a plate onto the pipe to seal it. Later on, whenever they decided to put off another nuclear test close to the old test location, we would have to "plug back," or pump cement into the old test cavity to prevent it from leaking.

During these plug-backs from 1968 to 1971, I often had to cut the cap off of the pipe. Whenever I cut the cap, the gases from the prior nuclear test always came out of the pipe and I had to breathe the nuclear gases. The gases were contaminated with kryptonite, plutonium, tritium, etc. My co-worker would know all of the names of the gases that would come up on a regular basis. He was the Head Engineer for the Operations Equipment Department in Area 6. After I would cut the cap, Halliburton would pump cement in until the nuclear test cavity under ground was completely filled with cement. Sometimes this would go on for several shifts. At the end of the shift someone from CP (Control Point) would come by and take your film badge and give you a new one. Who knows what they did with the badges, because all you see on my record is the standard once a month badge change, but they took our badges a lot more than once a month. It was during these first few years of working out at NTS (1968-1971) that I first started having health problems—high blood pressure and headaches.

In 1972, my union representative talked me into going back to the test site because they were having a hard time getting people to fill their job requests. I worked for REECo and was assigned to the Area 12 machine shop. was my Foreman. We supported drilling, the tunnels and the whole test site. During this time I was a welder, saw operator, forklift operator, steam cleaner, burning machine operator, and a shop steward for the union, I did what ever needed to be done to support the machine shop operation. A lot of the tunneling and drilling equipment I worked on during this time was contaminated. It should have gone to decon before we worked on it, but most of the time it didn't. In the early 1980s they finally required that everything had to go through decontamination before it could be worked on, but up until that point we had worked on a lot of contaminated equipment. I left this job in 1973.

In 1974, I went back to work for REECO at NTS. was the Department Manager, was the Assistant Manager and was the General Foreman. I worked in the heavy duty repairman shop in Area 6 for who was the Foreman. On 1974, I was promoted to of the casing crew. I was until I was terminated due to my poor health conditions in 1992.

In 1987 we built boxes in Area 6 and hauled them to Area 2 for containment. Rad Safe workers dressed out in yellow coveralls and face masks used forklifts to dump depleted uranium (D-38) and lead into the casks. When they dumped the uranium and lead into the casks dust flew everywhere. We, welders, were right there just a few feet away from the casks with no protective clothing or face masks on. We were told it was safe, yet the Rad Safe workers were all suited up. After they dumped the uranium and lead into the cask we would weld the cask shut. The whole time we worked in this area the wind would blow the contaminated dust from inside the cask all over the place, not to mention whatever else was in dust around Area 2. How will NIOSH account for this dose?

Starting in the late 1970s and continuing until I left in 1991, I worked in drilling support. On a daily basis radiation alarms would go off, but management would tell us to keep working. We were supposed to go to the dog house or get off location if an alarm sounded, but we were always told just to keep on working. The Fenix & Scission employees in charge of the alarms would turn them off, remove the paper from the record graph and then destroy it. Then, they would put a new sheet of paper on the record graph and restart the alarm. I witnessed this on a daily basis after they started using these alarms in the late 1970s. If an alarm went off during a day shift, someone from CP Dosemetry would come out and take the film from our badges and give us a new one. These changes in film were not recorded because my records only show the standard once a month badge change when my film was changed a lot more than once a month.

In the 1970s and 1980s I was exposed several times while Holmes and Narver employees x-rayed casing. In the early years, in the casing yard, we would put stiffener rings on the casing to make it stronger so it would not collapse. Holmes & Narver employees were then supposed to x-ray the pipe to make sure it was ok. They were supposed to check with a Geiger counter to make sure the radioactive pellet was completely encased. Then we would put a root weld in and then Holmes & Narver would put a film on it. After that we had to wait for Fenix and Scission to give us the ok to continue working. A lot of time the Homes & Narver employees would set up the x-ray without marking the area as radioactive with ropes or warning lights. I can remember numerous times that I drove up to the casing yard and saw the x-ray set up. Every time this happened I complained. Finally, in the 1980s they started to use a yellow flashing light to notify workers not to come in the area because of the radiation. One time in Area 20 in the 1980s everyone had finished their jobs except for an apprentice, I moved over to help out. The next morning, we found out that the source, or pellet, did not retract and it was exposing us the whole time we were welding which was at least four hours. ɔecame very sick after that incident.

I worked on the M1/A1 Abrams Tank in the 1980s. The whole time I worked on this project, I was exposed to uranium because the shielding on the tank was made of depleted uranium.

In the 1980s I worked in Plutonium Valley when they started experimenting with HazVac trucks. The trucks were supposed to vacuum up the top layer of soil and then take it to Area 5 and bury it. Every time a HazVac truck would run over a sage brush or a piece of metal it would tear it up. Whenever this happened I was called out to fix the truck. Sometimes I would spend days at a time repairing the truck on site. I would be on the ground lying in the contaminated dust getting covered in it and breathing it in. In the 1990s they passed regulations saying you could not go in Plutonium Valley without suiting up. Well I went in there countless times without any protective clothing or respirators. Ingestion and inhalation of plutonium from this kind of work is not accounted for anywhere in the site profile, and represents an intractable problem for purposes of dose estimation.

Attachment 16:

Test Site Workers' Records Dumped Las Vegas Review-Journal (Nevada), September 25, 2006 Monday, B; Pg. 1B, 1303 words, Keith Rogers reviewjournal.com PRINTTHIS

Sep. 25, 2006

Test site workers' records dumped

25 years of data listed tunnel comings, goings

By KEITH ROGERS
REVIEW-JOURNAL

For 25 years, Sandie Medina filed records for Nevada Test Site workers, keeping in cardboard boxes the toxic-materials reports, personnel rosters, weekly safety meetings, accident log books and lists of miners and craftsmen who re-entered a tunnel where nuclear bomb tests were conducted.

In all, 100 green-and-white Xerox boxes that held the records from 1970 to 1995 were stored in an alcove building at the entrance to N Tunnel in Area 12 at the test site.

It was diligent work Medina was proud of because she thought the information would be useful to any of the workers who might later seek compensation for illnesses they believe stem from their jobs at the test site, 65 miles northwest of Las Vegas.

When she last checked in the fall of 1997, Medina said the boxes of records were still in the alcove building.

"But when we went back in February 1998, they were gone," she said Thursday in the hallway of a Las Vegas hotel near where a presidential advisory board had gathered to discuss problems that former test site workers have in proving their compensation claims.

What she found out from a forklift operator who carted off the boxes was that they were taken to a landfill at the test site and buried.

"It really hurts," she said. "It destroyed a lot of information that could be helpful to what we're doing now."

After her job as chief clerk for a test site contractor, she became union project manager for the Southern Nevada Building and Construction Trade Council's test site medical surveillance project. As such, she said, she has seen the result of exposures to radiation and chemicals that many miners and craftsmen endured.

"Now with the job I'm doing, I see my friends sick, funeral after funeral," she said.

In interviews since July, officials with the Department of Energy's National Nuclear Security Administration have denied that any records that would be useful to resolving worker claims under the Labor Department's Energy Employees Occupational Illness Compensation Program were destroyed.

They said many records were kept in duplicate and triplicate forms and are being scanned in a computer database under a cataloguing project with the University of Nevada, Las Vegas.

Ken Hoar, acting assistant manager for safety programs at the test site, said Friday any industrial hygiene record would have been sent to the Safety Department at Mercury and stored in a warehouse for archiving.

Some records might have to be kept for three years or 75 years, for example, based on the government's records retention requirements.

"Is it a record or operational information? If it's a record we should have it," he said.

Documents and reports about site operations that didn't contain information about industrial hygiene or exposure to radiation, or information that didn't deal with health and safety, might have been disposed of, Hoar said.

"That kind of stuff probably ended up in the landfill," he said.

However, Hoar said, if it was a record pertaining to the health and safety of workers, then "the government has been very studious about making sure the records have been managed in a professional manner."

Test site spokesman Darwin Morgan said hundreds of thousands of pages of historical records from 1955 through 1992, including health data reports, radiation personnel listings as well as industrial hygiene logbooks and reports from 1986 to 1990, have been supplied to Dr. Lew Pepper.

Pepper, of Boston University, was selected in 1996 by the Department of Energy to conduct medical screening and surveillance of former test site workers.

Pepper's proposal for independent research was reviewed and recommended by the National Institute of Occupational Safety and Health.

Morgan said Thursday that his agency has maintained "a very defensible and trackable system" of records.

"Our position is there is enough other records ... to establish claims," Morgan said.

Nevertheless in a July interview, Pepper recalled the time in late 1997 when he was making arrangements to check the N Tunnel records that had been kept by Medina.

"I was coming out to review the records, and I was told they were no longer available. We were told they were put in the landfill, accidentally placed in a landfill," he said.

Pepper said he doesn't know for sure what records were hauled to the dump, but the test site's prime contractor at the time did provide him later with 10 years' worth of electronically stored industrial hygiene data.

In telephone conversations last week, Pepper said for the most part he has been pleased with DOE's effort to provide him records.

However, he said, "The absence of data doesn't help us. I think any information can be useful in general to improve the understanding for a group of workers from a particular part of the test site. Better data always helps."

At last week's meeting of the Presidential Advisory Board on Radiation and Worker Health, the chairman of the Nevada Test Site working group, Robert Presley, noted in his report to the board that missing data and employee misuse of radiation detection badges are among the issues that fog the compensation process.

During a break in the meeting Wednesday, he said some exposure and industrial hygiene records are probably missing from throughout the nation's nuclear weapons complex.

"There have been campaigns over the last 40 years that we don't need these records so let's get rid of them. We didn't think we'd need them 30 years later," Presley said. "Yeah, there could have been records that were taken out and dumped."

Sen. Harry Reid, D-Nev., also referred to the plight of former test site workers, many of whom "have already died while waiting for the compensation, stuck in a bureaucratic nightmare of obstruction and delay."

They have been denied compensation "as a result of flawed calculations based on records that are incomplete or in error as well as the use of faulty assumptions and incorrect models," Reid told the board in a videoconference from Washington, D.C.

Medina, former test site miner Oscar Foger and John Funk, a carpenter who installed bulkheads in tunnels, said among faulty assumptions is that the dosimetry records based on film badge readings are accurate.

They noted, too, that working conditions inside the tunnels didn't always meet health and safety standards.

Medina said in some cases dosimetry badges were not worn inside the tunnels or were covered to prevent detection of exposure to radioactive materials.

In other cases, workers who approached the safe limit for exposure over a certain period were told not to come to work or risk losing their access to the tunnels.

"Those are nothing but a joke, because those guys worked in these hot areas and they show zero, zero, zero," Medina said about the dosimetry records. "Then why would they send a guy home for four days?"

Funk wonders why workers would register triple zeros for exposure to radiation when they knew they were entering so-called "hot" areas for radioactivity.

"Guys were laid off because they exceeded their allowable rate, and they still had triple zeroes on their report card," Funk said.

Foger, the miner, said he and co-workers used rags instead of respirators or masks to keep from inhaling dust laced with toxic substances or radioactive particles while they worked inside tunnels.

"You got a bandanna thing to put across your face to keep dust out of your mouth," Foger said.

He said managers also provided the miners with an ample supply of beer and pizza. The beer was for flushing contaminants from the body.

"They would pacify you to keep your mind off of it. They would bring beer and told us it would keep your kidneys flushed. ... They really didn't care," he said.

Asked Friday whether the landfill could be exhumed in an effort to locate the records described by Medina, a test site spokesman wouldn't comment.

Find this article at:
http://www.reviewjournal.com/lvrj_home/2006/Sep-25-Mon-2006/news/9820251.html

☐ Check the box to include the list of links referenced in the article.

Attachment 17:

Anspaugh, Lynn R., et. al. "Movement of Radionuclides in terrestrial Ecosystems by Physical Processes." Health Physics. Vol. 82, No. 5., May 2002. 669-79.

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Attachment 18:

Anspaugh, Lynn R. Technical Basis for Dose Reconstruction. Virginia: Lawrence Livermore National Laboratory, UCRL-JC-123714. 31 Jan. 1996.

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Technical Basis for Dose Reconstruction

Lynn R. Anspaugh

This paper was prepared for submittal to the
Proceedings of the 31st Annual Meeting of the
National Council on Radiation Protection and Measurements
Arlington, VA, April 12-13, 1995

January 31, 1996

Lawrence Livermore National Laboratory

Technical Basis for Dose Reconstruction[*]

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The purpose of this paper is to consider two general topics: Technical considerations of why dose-reconstruction studies should or should not be performed and methods of dose reconstruction. The first topic is of general and growing interest as the number of dose-reconstruction studies increases, and one asks the question whether it is necessary to perform a dose reconstruction for virtually every site at which, for example, the Department of Energy (DOE) has operated a nuclear-related facility. And there is the broader question of how one might logically draw the line at performing or not performing dose-reconstruction (radiological and chemical) studies for virtually every industrial complex in the entire country.

The second question is also of general interest. There is no single correct way to perform a dose-reconstruction study, and it is important not to follow blindly a single method[†] to the point that cheaper, faster, more accurate, and more transparent[‡] methods might not be developed and applied.

[*] This work was performed under the auspices of the U.S. Department of Energy at the Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

[†] Even the recommendations of a presumably knowledgeable committee assembled by the National Research Council (1995) seem to convey a message of, "Let's keep on doing things the way we do now."

[‡] A method is transparent if it can be explained to the general public without invoking an oftentimes unwarranted leap of faith; such a quantity is important to credibility. A statement that "Model X was used," is completely non-transparent.

History of Dose-Reconstruction Studies at DOE Facilities in the United States

A brief history[§] of major radiation-related dose-reconstruction studies at DOE sties in the United States is provided in Table 1. Much early activity was related to the Nevada Test Site (NTS) (Church et al. 1990), where nuclear weapons were tested in the atmosphere from 1951 through 1958. This dose-reconstruction study for the nearby states was undertaken and performed by the DOE itself. The next site of major interest was the Hanford Works (plutonium production and separation), after it was revealed in 1986 that large quantities of radioiodine had been released during the early years of the plant's operation (see Cate et al. 1990). This study was begun by the DOE, but authority and responsibility for it were transferred to the Centers for Disease Control and Prevention (CDC) (Miller et al. 1994). After these beginnings, dose reconstructions became quite fashionable. The dose-reconstruction study at the Fernald Feed Materials Production Center (uranium processing) was begun by the CDC at the request of the U.S. Congress (Miller et al. 1994), as was the National Cancer Institute's study of thyroid dose to the entire country from testing of nuclear weapons at the NTS (Wachholz 1990).

Studies at the Rocky Flats Plant (plutonium machine shop), the Oak Ridge Site (three major facilities, including a gaseous diffusion plant for uranium

[§] Of course, the first major dose-reconstruction study was that undertaken for the survivors of the atomic bombings in Japan. These reconstructed doses have moved in stepwise fashion from the Tentative 1957 Doses (Arakawa 1960; Auxier 1977) to the Tentative 1965 Doses (Milton and Shohoji 1968; Auxier 1982) to the Dosimetry System 1986 (Roesch 1987). The last major revision occurred only after it was overwhelmingly apparent that the T65 Doses contained major discrepancies (Loewe and Mendelsohn 1981). Unfortunately, there are still major unresolved questions about the neutron doses to the survivors in Hiroshima (Straume et al. 1992). There is, perhaps, no better illustration of the pitfalls of conducting an epidemiologic study with major devotion to developing data for the dependent variable and only grudging attention given to defining data for the independent variable.

enrichment and a facility for the production and fabrication of parts for weapons), and the Idaho National Engineering Laboratory (reactor research and development; chemical processing to recover highly enriched uranium) have been undertaken at the request of the states; the studies at Rocky Flats and Oak Ridge are actually being directed by the States of Colorado and Tennessee, respectively (Miller et al. 1994). Studies at the Idaho National Engineering Laboratory and the Savannah River Site (plutonium and tritium production and separation) are being conducted by the CDC at the request of the DOE (Miller et al. 1994).

An open question is how many more dose-reconstruction studies might be undertaken in the future and whether such studies are really needed or useful. Completed dose-reconstruction studies have been expensive. The NTS and the Hanford studies have cost a few tens of millions of dollars each.

Reasons for Undertaking a Dose-Reconstruction Study

Some of the reasons for undertaking a dose-reconstruction study are indicated in Table 2. The most compelling reason is that there have been large releases of radionuclides that can be presumed to have had some biologic effect. This was clearly the case with the NTS, where more than 100 tests of nuclear weapons devices were conducted in the atmosphere with a cumulative yield of approximately 1 Mt (Church et al. 1990). Another emotionally compelling reason is the revelation of formerly classified data that indicates a substantial release of radionuclides took place, but without knowledge of the public concerned. This was the case with the Hanford Works (see Cate et al. 1990), where it was revealed in 1986 that large quantities of ^{131}I had been released. Much of these releases occurred during 1945, when the early production runs of Pu were being done under great time pressure and without prior experience. A particularly troublesome revelation was that one significant (but minor compared to those earlier) release occurred in 1962 as part of a "controlled-release experiment" (Heeb 1994). As far as is known to the author, the reason for this deliberate release has not yet been revealed to the public.

Other reasons for undertaking a dose reconstruction pertain to social justice. It is not at all uncommon to find that the public living in the vicinity of an atomic or industrial plant (or other source of emissions) believes that it has been harmed by the emissions from the plant. Such beliefs can be profound and can be greatly enhanced if the public also feels that it has been *wronged* by the withholding of information. In such cases the desire or demand for social justice may compel a dose-reconstruction and an epidemiologic study by investigators independent of those responsible for the emissions.

Another reason for undertaking a dose-reconstruction study is as a precursor for an epidemiologic study. That is, a dose-reconstruction study might be undertaken solely as a means of providing the independent variable for a study of risk factors. This does not seem to be a very persuasive reason by and of itself, although one attendee at a recent workshop (see NRC 1995) asserted that this is the only reason that could justify a dose-reconstruction study. However, except in rare circumstances such as the Chernobyl accident (Balonov 1995) or emissions from the Mayak Industrial Association (Degteva 1995; Kossenko 1995), it seems unlikely that there has been or will be sufficient collective dose to provide a meaningful study of radiogenic risk factors.

Finally, there are many of us who simply love the challenge of dose reconstruction, particularly for those cases that seem to be intractable. This is not offered as a justification for the undertaking of a major study, but many scientific studies have been conducted solely because someone *wanted* to do them. This, of course, is not at all unusual in science; the only compelling need is to find someone who can supply the funds.

A Case History for the Nevada Test Site Studies

As mentioned above, the Nevada Test Site was the subject of the first modern dose-reconstruction study. In addition, all of the planned epidemiologic studies have now been completed and published (Stevens et al. 1990; Kerber et al. 1993). Thus, consideration of the NTS as a case study offers a unique opportunity to assess what has been learned and what might be used as a guide for the future.

A commitment to conduct the NTS dose-reconstruction study was made by the DOE in 1979 (DAAG 1987). This followed a long-simmering public unease about the possible health effects of these NTS tests,** other tests by the U.S. in the Pacific, and tests conducted by the USSR. Peaks of concern were noted in the late 1950s and the early 1960s when Congressional Hearings (U.S. Congress 1957, 1959, 1963) were

** Atmospheric tests were stopped at the NTS in 1958, but several other shallowly buried tests or experiments not designed for containment were conducted. The last such experiment was Schooner in 1968. The last major, unplanned release resulted from Baneberry in 1970. A list of all U.S. tests conducted at the NTS and at other locations is provided in DOE (1994).

held. The Limited Test Ban Treaty signed in 1963 resulted in the relaxing of much immediate concern about the health effects from current tests in the Pacific, but specific concerns about the past tests in Nevada resurfaced in the late 1970s. An underlying cause was the controversy surrounding reports that low doses of radiation might be implicated in increases of cancer incidence in workers at the Hanford Works (Mancuso et al. 1977) and at the Portsmouth Naval Shipyard (Najarian and Colton 1978). More specifically, the report in 1976 of a case of leukemia in a former military person who was present at the NTS during the Smoky test in 1957 led the Centers for Disease Control to start in 1977 an epidemiologic study[††] of military personnel present during the Smoky test (Caldwell et al. 1980, 1983). In February 1979 Lyon et al. (1979) published a paper that was widely viewed as indicating that there had been a radiogenic increase in leukemia[‡‡] in Utah children exposed to fallout. These reports led to several new Congressional Hearings (e.g., U.S. Congress 1979), demands from governors in the affected states for the release of all information on fallout, a report from Congress entitled "The Forgotten Guinea Pigs" (U.S. Congress 1980), the filing of thousands of claims, and

[††] The preliminary report (Caldwell et al. 1980) found that nine cases of leukemia had occurred in 76% of those contacted of the 3,224 men exposed at Smoky, whereas 3.5 would have been expected. A later report (Caldwell et al. 1983) provided a more complete follow-up (95.5% contacted) of these men and a study of other cancers. The more complete results were 10 cases of leukemia with 4.0 expected. However, there were 112 cases of all neoplasms, whereas 117.5 were expected, and leukemia was the only site showing a statistically significant increase in incidence rate; these and other results led the authors to summarize that, "...the leukemia findings may be attributable either to chance, to factors other than radiation, or to some combination of risk factors possibly including radiation."

[‡‡] This paper actually reported that the mortality rate for childhood leukemia in "high fallout counties" was *lower* than that of the entire state for low exposure cohorts (1944–1950 and 1959–1975), but that it equaled the rate in the entire state for the high exposure cohort (defined as Utah residents under the age of 15 in 1951–1958). However, the mortality rates from all cancers for the high-exposure cohort in the "high fallout counties" actually *decreased by a factor of two* from that observed for the 1944–1950 low exposure cohort. It is also now clear that the Lyon et al. demarcation of high and low fallout counties was markedly wrong (Beck and Krey 1983; Beck and Anspaugh 1991).

eventually to two major law suits. In addition there were nagging concerns about the correctness of the external exposures (Dunning 1959) reported for surrounding communities from the NTS tests, and an evaluation of internal doses had not been done; the latter by itself was a problem that had led to considerable controversy (Knapp 1963; Mays 1963; Reiss 1963).

From the above it seems obvious that there was a compelling need to conduct a dose-reconstruction study for the NTS; a more realistic question is why it took so long for it to be initiated. The initial commitment made on 28 March 1979 was only "...to collect, preserve, and disseminate historical data related to radioactive fallout and health effects from nuclear testing." (DAAG 1987). A later commitment was made on 8 June 1979 "...for reconstructing, insofar as possible, estimates of the exposures to the off-site public from nuclear testing at the NTS, and the doses to these individuals resulting from the exposures." (DAAG 1987) This latter commitment was rather weak, as at that time there was no assurance that such a reconstruction could actually be accomplished. This dose-reconstruction study for the NTS became known as the Off-Site Radiation Exposure Review Project (ORERP).

The results of the ORERP dose-reconstruction study have now been widely published in a variety of articles, including more than ten in a special November 1990 issue of the journal *Health Physics*. Other results are still in press and some are in preparation.

Some of the key results of the ORERP and collaborative studies are as follows:

- The historical estimates of external exposure reported by Dunning (1959) were essentially correct (Beck and Krey 1983; Anspaugh and Church 1986; Anspaugh et al. 1990; Henderson and Smale 1992; Haskell et al. 1994).
- Some initial estimates of infant-thyroid dose from the ingestion of ^{131}I and other radioiodines for event Harry in 1953 were essentially correct (Anspaugh et al. 1990).
- Only for the thyroid did the internal dose exceed or even attain a substantial fraction of the dose from external exposure (Ng et al. 1990).
- The calculated collective whole body dose from external exposure was 10,000 person-Gy for the areas considered in the western U.S. (Henderson and Smale 1992).
- The collective thyroid dose from internal exposure for the same areas in the western U.S. was 140,000 thyroid-Gy (Whicker et al. in press).

With use of the intermediate results (Beck and Anspaugh 1991; Grossman and Thompson 1993; Thompson et al. 1994) of the ORERP dose-reconstruction study, investigators at the University of Utah have completed epidemiologic studies designed to look for the two outcomes judged to be more likely to be detected in the affected population. These two outcomes are leukemia and childhood-thyroid cancer.

The leukemia study (Stevens et al. 1990) used a population-based, case-control design. Both cases and controls were required to meet these criteria among others: 1) Been born before 1 November 1958 and 2) Died between 1 January 1952 and

31 December 1981 while a resident of Utah. There were 1177 cases of leukemia found to meet all criteria; one or more controls were matched by year of death, age, and sex to each case. The number of controls totaled 5330. Individual bone-marrow doses were calculated for each case and control (Simon et al. 1994). The median bone-marrow dose from fallout for all cases and controls was 3.2 mGy, which can be compared to the bone-marrow dose from natural background of 0.7 mGy y^{-1}. Data were examined in the form of conditional logistic regression analysis of odds ratios with dose. For all forms of leukemia combined, no significant effect was found. A significant association ($p = 0.005$)[§§] was found for a defined subgroup: Acute leukemias discovered from 1952–1963 among those individuals younger than 20 years at exposure. No significant associations were found for other subgroups.

The thyroid study (Kerber et al. 1993) examined a cohort originally defined in the late 1960s of 4818 children; 2687 of these children were enrolled in grades 5 through 12 in 1965–1970 in Washington County, Utah, and in Lincoln County, Nevada, two counties judged to be heavily impacted by fallout; the other 2131 children were of a similar age and lived in Graham County, Arizona, a county judged suitable for a control. Reports of the original study indicated that two carcinomas were found, one in Nevada and one in Arizona; evidence for any radiation effect on thyroid disease was judged to be statistically insignificant (Rallison et al. 1975). Some members (2579; limited to white non-Hispanics still living in the three-state area) of the original cohort were re-examined in 1985 and

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§§ This association is based upon five cases of acute leukemia as shown in Table 3 of Stevens et al. (1990); also there were only 17 cases of leukemia (total except those with chronic lymphocytic leukemia) in the high dose group, all of whom resided in Washington County, Utah.

1986; interviews were also conducted of the parents of all but 53 subjects in order to provide input data for calculation of individual-thyroid doses for the subjects in all three states*** (Till et al. 1995). A total of 2473 persons were included in the analysis of the data for the period prevalence of 1965 through 1986 (Kerber et al. 1993). There were 56 subjects with thyroid nodules, 19 with neoplasms (adenoma plus carcinoma), and eight with papillary carcinoma (no follicular carcinomas occurred among the analyzed subjects). A statistically significant positive dose-response trend was observed for neoplasms ($p = 0.019$), but not for thyroid nodules ($p = 0.16$) or for carcinomas ($p = 0.096$).

What can be generalized from the results of the NTS dose-reconstruction and epidemiologic studies? First, although the public and the U.S. Congress (1980) seem to have a rather opposite impression, it is very difficult to find an effect in the local population that might be attributed to the releases from the NTS. The results of the epidemiologic studies are plagued (or blessed) by a small number of cases, and any observed associations are weak or confined to smaller subgroups. On the other hand, the releases from the NTS were very large; some of the relevant numbers are summarized in Table 3. These results will be used later to derive some suggested boundary conditions for the conduct of dose-reconstruction and epidemiologic studies. However, one conclusion seems inescapable: If an effect cannot be demonstrated readily for the NTS, it is not likely that an effect will be demonstrated in the public at other DOE facilities.

*** The "control" group in Arizona was not truly unexposed; individual doses for these subjects were calculated, also.

Intermediate Results for the Hanford Study

The Hanford Environmental Dose Reconstruction (HEDR) has also been completed. One supporting analysis is that of the amount of ^{131}I released from the site; this value is approximately 3×10^{16} Bq (Heeb 1994), about 200 times less than the amount released at the NTS. Unfortunately, the HEDR results (Farris et al. 1994a) do not provide an estimate of collective thyroid dose, but it is not likely to be higher than that from the NTS.[†††] Thus, although the follow-on Hanford Thyroid Disease Study (Davis 1995) was mandated by Congress, the possibility of statistically meaningful results is questionable. Once this study is completed, however, it will provide one more comparison point against which other proposed studies might be judged.

Methods of Dose Reconstruction

One observation from the NTS and HEDR studies is that such detailed studies are very expensive. The NTS epidemiologic studies were also very expensive and barely yielded results of statistical significance. Another point to be examined is whether much simpler methods might be employed to provide an approximate value of collective dose that might then be used to judge whether a detailed dose-reconstruction study or an epidemiologic study might be useful. As an aid to this discussion, methods of dose reconstruction are indicated in Table 4; an attempt has

[†††] This comparison is not obvious. The releases from NTS were lofted to a high altitude by the explosions, so that some significant fraction of ^{131}I was carried beyond the analysis area. Also, the distances from the release point to the nearer populations were much shorter at Hanford.

been made to arrange the methods in an hierarchy of relative reliability. Unfortunately, the characteristic of reliability appears to scale directly with cost. Other considerations are important as well; some methods do not have sufficient sensitivity for application in many situations now being encountered.

The most satisfactory dose reconstruction would be based upon some measurement made on a biological sample drawn from every individual of concern. This is actually possible in some cases. For example, the measurement of stable translocations in chromosomes of circulating lymphocytes can be performed using the technique of chromosome painting (Lucas et al. 1995). This technique has a sensitivity of about 100 mGy, but is time consuming and expensive; to date the technique has only been used successfully in a small number of cases. Another technique that measures a sample of biologic material is electron paramagnetic resonance (EPR) analysis of dentine (Haskell et al. 1995). The EPR technique is now finding wide application to assess doses to liquidators of the Chernobyl accident, although the technique is subject to uncertainties that can result in significant errors. Many of these uncertainties will be resolved by future research and intercomparison studies. The application of the technique, however, requires the extraction of a tooth, and the EPR analysis is also time-consuming and expensive. A sensitivity of 100 mGy or less may be achievable routinely in the future.

If biologic samples can not be measured, the next line of choice might be (at least for external dose) to measure some natural dosimeter taken from the home environment of each individual. Thermoluminescence analysis of bricks, tiles, porcelain and other ceramic materials has been used very successfully for this purpose. One requirement is that the materials must have been fired to "zero" the dosimeter at some known time in the fairly recent past. The sensitivity of this method is around 50 mGy, and the method has provided very valuable input to the dose-reconstruction studies for the atomic bomb survivors (Maruyama et al. 1987), for the population nearby the NTS (Haskell et al. 1994), and for the population living downstream of the Mayak plutonium-production facility (Bougrov et al. 1995). Similar sensitivities and usefulness appear to be possible with optically stimulated luminescence of fired quartz (Godfrey-Smith and Haskell 1993) and of porcelain and its glazing (Poolton et al. 1995); this technique has yet to be applied widely, but it is simpler than that of thermoluminescence and may be more cost-effective under some conditions.

The analysis of environmental residues as a dosimetric tool is an old, well established technique that dates to the early studies of fallout and efforts to determine the resulting doses (e.g., UNSCEAR 1962). One of the major components of such studies was to measure for ^{90}Sr both the deposition rate through the use of a variety of collectors and the cumulative deposition through the analysis of samples of undisturbed soil. A major practitioner of these studies in the United States was the Atomic Energy Commission's (now the Department of Energy's) Health and Safety Laboratory [now the Environmental Measurements Laboratory (EML)].[‡‡‡] The data from EML were used extensively by the UNSCEAR (1982) in refining the dose estimates from global fallout.

[‡‡‡] Some of their work is summarized briefly in Hardy and Krey (1971).

One of the more significant events effecting the concern for dose reconstruction was the massive 1969 Pu fire at the Rocky Flats Plant.[§§§] Members of the Colorado Committee for Environmental Information (CCEI) did not believe assurances that no significant amounts of Pu had been released by this fire, and they collected and analyzed a series of soil samples from around the plant. Their results for about half of the samples were so provocative that they sent a preliminary report (Martell et al. 1970b) to the then Chairman of the Atomic Energy Commission, Glenn Seaborg. On the basis of their partial results, they estimated that, "...curies to tens of curies have been deposited in offsite areas." This was in marked contrast to the data from the Plant; their records indicated that only 42 mCi had been released through the stacks (Hammond 1971).

The expertise of the EML in collecting and analyzing soil samples was immediately brought to bear on this problem; their results (Krey and Hardy 1970) confirmed those of the CCEI; however, it eventually became clear that the Rocky Flats Plant numbers for releases through the stacks were essentially correct, also. The major point of release was determined to be not the stacks, but a large number of barrels used to store Pu-contaminated machine oil; these barrels corroded and leaked the contaminated oil onto the ground from where the Pu was dispersed by wind and man-caused disturbances (Hammond 1971; Poet and Martell 1972). The estimated inventory of Pu deposited off site was reported by Krey (1976) as 3.4 ± 0.9 Ci on the basis of soil-sampling and -analysis results.

[§§§] Generally contemporary information about the fire and other releases of Pu from the Rocky Flats Plant is provided in Hammond (1971) and Martell et al. (1970a).

These surprising results for the Pu contamination at the Rocky Flats Plant led to the extensive use of soil-sampling programs at other sites. Other off-site areas were found to have unexpected levels of Pu contamination, including the NTS (Anspaugh 1992) and the Mound Plant in Ohio (Rogers 1974). The finding for the NTS was not a particular surprise, but the result for the Mound Plant was. Again, the off-site Pu contamination was found to be the result of non-routine operations. In this case the cause was an unusual storm that washed contaminated soil away from an area where a leaking pipe used to transfer Pu in solution was being uncovered and repaired. The main point, however, is that the measurement of accumulated depositions in soil samples has proven to be an extremely useful tool not only in identifying unknown releases, but in quantifying the magnitude as well.

Sophisticated measurements (^{137}Cs deposition density, $^{239+240}$Pu deposition density, and the ratio of ^{240}Pu-to-^{239}Pu) of soil samples collected from Utah were also very useful in defining the deposition in Utah that had come from the NTS, even though the majority of ^{137}Cs and Pu had come from global fallout (Beck and Krey 1983). These same techniques were used more broadly in a multi-state area to define the contamination from the NTS (McArthur and Miller 1989), and the results became one of the primary inputs for the County Data Base (Beck and Anspaugh 1991).

Another closely related technique is the use of external gamma-exposure-rate measurements. Obviously, such exposure rates are derived from the radionuclides deposited on the ground, and, if the relative amounts of radionuclides are known, it is relatively straightforward to define the deposition densities of even hundreds of different radionuclides based upon a single measurement of exposure rate. Such exposure-rate data were routinely collected after every nuclear test at the NTS at nearby locations. These data were collected and preserved in a database (Grossman and Thompson 1993), which became the primary input for the Town Data Base (Thompson et al. 1994), which became in turn the primary input for the reconstruction of external and internal doses in the local area (Henderson and Smale 1990; Ng et al. 1990; Whicker et al. 1990). Data on the relative abundances were calculated based upon the content of fissile and other materials and on the spectrum of neutron energies (Hicks 1990). The other key data were the radionuclide-specific conversion factors for deposition density to external gamma-exposure rate; these values were calculated for more important radionuclides by Beck (1980).

These techniques have been found to have wide application. For example, following the Chernobyl event, it was possible to infer doses over very broad areas with the knowledge of the relative mixture of radionuclides released and either the deposition density of one or more radionuclides or the measured external gamma-exposure rate from radionuclides deposited on the ground (Anspaugh et al. 1988; UNSCEAR 1988).

The results calculated with the use of the last three methods listed in Table 4 become much more uncertain in many cases. The use of a computed source term and an atmospheric transport model was specifically rejected for the ORERP dose-reconstruction study in favor or the more direct and useful measurements that were available. Plans to use a meteorological model to derive ^{131}I-deposition densities for the study of radioiodine doses to the entire country were abandoned, because of the unreliable results (Hoecker and Machta 1990). Other studies performed as part of the ORERP found that it was not possible to reproduce fallout patterns with primary input data. However, it was found that meteorological models were useful tools in extending known patterns downwind (Cederwall and Peterson 1990). One reason for the failure of models of atmospheric transport in this case was the episodic and short-term nature of the releases.

On the other hand, when releases occur over long-time periods the ability of atmospheric transport models to provide accurate time-integrated values is much improved. Thus, the results from the HEDR, which depended almost entirely on defining the source term and then using an atmospheric transport model (Farris 1994a) should be reasonably accurate. There was also no other viable choice for the HEDR project. No environmental residues were left that could be used to define the trace of the only radionuclide of importance, ^{131}I. The source of the ^{131}I was known precisely, the release fractions were known (essentially 100% of the decay-corrected inventory during the early days), and it was possible to derive rather good estimates of the release rates (Heeb 1994).

If the release is not known or not readily knowable on the basis of the analysis of environmental residues, then the release must be inferred. Such inferences can be subject to very large errors, especially if large amounts of very long-lived materials are processed. As the results at the Rocky Flats Plant and the Mound Plant showed, the purported release data may not even account for the major releases that occurred.

Depending upon the purpose and the desired accuracy of the dose reconstruction, it may be preferable to dispense with an atmospheric transport model and to attempt a simple estimate of the collective dose from an inferred release. As a scoping calculation, this can be very useful. Such techniques have been discussed in WHO (1983)[****] and IAEA (1985); Cohen (1984) has also provided some useful general methods for this problem. Of course, it is not possible to estimate the dose to individuals.

An Example Calculation for the Rocky Flats Plant

After seemingly heroic attempts at defining the source term for the Rocky Flats Plant, it is this author's opinion that the results are still the same as those Martell et al. reported in 1970: That there were curies to tens of curies deposited in offsite areas. This number was stated to be 3.4 ± 0.9 Ci by Krey (1976). From WHO (1983) the effective dose equivalent per unit activity of ^{239}Pu released from nuclear installations to the air is 10^{-10} man-Sv Bq^{-1}. Thus, although the real release was essentially at ground level, we can estimate that the collective dose resulting from this release must have been about 10 man-Sv or less. Using an estimate of approximately 0.05 cancers Sv^{-1} (ICRP 1991), we can estimate that this might result in the probability of not even one fatal cancer.

The logical question is, why are we so concerned about Rocky Flats? Clearly, the social issues are dominating. In point of fact, there have been three public

[****] The results in WHO (1983) are based on the long-term, detailed studies of the UNSCEAR, e.g., UNSCEAR (1976, 1982).

relations disasters at Rocky Flats. The first was the finding of Pu offsite by a local citizens' group, and not the Plant personnel. A second disaster, not mentioned previously, was the finding of a substantial release of tritium offsite in 1973 (Colorado Council 1993); again, this finding was not by the Plant personnel, but by the Colorado Department of Health.[††††] The final public relations disaster was the well publicized raid by the FBI and the EPA enforcement arm. The fact that the latter invasion found essentially nothing that they were seeking seems to have been forgotten. However, it is clear that the local public feels they have been wronged by the operators of the Plant, and there seems to be little choice but to perform extensive studies to reassure this public.

What Do We Know About Fernald?

The Feed Materials Production Center at Fernald, Ohio, is another production plant that processed very large amounts of stable material, in this case uranium. The Plant has also been the subject of substantial controversy and many lawsuits with the success of the plaintiffs' cases leading to law suits at virtually every similar facility in the country. There is also an ongoing dose-reconstruction study (Miller et al. 1994; Voillequé 1995), and there has been an extensive soil-sampling and analysis program (Stevenson and Hardy 1993). Both of these efforts have focused on the airborne release of uranium, although there are other problems of radon emissions and groundwater contamination by uranium (Hamilton et al. 1994).

[††††] Plant personnel actually had no reason to suspect that the tritium was onsite. The tritium was an unknown contaminant in material shipped to Rocky Flats by the Lawrence Livermore National Laboratory.

Fernald is of particular interest now, because of the enormous conflict that appears to exist between the results of the application of two of the methods of dose reconstruction indicated in Table 4. In reality, the conflict is narrowly confined to inferences of how large the source term was for uranium. The study of environmental residues has been reported by Stevenson and Hardy (1993) and is based upon the analysis of uranium in hundreds of soil samples collected in the near offsite area. Their average estimate of the material deposited in the offsite area is 2130 kg (1.4 Ci or 53 Gbq); their highest estimate is 6140 kg (4.1 Ci or 152 Gbq). On the other hand, the source term derived by Voillequé (1995) on the basis of examining plant-process records is stated to be 200,000 to 900,000 kg. This enormous difference might be explained by the bulk of the latter estimate having been retained within the plant boundary. If the material had actually gotten offsite, there is no reason to believe that it would not still be there.

Cohen (1984) estimates that the probability of human intake for material released to the air is 5×10^{-6} (inhalation) and 3×10^{-3} for release to the ground (ingestion); the dose-conversion factors for U are 2×10^{-6} (inhalation) and 6×10^{-9} Sv Bq^{-1} (ingestion) (Eckerman et al. 1988). The resulting calculation for collective effective dose equivalent is about 2 man-Sv. Again, it is reasonable to conclude that there is little scientific justification for either a dose-reconstruction or an epidemiologic study.

What Can We Learn from the Past?

Our experience in dose-reconstruction in the U.S. can be summarized rather briefly. First, the major studies have been very expensive, in the tens of millions of dollars. Second, even for the NTS, where the releases were large and the resulting collective doses were appreciable, it has been very difficult to find a statistically significant biologic effect. The results of the thyroid study at Hanford are not yet available, but it will be surprising if the results will be any more conclusive than those from the NTS study; this conclusion follows from the rather similar numbers for the size of the population and the doses involved (Davis et al. 1995). Third, for most of the other sites in the U.S. there is little reason to believe that releases or doses could be even remotely comparable to those from the NTS.

A recommendation might logically be made to set some boundary conditions on the results of scoping calculations (such as the examples indicated above) on individual doses and collective doses that might be used to determine whether a major study should be done or not. The author's suggested boundary conditions are

Collective effective dose	10,000 man-Sv
Dose to maximum individual	0.4 Sv

If either of these conditions should be exceeded, then a more detailed dose-reconstruction study might be warranted or of interest.

The exact boundary values, of course, are not so important. What is significant is that so many studies are now being undertaken with screening values orders of magnitude less than the above suggestions. If the social justice issues are compelling, then the studies might be done regardless of the screening values. A key question is whether communities will be satisfied with screening analyses. Another question for federal and state agencies is whether they will be willing to continue to fund major studies.

As a final point, it seems compelling that credibility of any dose-reconstruction study is a precious commodity. It is absolutely essential that any major dose-reconstruction study should receive rigorous peer review at all stages and should conclude with all major results published in the peer-reviewed scientific literature.

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Table 1. Major dose-reconstruction studies at DOE facilities in the United States.

Site	Object of assessment	Reference
	Completed	
Nevada Test Site	Hypothetical individuals	Henderson and Smale (1990)
		Ng et al. (1990)
		Bouville et al. (1990)
	Collective	Henderson and Smale (1992)
		Whicker et al. (in press)
	Specific individuals	Simon et al. (1995)
		Till et al. (1995)
Hanford Works	Hypothetical individuals	Farris et al. (1994a)
		Farris et al. (1994b)
	In process	
Fernald Feed Materials Production Center		Miller et al. (1994)
Rocky Flats Plant		Miller et al. (1994)
Oak Ridge Site		Miller et al. (1994)
Idaho National Engineering Laboratory		Miller et al. (1994)
Savannah River Site		Miller et al. (1994)

Table 2. Reasons why dose-reconstruction studies may be undertaken.

- Known large releases that can be presumed to have a biologic effect
- Stunning revelation of formerly classified data
    - Operational releases
    - Deliberate releases with public exposure
- Social justice
    - The public believes it has been harmed.
    - The public believes it has been wronged.
- To advance knowledge of risk factors
- "Because it's there."

Table 3. Characteristics of the releases from the Nevada Test Site.

Characteristic	Value
Number of atmospheric tests	>100
Approximate total yield	1×10^6 tonnes
Approximate energy release[a]	1×10^{15} cal
Fission-product atoms created[a]	3×10^{26}
Cesium-137 released[a]	6×10^{15} Bq
Iodine-131 released[a]	6×10^{18} Bq
Collective external dose[b]	1×10^4 Gy
Collective thyroid dose[c]	1×10^5 Gy

[a]These values follow from the 1 Mt total yield and conversions provided in Glasstone and Dolan (1977).
[b]From Henderson and Smale (1992)
[c]From Whicker et al. (in press)

Table 4. Methods of dose reconstruction.

- Individual biologic analysis
    - Chromosome translocation analysis of circulating lymphocytes
    - Electron paramagnetic analysis of teeth
- Dosimetry of materials in homes
- Analysis of environmental residues
    - Deposition densities, past or current
    - External gamma-exposure rates (past)
- Known releases, plus atmospheric models
- Inferred releases, plus atmospheric models
- Known or inferred releases