time position." Which I did. So in 1994, September of '94 I started with British Nuclear Fuels in the United Kingdom. Again in that corporate marketing department.

Colin Jones: That's always one of the first questions. But a lot of people just don't have an appreciation. So the work that we do at North American Nuclear Group, we actually 10 major contracts that we manage on a daily basis. And that's nine of those contracts are supporting the U.S.Department of Energy. The majority of those are in the Office of Environmental Cleanup. We have one contract out in Nevada that supports their nuclear security work. And then we have an Office of Science Project Support in Argonne National Lab. And then the one remaining contract we have up in Canada, which is managing the Canadian nuclear laboratories. But as I mentioned, the lion share of our work is in nuclear remediation and cleanup. And this really kind of started in the 1940s during World War II. And it really was if you go back in that time, it obviously is... World War II was dominated in the global scene at the time but there was a real belief that the Germans and Adolf Hitler had access to nuclear technology.

And so that kind of created a race to be able to have the access to nuclear weapons technology in recognizing how important that is from a world security perspective. So that really started off in 1943, up at the Hanford Site which is based in Washington state. Is where you saw a real kind of national endeavor to go and actually create nuclear weapons. Over the years the country, the United States, has created thousands of nuclear weapons. At one point, they had over a hundred sites responsible for different parts of the nuclear weapons production program. So in about 1989, a lot of the states that were hosting these sites were started to get concerned about some of the environmental damage or the environmental mass that had been left behind as a result of this weapons making program.

So at that point, the Federal Government and the states decided that obviously the weapons program would continue as it was. But they would also create a separate environmental management program. So that's how we really got started, really focusing on cleaning up the environmental messes, if you like, that was left behind from the Manhattan Project. As I mentioned, this started back in 1943 or at the Hanford Site. One of the things that they needed back in those times, it was access to a lot of land and they needed water supply. And so as you look at the Hanford Site, which is 560 square miles, there was a few farmers and a few tribes on the land that the Federal Government displaced, but it had access to the Columbia River, which goes right through the Hanford Site.

So if you can imagine back in the 1940s, they had tens of thousands of people relocate to this part of Washington state and started building nuclear facilities, like nuclear reactors. So that they could process uranium based nuclear fuel, turn it into spent fuel so that they could mine plutonium from that spent nuclear fuel to put into nuclear weapons. The human feat that went into this, it truly is amazing. Back in those days, they were designing and building reactors in the matter of 18 months or two years. And obviously these were of smaller scale production reactors at the time. But just to kind of put that in context, some commercial utilities are building some new commercial reactors in the

state of Georgia right now and that's probably taken them 10 years to be able to complete the design licensing and construction of those reactors, probably more than 10 years. So just to kind of again put it in a little bit of perspective of what was going on back in the 1940s at a site like Hanford.

Stephen Ludwig: Now, talking about the Manhattan Project and World War II and that the Federal Government didn't really begin to look at these waste sites until 46 year years later in 1989, if they started in 43. What didn't they know about nuclear waste or what the dangers were that we about now, like, what would happen if we just left the waste there and left it alone?

Colin Jones: Right. These folks truly were pioneers and that they with the leading edge of their industry at the time. And there was a lot of stuff that they didn't know, but, and that's one of the things as you look across the DOE complex and you go from site to site, you see how that learning matured and how the technology matured. And you can actually, as you follow that technology maturation around the DOE sites, you can actually see how that held from a waste management perspective. Again, I'll go back to the Hanford Site. And the reason I keep going back there is because it is one of the most contaminated sites in the world with regards to radiological and chemical contaminants. And it really was one of the birth places of the nuclear industry as we know it today.

As part of this process in being able to mind plutonium from spent nuclear fuel, they use a technology that they call reprocessing. And back in the day, Hanford again, they were one of the pioneers. They tried out many different types of reprocessing technology before they selected the most effective technology. And so as a result of that, this process that they use is an aqueous process as they take spent nuclear fuel, which is a solid, put it through a chemical process so that they can extract the plutonium. You're left with a liquid effluent, which is contaminated. Millions of gallons of this contaminated waste was just poured in the ground or poured in cribs and trenches at the Hanford Site. It wasn't until a few years later that they thought, maybe we shouldn't do that. Maybe we should put them in underground tanks. And so as you look in the 50s and onwards, they actually ended up building 177 underground tanks, which now contain about 56 million gallons of radioactive waste.

Stephen Ludwig: Wow.

Colin Jones: Which is again, is just what is an environmental liability that not most folks really know about. And that is the responsibility of DOE using contractors like Jacobs, to be able to manage that waste.

Stephen Ludwig: Now you mentioned Hanford's one of the worst sites in the country. There have been a number of, you mentioned, I think over a hundred sites that were being used at one point. And I think if I understand correctly, most of those sites have been cleaned up and remediated. Why is the remaining work on these remaining sites so difficult? What's taking so long and why is it so hard?

Colin Jones: So yeah, we started off with a hundred sites and now we're down to 16 sites. And I would say the 16 sites are some of the hardest sites left. And again, I think one of the big things is high level waste that we just talked about. That process I talked about, the 56 million gallons at Hanford. There's about 25 to 30 million gallons at the Savannah River Site. It's based out in South Carolina. And they actually have some smaller amount of high level waste at the Idaho Site.

That really truly is one of the big ticket items with regards to, as you look at the future cleanup and closure of these sites. It's some of the most challenging ways that they have to deal with, primarily because it's a liquid. Obviously liquid it's movable. And the process that we use, and we are using this as an industry, are using this process at the Savannah River Site to process that liquid waste into a glass fall. We call it vitrification. It's basically just using melters and glass frit, combined with a high level waste to make a glass block that can ultimately disposed of at a deep geologic repository one day. And obviously that makes sense in turning that liquid into a solid, makes it so much easier to manage.

Stephen Ludwig: What's a high level waste versus a low level waste? I don't, what's the difference there?

Colin Jones: Well that's a good question because there is, right now the definition of high level waste... the Department of Energy is looking at changing it. Historically, the high level waste definition is been based on the stage within which the waste was generated as it went through the cycle to become as part of the weapons program. And I know that gets kind of a little bit complicated. The department now is looking at saying, "Hey, why don't we look at it based on its radiological content?" Based on in layman's terms, how hot is it? Because depending on, there's different types of radio active waste, the high level waste being considered to be the most dangerous and requiring the most security safeguards and management. We have plutonium contaminated waste, which is equipment that has been contaminated with plutonium as part of the weapons making program.

Now that has a measured degree of units that are actually measured to dictate whether or not it's got a transuranic waste. And we actually have a disposal path for that kind of waste right now that goes to the Waste Isolation Pilot Plant, which is in New Mexico, which is an under the ground repository based in a salt formation, which has actually been operational for about 20 years now and is actually doing a pretty good job of being able to dispose of that kind of waste. And then we have low level waste. Low level waste for the most part is contaminated buildings and facilities. What we do with that is in a lot of places, we will build onsite disposal cells or there actually is some commercial disposal cells that can actually dispose of low activity waste. Each of the disposal cells will have something they call a waste acceptance criteria, which will dictate the range of waste that they can take and that can be disposed up in those facilities.

extension programs. So they have to prove to the Nuclear Regulatory Commission that they can maintain safe operations of those reactors. So what you see at each of the individual reactors through their maintenance programs,

but they are. Obviously that they're very oil dominated, fossil fuel dominated. But I think that they've realized is that using oil for electricity supply, how effective is that right? Why are they using their own oil supplies to generate electricity when they can potentially invest in nuclear power and then have that oil to sell? So I do think that there is support for nuclear globally. It is going to be interesting to watch where the rest of the world goes.

The other big component in nuclear right now, too, is up until this point we've had these 1,000 megawatt kind of reactor types, even up to 1,600 megawatt reactor types. There is a big push now to look at what we're calling small module reactors. And that is one area where we have a number of U.S. vendors that are trying to play in that area. And so you're not looking at making such a large commitment and building a 1,000 or 1,600 megawatt reactor. Maybe you can build a 50 megawatt reactor. Maybe that's more helpful in more remote regions. Maybe you can make it more modular as you can just kind of add in on 50 megawatts at a time. And there is some safety benefits. I'm no expert in the small module reactor technology but they tout safety benefits as well to the small module reactors.

Stephen Ludwig: It's interesting when you say modular, I always think of like the Lego building block approach to building but I get it's far more complicated than slapping some Legos together.

Colin Jones: No, but that's what the principle is based on though. And again, this is not a particularly new technology because when you think of, again... the Naval Nuclear Program plays a very big part in our industry. And you look at nuclear submarines, right? They're powered by a nuclear reactor on a submarine. That is of the genesis of small module reactors. But no, that's how the small module reactive vendors will tell you it is just like Lego blocks, adding one with another and making it modular.

Stephen Ludwig: Interesting. So I'm sure we could talk for another few hours about all aspects of environmental cleanup for nuclear, running a facility and doing that safely. This new modular conversation we're having is super interesting and how there's a lot of areas we didn't touch on and how nuclear energy and nuclear ideas are used in industry, as well as the military. But beyond all those things, is there anything I didn't ask you about that you'd like to mention?

Colin Jones: You know, obviously I've been doing this for 25 years and will do this for the rest of my career. No doubt. I would just... is highlighting the people, what an amazing mission this is. In recognizing the historical importance of nuclear weapons technology and how it helped end World War II. How it helped prevent the Cold War with the standoff between the United States and Russia. The political implications it's had, we're now playing our part. And we have done for the last over 20 years and been able to clean up the environment that resulted from the creation of those nuclear weapons. So to me, it's such a vital and important mission. I like to talk about as being environmental superheroes.