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The Journey Our Nuclear Waste Must Make: Into Eternity

Interview with Michael Madsen, Director of Into Eternity.
by Dr. Helen Caldicott

If You Love This Planet
15 July 2011

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Michael Madsen on the staggering problem of storing the world's nuclear waste


Michael Madsen

Michael Madsen, the Danish director of the new documentary film "Into Eternity", joins Dr. Caldicott for a riveting conversation with worldwide implications. "Into Eternity" focuses on the vast amounts of radioactive waste created every day by nuclear power plants the world over, and the constant challenge to find an adequate way to store it, with a special emphasis on the Onkalo nuclear waste repository being built in Finland (to be completed in 120 years). Read two 2011 articles about the film: 'Into Eternity': Effort to store nuclear waste and Nukes are forever which includes the trailer for the film. Check out Conversation with Michael Madsen: Director of Into Eternity which includes stills from the documentary. Also read the 2006 BBC article Finland buries its nuclear past. To learn more about Madsen's film and inquire about future DVD sales, visit intoeternitythemovie.com.

Helen Caldicott: Welcome to If You Love This Planet. I'm Doctor Helen Caldicott and in this program we talk about the greatest medical and environmental threats to all life such as nuclear weapons and nuclear power, global warming, ozone depletion, toxic pollution, deforestation, and many other social and political issues that relate to global well being. So if you love this planet, keep listening.

Hello and welcome to If You Love This Planet. My very special guest today is Michael Madsen, director of the new documentary film, Into Eterntiy. Into Eternity is a film about the vast amounts of radioactive waste, created every day, by nuclear power plants the world over and the constant challenge to find an adequate way to store it.

A review of the film in *The Guardian* said, "jaw-dropping . . . tackles a subject almost beyond comprehension . . . one of the most extraordinary factual films to be shown this year . . . Madsen's film does not merely ask tough questions about the implications of nuclear energy . . . but about how we, as a race, conceive our own future."[1]

Michael Madsen is a film director and conceptual artist who has been guest lecturer at the Royal Danish Academy of Art, the Danish Film School, and the Danish School of Design. He is the director of several documentaries

including the award-winning, To Damascus, a film on interpretation produced in 2005.[2]

Michael Madsen joins us now on the phone from Denmark. Welcome to If You Love This Planet, Michael.

Michael Madsen: Thank you very much.

Helen Caldicott: I think I'd like to ask you first how did you conceive to do a film about nuclear waste? What was it that initiated your interest in the whole thing?

Michael Madsen: Essentially it was the 100,000 year aspect that somebody in Finland is building a facility that has to last in a fool-proof manner for 100,000 years. That was what caught my attention. Because I thought that first of all these persons, these experts, they will have to be able to relate, to understand, what 100,000 years is. Which I think is very, very difficult.

And secondly, they will have to have some kind of scenarios for the future, some ideas about how the future will look like in this time span. That is what got me really, really interested.

Then I thought that this has to be the first time in the history of mankind that we are building something like this. And also something which is not in any kind of religious context, as would be the case with the cathedrals of the Middle Ages or the Pyramids.

So my basic question has been, throughout making this film, what does such a facility tell us about our own time and what is its true significance? Perhaps it's something beyong being a storage place for nuclear waste.

These are the things that I was trying to look into.

Helen Caldicott: What do you mean by that last statement: Perhaps it's something beyond being a storage facility for nuclear waste. What do you mean by that Michael?

Michael Madsen: I had this suspicion that this is not just beating a hole in the ground and essentially building a bunker-like structure. I think that the aspect of the facility where this shows most clearly is that this facility is built in a way so that it is able to operate without any human interference.

Once it is completed about 120 years from now, it will be sealed off and then it will enter a kind of silent mode operation. And the reason why this facility has to be independent of human surveillance and power supply – which is of course the case with *any* such interim facility in the world today where the waste is in pools that are cooling the waste,[3] et cetera – the reason for this silent mode element is that in this time span these scientists simply do not expect civilization as we know it today to last.

That means that the knowledge about what nuclear energy is and therefore what radiation is will simply vanish at one point.

And therefore it is not considered possible that any kind of, you can say that it has to be independent of what we humans know in the future because otherwise it would be too dangerous. It's more safe if it can operate by itself.

And that is because you can say that this facility, the Onkalo facility in Finland,[4] is the first possibly, as one critic said or wrote, possibly the first post-human structure on earth. In it's very construction it has the notion that civilization as we know it today will not last for this time span.

Helen Caldicott: Or maybe humanity.

Michael Madsen: Well, [laughter] I can tell you that some of the scientists that I've been working with for this film, they, in a way, have expressed less concern in terms of the danger, at least towards humans, because yes, it is conceivable that mankind will not last for this long. I can also tell you that in the Swedish legislation concerning high-level nuclear waste, the talk is about creatures, living creatures, and not just humans.[5]

Helen Caldicott: Interesting. There are several questions I have then, Michael. I've always thought that the waste – and I think the Environmental Protection Agency (EPA) in America or some such agency says it should be isolated from the environment actually for half a million years, not a hundred thousand years.

Michael Madsen: It's a million years in the U.S.

Helen Caldicott: A million. Well therefore why are you using the figure of a hundred thousand [years] when it is a million in the U.S?

Michael Madsen: Yes, that's a very, very good question. I'm using the figure of a hundred thousand years in Into Eternity because it is what the law in Finland states.[6]

Helen Caldicott: Oh it's the law in Finland.

Michael Madsen: So in Finland this is the quarantine time so to say. And I can't tell you why it's *only* a hundred thousand years in Finland and a million years in the U.S. I think that the only thing that these two figures really tell us is that the experts do not agree about how long this is actually dangerous.

Helen Caldicott: [Laughter] Of course not. Well why do they put the figure at a million years in the U.S. then Michael?

Michael Madsen: I don't know. I simply don't know. I know that there may be some differences in how some of the legal system works in the U.S. as we all know. And it

may have something to do with that. One independent nuclear waste scientist whom I consulted in making the film so that I would have somebody to verify what I was being told by the participating experts in the film (and also just to make sure that I got the points), she told me that it should be at least 250,000 years.

But one of the problems and one of the unknowns, in making such a facility is that we don't have any experience with nuclear waste in such concentrations as will be the case in such a repository.

What happens inside the waste is unknown because nuclear waste does not only contain plutonium and uranium. In the process, inside a reactor in a nuclear power plant, almost every known element in the universe is created. And that means that the exact composition of the waste is not entirely known. And what will happen inside the reactions that goes on in the waste is not fully clear.

Helen Caldicott: Yes. There was a fair bit of work done on that by scientists relating to Yucca Mountain where the U.S. decided to store its 64,000 tons of civilian radioactive waste[7] in a volcanic mountian made of, actually, pumice which is just ash from the volcano.

And they talked about the fact that after 100 years things are going to be very hot. I mean we've got the zirconium fuel cladding which probably will go along with the radioactive waste. And that reacts with water and that causes hydrogen and they also said it could get terribly hot and that by 100 years it would have corroded through any containment that it was put in. And also it shouldn't get wet. But they also found that the pumice in Yucca Mountain let water through. Therefore after 100 years they were going to put titanium baffles over the top of the containment vessels.

But who would decide to do that? We'll all be dead and will our second generation or our great grand children or great great grand children know to do that or want to do that or ... ?

Michael Madsen: Yes.

Helen Caldicott: Yeah.

Michael Madsen: This is the basic problem: can we, first of all is it fair towards the future generations, to impose a burden on them in terms of maintenance? Secondly, is it at all possible? Because that will require that knowledge about what it actually is can be passed on. This is of course this question about should we warn, slash, inform the future, or not, for a hundred thousand years? That is what Into Eternity is really circling around.

The problem is, of course, you can also put the argument forward that in fact it's better *not* to inform the future. That is, at least, actually the preferred

strategy in Finland; simply to hide it. And Onkalo, which is the name of the facility, means “hiding place.”

The idea is that what we are actually fighting here is not a technological problem. We can make a kind of bunker. That's possible, we think. But an even bigger problem is human curiosity. And even though we may have some kind of stone tablets with information it is still not clear if this will be understood 50,000 years from now.

Helen Caldicott: Well, sure, because when you think back 2,000 years ago, which we now think of as antiquity, that's when Jesus lived, they didn't even speak English. English hadn't been developed. That's only 2,000 years ago.

Michael Madsen: Yes. That is true. Regarding language, what we know for certain – the only thing is that it changes over time. That is why we would have problems understanding a person from the Middle Ages, et cetera.

But if the real problem is human curiosity; somebody would like to open such a place if they find some kind of indication that something is buried there. And you are not able to detect what it is because all knowledge about radiation is gone and you cannot smell it, feel it, or sense it in any way, then you have the real problem. Because then you may have somebody who, inadvertently, opens it and brings out some of the material.

Helen Caldicott: It reminds me a little bit of the village in Brasil where a hospital sent a capsule of cesium-137 to the rubbish dump because they didn't need it anymore. And a family found it and they found that it glowed blue in the dark. They used to paint it on their faces and they ate it and they put it under their beds and watched it at night. That whole family died but the whole village was contaminated simply because people had *no idea* what they were dealing with.

Michael Madsen: Exactly. And the problem is also that this may happen and then somebody gets an idea that this is actually dangerous and then it can be used as what we today would call a kind of dirty bomb. So there is also a source of military power in the waste deposits like this.

Helen Caldicott: I think the Americans choose a million years because when you think about it plutonium has a half-life of 24,400 years. Some people multiply that by 10 to get the total radiological life. But some multiply it by 20 which brings you up to half a million years. And then you see radioactive iodine-129 has a half-life of 17 million years. There are quite a few isotopes that have extremely long half-lives. So I suppose to encompass the whole gradient of radioactive elements, and as you said almost every element is made in a reactor, they would put the number at a million. But it would be interesting, wouldn't it Michael, to research why the Americans have chosen a million years.

Michael Madsen: Yes, but when I asked the scientists in Finland I received two kinds of answers within the same company. The communication manager said, 'Michael, you have to understand that high level nuclear waste becomes less and less toxic because of the half-life. So really Michael it's all the time diminishing the problem, from day to day.'

Then the head expert of the long-term safety [group] said, 'Michael, I do not agree with this way of talking about high level nuclear waste because essentially, when we are talking about these time spans, it is forever. In the human time scale it's forever.'

Helen Caldicott: Yes.

Michael Madsen: I think that is very, very true. To talk about a hundred thousand years or a million years doesn't really make sense. What we have to think about is that it is about a hundred thousand years [ago] that homo sapiens left Africa for the first time. That is what we're talking about.

Helen Caldicott: A hundred thousand years. And that's not many generations. I read that the other day.

Michael Madsen: It's about 3,000 generations.

Helen Caldicott: 3,000 generations in 100,000 years. That's not many.

Michael Madsen: No.

Helen Caldicott: Then we could move on. I know that the Department Of Energy in America has been employing anthropologists to work out what sort of signs to put on the radioactive waste dumps: skull and cross bones, or The Scream, or what to put. Would you like to talk about that a bit?

Michael Madsen: Yes, because this is also what is discussed in Into Eternity as I refer to these reports which are just about the only ones in existence in the world.[8]

Helen Caldicott: The anthropological reports.

Michael Madsen: Yes. And these discussions about what kind of marker could we envision.[9] The only thing that there has been some kind of consensus about is The Scream;[10] to be some kind of universal symbol that would be able to be understood by any society, any culture, at any point in time.

The problem is, of course, that it's impossible to test if this is possible. But also you will still need the marker to survive for a hundred thousand years or a million years –

Helen Caldicott: – That's right.

Michael Madsen: – and you will also need this marker to stay at the same point. I can tell you that there is an interesting case in the U.S. I think it is the first nuclear test blast. A concrete slab was placed there about a cubic meter, or something like that, and with a plaque on it. But it is also a cow field. So the cows have been scratching their backs against it, this concrete slab, for 40 years. And now it's moved something like 10 meters from the scratching.

Helen Caldicott: And you wouldn't want any earthquakes either or that sort of thing.

Michael Madsen: Yes exactly. Essentially there are three strategies in terms of communicating towards the future. One is this kind of a marker with the universal symbol on it. The second one is to have a kind of archive system which is really what the Finnish state opts for and which is discussed in the film. But then that depends on that one generation actually will pass on the information to the next generation as there is a kind of institution –

Helen Caldicott: What do you mean, an archive system?

Michael Madsen: The Finnish idea is simply to have a kind of library, a manned library for 100,000 years. People who constantly operate the information and pass it on.

Helen Caldicott: Oh that's a good idea. How absolutely, pathetically – that's like a fairy tale. I mean, God almighty.

Michael Madsen: Yes. But I have to say in the film there is the man responsible for this, he hesitates a little bit towards where he actually thinks this will take place.

The last [third] idea which has been discussed is that if we could create a kind of a myth that, would then by itself be re-told because of the strength in the narrative, from generation to generation, then this would be another way of perhaps passing down information. And Into Eternity in a way tries to perform such a task in the way that it is narratively constructed.

But these are three strategies and they all have problems or perhaps even dead ends.

Helen Caldicott: We are talking about Jesus Christ parables that have lasted, and passed on, generation to generation, for 2,000 years.

Now the other thing, talking to you, Michael Madsen – I'm interviewing Michael Madsen who made this absolutely wonderful film called Into Eternity – which, it's very slow moving, very thought provoking. People's jaws just drop when they watch it. They haven't entertained this sort of philosophical approach to what we're actually doing at the moment. We'll get into that in a minute.

But as we talk, Michael, becuase I'm a pediatrician, a physician, I always say nuclear waste will produce random, compulsory genetic engineering for the rest of time. And that we all carry several hundred genes for disease like cystic fibrosis or diabetes and the like. But as we increase these internal emitters that get into our bodies, into our testicles and ovaries, we will have more and more and more genetic mutations and deformed babies being born. You could imagine a kind of mutant population which may not be nearly as intelligent as the one we're dealing with now.

Michael Madsen: Yes. I think that the main fear is mutations stemming from the opening of such a nuclear waste repository. It is not actually who will perhaps die from exposure. It is more if the whole ecosystem recieves some kind of imbalance because a creature suddenly becomes superior by mutation. That is the main fear.

Helen Caldicott: Really. They expressed that did they?

Michael Madsen: They have only gotten so far as to say – which I believe is extremely cynical – that if such a place inadvertantly is opened in the future by somebody who doesn't know, somebody will die and then you will understand that it's dangerous. And then there is no problem because then it is identified as a threat.

But I believe that the reason why one is going to such extremes as to try to build something for a hundred thousand years is that it is extremely dangerous. And that there are dangers beyond a few casualties.

Helen Caldicott: Like you describe, the dangers beyond a few casualties, Michael.

Michael Madsen: The film Into Eternity does not go into – there is, of course, an explanation about what does radiation do to living tissue, to living creatures.[11] And it talks about the instant effects which is what we have now also seen some of the workers at the Fukushima power plant being exposed to burns which is really a burn that will never heal. But also the aspect of mutation. That the genetic code is not only damaged but also changed.[12]

What that will mean, I think, nobody knows that. I can tell you that I am going on a trip next week to the Chernobyl exclusion zone with artists and one of these artists is, as I understand, taking photographs of insects who have peculiar shapes.

Helen Caldicott: Mutation. Yes and the birds too. The birds – the barnswallows, the insects, and the other animals are showing evidence, now, of mutation and it's quite common.[13]

Michael Madsen: Yes. That is the main threat. And of course, we have to understand that today

all the waste in the world is sitting next to every single power plant in these pools where it needs to be cooled for 40 years at least. If we imagine that these facilities will need – and they will need to be turned into some kind of permanent solution – then there will be these repositories all over the world.[14]

So it is not only certain parts of the earth that may have a problem if they reach these facilities. It may be many different zones.

Helen Caldicott: Yes, it will become ubiquitous. When I first wrote my book *Nuclear Madness* back in 1978, I said you can imagine generations hence waking up in the morning [with] the food already radioactive, the breast milk already radioactive, the children being born deformed or with genetic disease, developing their cancers at the age of six because they are exposed to radiation so much earlier than getting their cancers at 60.

That's the legacy that we leave to future generations. Although the Finns are trying to do something about putting this waste deep in the earth (and we'll talk about that in a minute) I can't see with the spread of nuclear power all over the world at the moment – the irresponsible spread – I can't see people doing what the Finns have done. Can you Michael?

Michael Madsen: I am, so to say, trying to stay out of this part of the discussion because I am trying to pass on those sorts of questions through my film to any individual in the audience.[15]

But I think that it is clear that something needs to be done. Because the nuclear waste does exist. And even though you may be against the use of nuclear power this will not, in itself, make the nuclear waste go away.

Helen Caldicott: No.

Michael Madsen: So something needs to be done with the waste we already have. As we have seen at the Fukushima power plant, also the spent nuclear fuel, the nuclear waste sitting next to the reactors has made troubles because the cooling of this waste also went away along with the reactor cooling.

And this is the situation all over the world. This can happen at any site in the world with a nuclear power plant. As is discussed in Into Eternity, also the problem of world wars or wars, new states being formed, all of this instability above ground is a real threat to such facilities. And therefore I could also get the idea that having it buried may be a better solution than having it above ground.

Some of the scientists in the film told me that they find it very difficult to think that every nation in the world will be able to have such a facility as they are building, due to financial restraints in the so-called third world. But also in a country like Japan they said they can never build a repository because of

the geological conditions.

But now, in my opinion, I fear that this is the fact of what they have now in Fukushima because it will never be possible to dismantle this retch of a nuclear power plant. They simply have to cover it up like in Chernobyl.

Helen Caldicott: Yes, but it's still hot and Unit One is still fissioning.

Michael Madsen: That's why if they can get total control, they can only cover it up. But what I think is important to understand in all of this discussion is that a hundred thousand years is, perhaps, beyond human comprehension. It is, perhaps, such a vast time span, that we simply cannot relate to it.

We may have a similar problem, for example, in Japan. One reason why the authorities, as I understand it, constantly have not been telling the full scope of the events, one reason behind that could be that it is more or less unthinkable that [to] evacuate more than 30 kilometers, perhaps the whole of Tokyo area, et cetera – these things are bordering on not only what is physically possible. But also to really understand how bad this is can also be difficult to understand because it is simply outside of human comprehension.

We humans tend to hope for the best. Which is probably a good thing. But in these matters – and as I always say about this film – nuclear energy stands on the shoulders of almost all the scientific knowledge that we have about the universe. It is really the powers of the universe that we are harvesting.

So much knowledge is fused together in this technology. In that sense it's the *hallmark* of human civilization. But the flip side is the waste which has this time span built in to it which I believe is beyond what we can really understand.

So on the one hand it's based on deep understanding in a scientific respect. But it also has this very, very difficult time span for us even to relate to.

Then if we cannot relate to it – if we cannot understand it or grasp it – it's suddenly impossible to act responsibly.

Helen Caldicott: I'm interviewing Michael Madsen who made this incredible film called Into Eternity and it's about the Onkalo Project in Finland.

Michael, would you like to describe to the listeners what the project is. What are they doing in Finland?

Michael Madsen: In Finland they are trying to create the world's first permanent repository for nuclear waste. So for first time it's [being] attempted to create a kind of a bunker-like facility which, half a kilometer down in the ground in a system of tunnels, will contain the waste of Finland,[4]

Helen Caldicott: Is it granite formation?

Michael Madsen: Yes, this is granite bedrock.

Helen Caldicott: It's got bedrock. But does it have cracks in the granite so water can seep through?

Michael Madsen: Yes. It has cracks as I believe all bedrock has. It is the groundwater flow which is the main threat to such a facility because the groundwater is what will flush out the nuclides. What you also have to understand is that any man-made structure is bound to crumble over time.

The Onkalo facility (as I said earlier, meaning "hiding place") is really just a delay mechanism. And the idea is that this will delay long enough – for 100,000 years at least – to render the waste harmless due to its half-lives, et cetera.

But that's the basic idea: to bury it, so to say, having different sort of barrier systems so if one system fails another system will still contain the waste. Just like you have several city walls around a medieval city. It's the same idea. If you breach one barrier you still have another one.

What I am interested in in Into Eternity is really the question about communication and therefore the question about human curiosity. Because even though you have this facility and it is safe, it may not be safe from human curiosity.

We know that everytime we have found something in the ground or found a pyramid or any burial chamber we have opened it because we wanted to see what's in there. And as is discussed in the film, this is also conceivable that [it] will happen in the future. Even if you know it's dangerous, you may still want to have a look.

Helen Caldicott: Yes. Curiosity killed the cat. Absolutely.

Michael Madsen: [Laughter] Yes.

Helen Caldicott: How much nuclear waste do the Finns actually have in terms of tonnage? – number one. And number two, they're about to open this *huge* new reactor facility that was built by Areva, a French company. But there have been terrible problems with the construction. They've drilled holes in the wrong place in the concrete and God knows what and there's been intrigue and maybe some fraud going on.

Would you like to talk about the amount of waste they've got Michael Madsen and the new reactor that Areva has been constructing?

Michael Madsen: The new reactor, to start with that, is only a few kilometers away from the Onkalo facility.[16] And it is true that they have had very, very big difficulties in building it.[17]

We have to understand that if we were comparing nuclear reactors to the automobile industry we would have to say that a nuclear reactor, first of all, is a luxury car. It's the greatest car ever built. The problem with the nuclear industry, of course, is that they have not been building cars since Chernobyl. There have been no new reactors built since that [1986] in the western world.

That means that there is, basically, a lack of knowledge because the engineers have gone on pension or are dead –

Helen Caldicott: Or they're old,

Michael Madsen: – and you're still trying to build a luxury car.

Helen Caldicott: I gathered some information that in France they don't have *nearly* enough young engineers who understand the nuclear issue nor physicists. They're really running out of specialists who know how to run these reactors. Is that what you are talking about Michael?

Michael Madsen: Yes. This is exactly what I am talking about. Of course when you are building something that complex and you don't have, even perhaps the right knowledge anymore and you're also wanting to build something perhaps even more complex – as it's been claimed more safe – but you don't have the know-how anymore. Then it's, of course, extremely difficult.

I think this is one of the problems that has been faced in Finland. And I believe that since we were essentially unwanted at the Onkalo facility when making the film, this resistance that we encountered in the last part of the documentary, I think that came perhaps from the problems that the mother company of the company building Onkalo (which are all private companies) that they encountered with the reactor. So they wanted less, I mean as little public discussion [as possible] about the Onkalo facility also.

Helen Caldicott: Oh.

Michael Madsen: To return to the amount of waste in Finland, I can't remember the figure but the idea is that in 120 years from now 15,000 metric tons is the capacity of the Onkalo facility. And that will by that time hold all of the waste in Finland.

But the problem is now that another private operator has been granted a license to build another power plant in Finland and the waste production from this [new] power plant is not calculated in relation to the Onkalo facility.

So they will have to build their own facility also. Because the private company, Posiva, behind the Onkalo facility does not want to [share their technical knowledge] – I mean it's *their* facility.[18]

And what is so weird, in my opinion, about this is that the money this is financing the Posiva company building this [Onkalo] facility – and I believe the cost is something like 3 billion euros – that money is coming from a tax taken from the Finnish citizens ever since their nuclear energy production started. So this is paid [for] by every Finnish citizen.

But now the know-how rests within private companies. And other companies cannot use this. It's simply a competition parameter. That is a peculiarity, in my mind.

Helen Caldicott: So what do you think about private companies building nuclear power plants? Every single nuclear power plant in America has a different design built by private companies. They're like the plumbing in America. You go into a bathroom and can never work it out because every single bathroom is different. This is the same in nuclear reactors in America.

Michael Madsen: I think that it is in my mind absolutely clear that a private company can only have one goal in this world. And that is to earn money. Because that's the logic of private enterprise and the logic of capitalism also. So therefore it is simply not reasonable to expect from a private company to act beyond it's own survival.

This is what we see TEPCO do in Japan. To believe that they should be acting on behalf of society is simply false. It's a false belief. It's the wish thinking that simply is not compatible with what a private company is. I don't think you can actually blame a private company of acting in its own interest. Because that's the nature of this kind of construction –

Helen Caldicott: But in the nuclear area, Michael, do you then not believe in capitalism? I don't. After what you've just said.

Michael Madsen: My personal opinion doesn't really matter. I'm just saying that once you have such a construction, a private company, then you cannot expect it to act

Helen Caldicott: – responsibly

Michael Madsen: differently than what private companies do. Once you, if you realize that, then you have to say, 'Well then we simply have to have *another* system *if* we want to have control,' for example, 'or have transparency.' Things like that.

Helen Caldicott: Or have responsibility.

Michael Madsen: Yes, yes of course. As some people say, "Radiation does not know any borders.' And that's true. As we saw with Chernobyl the nuclear cloud traveled all over Europe.[19] There is a problem between a private company acting on it's own interest in a spot on this earth. But the consequences may travel all over the world. And then you can ask, 'Is that reasonable? Is that ratio fair? Is it even wise?' you can ask. That is the question to put forward.

Helen Caldicott: There are several points coming out of this conversation too, Michael. With Europe covered as it is with reactors, the Second World War would have meant that Europe would be uninhabitable for the rest of time. So any country that has nuclear power plants, they can't have wars. You can only fight wars in developing countries that have no reactors, *OR* waste repositories. Would you say that?

Michael Madsen: You cannot control where a war takes place. But it is clear; let's imagine that the Second World War was happening today with reactors in large parts of Europe. Then we again encounter a scenario that is very, very difficult to comprehend. Because we would then have to entertain ourselves with the idea that a visit to Paris, Rome, Berlin, would be impossible for –

Helen Caldicott: Does it worry you Michael – that you live in Denmark and you travel a lot through Europe and Kazakhstan and the like – that some of the food you're eating is almost certainly radioactive, containing plutonium and cesium and strontium and the like? Do you ever think about that?

Michael Madsen: No I don't think about that. Because, again if I was thinking about that it would be difficult to go to sleep or it would be a very long sleep so to say. Again, that's one of the problems in this. That if you really think it through you will get in a very bad mood, most likely.

Helen Caldicott: Or you have to practice, when I go to Europe I practice psychic numbing and try not to think about it. But luckily, living in Australia, in the southern hemisphere, we have non-radioactive food. We just sell uranium to the rest of the world, including to Japan. And then we should be advertizing the fact that we have non-radioactive food to a radioactive Europe and we should be selling our food in Europe. But they don't because they'd rather sell the uranium I think.

Michael Madsen: I'm sorry to tell you that ever since the first nuclear test explosions, blasts, the background radiation in the world has been higher than it was before.[20] So you will also have background radiation at a higher level than it used to be in Australia.

But even worse I can tell you that if you would really want to act responsibly in Australia, I can tell you that one of the perhaps foremost critics – a geologist in Finland – of the Onkalo facility, he said to me that to build a facility like Onkalo in Finland is crazy because we know that there will be an ice age.

[During] this ice age the weight of the ice will depress the crust of the earth for 700 meters down and that will of course enhance the fault lines that we know are in the bedrock. So the water flow will increase and perhaps new fault lines will break into the repository perhaps, et cetera, et cetera, et cetera.

But if we really want to act responsibly in terms of building such a repository it has to be Australia.

Helen Caldicott: – Thank you.

Michael Madsen: Because Australia has the most stable bedrock in the world.

Helen Caldicott: – Thank you Michael.

Michael Madsen: And there will be no ice ages.

Helen Caldicott: [Laughter] Well, you don't know there won't be an ice age down here.

Michael Madsen: [Laughter]

Helen Caldicott: We'll we're already heading into that situation because the federal government in its wisdom – and I'm being sarcastic – has found a place of aboriginal land and who cares about the aborigines? Let's be frank, we're a very racist country. It's in the Northern Territory and it's called Muckaty Station.[21]

It actually sits atop probably a tributary of the Great Artesian Basin which is archeological water that supplies a *large* part of the continent with water.[22]

The aborigines are against this. We have tremendous monsoonal rains in that area. Halliburton, which Dick Cheney ran, built the railway line from Darwin to Adelaide. I think a deal was done by our former Prime Minister John Howard, with George W. Bush in the Global Nuclear Energy Partnership,[23] to agree that we may receive some of America's radioactive waste.[24]

And this bill is being pushed through Parliament despite tremendous opposition by the indigenous people and many others.[25] I mean, we're already heading in that direction and this area is over probably the Great Artesian Basin. So you might say we've got good bedrock. And I can't say we don't deserve it by exporting all this uranium all over the world like there's no tomorrow and there may not be.

Michael Madsen: But perhaps it's not even a question about deserving it or not. Let's entertain the idea that you didn't even export uranium. Still, if this is the only really truly suitable place in the world, is it not fair that, in the spirit global brotherhood –

Helen Caldicott: Oh [laughter]

Michael Madsen: – and sisterhood that this is where we'll put the waste?

Helen Caldicott: I'm not sure that I'm glad I interviewed you tonight Michael Madsen [laughter].

Michael Madsen: [Laughter]

Helen Caldicott: You're making my hackles rise on the back of my neck [more laughter]. Oh my God, I mean I see from a philosophical perspective why you would ask that rhetorical question and I suppose from looking at the aspect of nuclear waste down the ages, the time track, I think it is a reasonable question to ask, God help us.

Michael Madsen: Actually I think it is too. The problem is, of course – and this is a problem that will encompass every such a facility – is that, in Finland the argument is that, 'We can put it in the bedrock because the bedrock has been stable for such-and-such a long time. And therefore it will also be stable in the future.'[26]

But it is not a scientific argument to say that because the past looked like that, so will the future look like that.

Helen Caldicott: Yes.

Michael Madsen: That's what the whole thing rests upon in Finland and in any such a repository in the world wherever they may be built. But the problem is – and it is one of the paradoxes involved in trying to handle nuclear waste responsibly towards the future generations – the problem is that we have nothing to compare with and we have no way for testing if it will work simply because the time span is so big. That is the real problem.

Helen Caldicott: It's something like the Fukushima accident where five meltdowns occurring within a few days of each other and hydrogen explosions left, right, and center. This isn't in the textbooks. This is totally unique in the history of the nuclear age –

Michael Madsen: Exactly. –

Helen Caldicott: No one has ever thought about this before.

Michael Madsen: No.

Helen Caldicott: But logical people like you and me, I've always said, 'You can't expect men to be infallible. And we've developed a technology with which we have to be

infallible,' number one. Number two, you have no idea what nature is going to do. Number three, there could be wars and the like. You can go on and on and on.

Why Michael Madsen are you going to go to Chernobyl? I don't think I'd go there. Or if I did I would not breath.

Michael Madsen: I'm going there in relation to an invitation that I'm thinking about [unintelligible]. But also I am working on a new project that will take me to Kazakhstan, to the Baikonur Cosmodrome where the Soviet and Russia has been firing the rockets into the sky. And this is partly what my new project is about.

Helen Caldicott: Describe what is happening in Kazakhstan and what has happened in the past Michael Madsen.

Michael Madsen: This is in terms of the new project (I can only talk in that respect) and that is simply that this is the world's biggest facility for launches into space. And that is partly my interest for the new film that I am working on which I cannot really talk very much about. So it's simply a new project.

But again it is a project that is trying to look at things from a more existential or philosophical angle because that is my interest and sometimes that, for me documentary film-making is in a way you can say it's a possibility to investigate my own time and to journey into my own time and that's what I find interesting.[27]

Helen Caldicott: Isn't America cozying up to Kazakhstan at the moment?

Michael Madsen: I don't know about that. It probably is what every country is trying to –

Helen Caldicott: Because America is moving in a whole new arms race in space and war in space. In fact I wrote a book with Craig Eisendrath called *War In Heaven* where they are planning to fight war from space down to earth. It's called the High Frontier.

Michael Madsen: I am not familiar with that book. And this new project is not really interested in that aspect. But if you look at something like the Space Law from the sixties, the last part of that assembly of principles is really concerned with not using outer space for weaponry of any kind.

Helen Caldicott: That's correct Michael but America is not going along with the space law

Michael Madsen: – Well who is?

Helen Caldicott: – and it's violating the last part . . . Oh my God.

Well look, we're running out of time. But you've got the Director's Note here and I want to read it out to people because I think it's absolutely profound. And it's from you:

> I am interested in the areas of documentary filmmaking where additional reality is created. By this I mean, that I do not think reality constitutes a fixed entity which accordingly can be documented or revealed in this or that respect. Instead, I suspect reality to be dependent on and susceptible to the nature of it's interpretation. I am in other words interested in the potentials and requirements of how reality can be – and is – interpreted.
>
> The ONKALO project of creating the world's first final nuclear waste facility capable of lasting at least 100,000 years, transgresses both in construction and on a philosophical level all previous human endeavors. It represents something new. And as such I suspect it to be emblematic of our time – and in a strange way out of time, a unique vantage point for any documentary.

Can you just, Michael, enlarge on that last point – "out of time," "emblematic of our time," – can you tell us what you mean by that?

Michael Madsen: I can best explain perhaps by the way the narrative is created in Into Eternity. Into Eternity plays around with the narrative idea of addressing a future audience – an audience far, far away in time from today.

This address to the future has the idea that when you watch the film, in a way, you are watching the film as if you were looking from 50,000 years from now or 100,000 years looking back at our time. This attempt to create this perspective gives, of course, what Brecht would have called verfremdung or alienation. It gives you a perspective. So suddenly it's possible to look at our own time with another perspective, with other eyes, so to say.

And the problem about being contemporary is, of course, always that as you say in Denmark, 'You cannot see the forest for the trees,' because you are in the midst of your own time. But [it is] interesting to try to create this perspective of looking back at our own time and that, I hope in making the film, that narrative device would in a way enable us perhaps to get a glimpse of things that otherwise in fact are invisible for us or not ready to be seen.

This kind of imaginary dialogue with the future is the attempt in this film of trying to put a new kind of gaze upon our contemporary time.

Helen Caldicott: Well Michael Madsen, it's been absolutely fascinating to talk to you about your thinking, your philosophy. You are one of the more extraordinary people I think I've ever interviewed, leaping out of our time into the future. Your film is *very* provocative, Into Eternity. So thank you *so much* for this fascinating interview.

Michael Madsen: You're welcome. Let me just add one last thing and that is that there is a new documentary film festival, Antenna, coming up in, I think it is the sixth to the ninth of October in Sydney and they have invited me to join the festival with Into Eternity. That would be a chance to see the film and also attend a Q and A.

Helen Caldicott: Wonderful. But also remember you're addressing an American and a Canadian audience. Are you going to America to do some film festivals Michael?

Michael Madsen: In America it is actually out in several cinemas through international film circles and also in Canada.[15]

Helen Caldicott: Okay. Excellent. Thank so much and very good luck on your future projects.

Michael Madsen: Thank you very much.

Helen Caldicott: My guest today on If You Love This Planet was Michael Madsen, director of the new documentary film, Into Eternity. If you want to listen in podcast to our episodes, feel free to do that. Go to our website, IfYouLoveThisPlanet.org, and then you can put on quite a lot of programs and listen to them as you doing the washing up, driving to work, lying in the bath with a glass of red wine, whatever. Also if you'd like to help with this radio program and you'd like to contribute there is a Support this Broadcast page. We'll be back with you with another fascinating program, probably on the nuclear issue, next week as it's so topical at the moment. Thanks for listening. Bye for now.

You have been listening to If You Love This Planet with Dr. Helen Caldicott. This program is broadcast on community radio across the United States including our host KPFT Pacifica, Houston, Texas. This program is produced and engineered by Jas Williams, co-produce by Scott Powell, and our publicity and outreach are coordinated by Amanda Bellerby. To listen to previous shows, or to make a donation, go to our website, IfYouLoveThisPlanet.org.

Footnotes

1. Into Eternity - review
   This jaw-dropping documentary tackles a subject almost beyond comprehension
   by Peter Bradshaw, *The Guardian*, 11 November 2010

2. To Damascus (2005); See IMDb Full cast and crew listing. From a "News" page of the Transilvania International Film Festival, quoting Michael Madsen:

   > "TO DAMASCUS (2005) was inspired, in terms of narrative and emotions, by Strindberg' first so-called dream-play – essentially about being alienated, not able to trust your own feelings. I had two co-directors, and to equate Strindberg's feelings, we drove in a car from Copenhagen to Damascus trying to film things with emotional connections with the play. We knew we had to go southwest, and our only guide was the sun reflected in the right rear mirror. For sure we made a lot of detours, including three weeks in Romania. In the end it was essentially made in the editing room – with a ratio of 100:1. A nightmare!"

3. Interim facility refers to the process of Interim storage. From the Nuclear Facts section of intoeternitythemovie.com:

> High-level nuclear waste is the inevitable end result of nuclear energy production. The waste will remain radioactive and/or radiotoxic for at least 100 000 years. It is estimated that the total amount of high-level nuclear waste in the world today is between 250 000 and 300 000 tons. The amount of waste increases daily.
>
> Spent nuclear fuel is normally kept in water pools in interim storages. Almost all interim storages are on the ground surface, where they are vulnerable to natural or man-made disasters, and extensive surveillance, security management, and maintenance is required. The water in the pools cools the fuel rods, as the heat emanating from them may otherwise result in radioactive fire, and at the same time, water creates a shield for radioactivity. It takes 40-60 years to cool the fuel rods down to a temperature below 100 degrees Celsius. Only below this temperature may the spent fuel be handled or processed further. Most interim storages are situated near nuclear power plants, as the transportation of waste is complicated, and subject to extensive security issues.

Spent fuel means high level nuclear waste. **See Also:**

From Wikipedia:

- High-level radioactive waste management
- Spent fuel pool
  spent fuel pools (SFP) are storage pools for spent fuel from nuclear reactors
- Spent nuclear fuel
  Spent nuclear fuel, occasionally called used nuclear fuel, is nuclear fuel that has been irradiated in a nuclear reactor (usually at a nuclear power plant). It is no longer useful in sustaining a nuclear reaction in an ordinary thermal reactor.

- Spent Fuel Storage in Pools and Dry Casks Key Points and Questions & Answers, Nuclear Regulatory Commission (NRC)
- Nuclear Waste - Disposal Challenges and Lessons Learned from Yucca Mountain, Government Accountability Office, GAO-11-731T, Jun 1, 2011

4. Onkalo is the world's first permanent nuclear waste repository. From the Nuclear Facts section of intoeternitythemovie.com:

> Onkalo is a Finnish word for hiding place. It is situated at Olkiluoto in Finland – approx. 300 km northwest of Helsinki and it's the world's first attempt at a permanent repository. It is a huge system of underground tunnels hewn out of solid bedrock. Work on the concept behind the facility commenced in 1970s and the repository is expected to be backfilled and decommissioned in the 2100s – more than a century from now. No person working on the facility today will live to see it completed. The Finnish and Swedish Nuclear Authorities are collaborating on the project, and Sweden is planning a similar facility, but has not begun the actual construction of it.

The ONKALO project in Finland is described on a section of the website presented by the builder, Posiva Oy. The company is headquartered on the island of Olkiluoto in the municipality of Eurajoki. This local PDF copy of a report by Posiva Oy – ONKALO - Underground Rock Characterisation Facility at Olkiluoto, Eurajoki, Finland – comes from http://www.posiva.fi/files/375/Onkalo_ENG_290306_kevyt.pdf and was accessed on 11 February 2012.
See Also: A corporate promo animation of building Onkalo by Posvia.

5. Regarding this statement "in the Swedish legislation concerning high-level nuclear waste, the talk is about creatures, living creatures, and not just humans, I asked Michael Madsen if there was legislation containing this wording. He responded:

> I just talked on the phone with Mikael Jensen [see Cast listing]. The above is not mentioned directly anywhere in the Swedish law. However in the different areas of what concerns the environment, it can implicitly be interpreted to be implicitly present. Mikael has himself, as this was part of his job at the Swedish Nuclear Safety Agency, advocated for this to be included as he has used it as an implicit example of what can be the de facto case in the future. So it has been discussed – also as a means to try to make these time spans comprehensible for today's policy makers.

6. I asked Michael Madsen for more information about the law in Finland he refers to here, including the name of the legislation and the year it was passed or enacted. His responded with:

> I am forwarding mail I received from Esko Ruokola [see Cast listing] who is STUK's law-writer. Apart from this, I have never understood where the 100,000 years comes from, but this is what Posiva and STUK both mentioned to me. France, as in the US, says 1 million years.

The e-mail Michael Madsen forwarded me was written by Esko Ruokola in 2008:

> The statements in legislation and regulations are given below:
>
> The **Nuclear Energy Act**[**A**] states the following:
>
> > The Radiation and Nuclear Safety Authority (STUK) shall be entitled, in order to carry out the supervision required under this Act, and by the provisions issued hereunder and by Finland's international treaties in the field of nuclear energy, to:
> > . . .
> > 6) issue prohibitions on measures concerning real estate when this is necessary in order to secure safety, when that real estate includes premises referred to in paragraph 5b of section 3. (738/2000)
>
> The **Nuclear Energy Decree**[**B**] continues the story with the following statement:
>
> > The Radiation and Nuclear Safety Authority (STUK) shall report the disposal site of nuclear waste and the prohibition on measures, referred to in paragraph 6 of section 63 subsection 1 of the Nuclear Energy Act, so that they can be entered in the real estate register, land register or list of titles.
>
> Finally, the Government Decree to be issued soon (will replace the Government Decision 398/91[**C**]) includes the following statements:
>
> > A record shall be kept of the disposed wastes which includes waste package specific information on waste type, radioactive substances, location in the waste emplacement rooms and other necessary data. The Radiation and Nuclear Safety Authority shall arrange for the depositing the information about the disposal facility and disposed waste in a permanent manner.
> >
> > An adequate protection zone shall be reserved around the disposal facility as a provision for the prohibitions on measures referred to in the Nuclear Energy Act (990/87), Section 63, first paragraph, point 6.

References to the above Finish Regulations are as follows:

A. Nuclear Energy Act 11.12.1987/990
   The first segment of this quote is from the beginning of Chapter 10 Supervision and coercive measures, Section 63 Supervisory rights.
B. Nuclear Energy Decree 12.2.1988/161
   quoting Chapter 12 Nuclear waste management, Section 85
C. Decision of the Council of State on the general regulations for the safety of a disposal facility for reactor waste 14.2.1991/398
   The section with wording close to that of the 2 paragraphs quoted above is in Section 7 Post-closure surveillance, which apparently is what was replaced by "the Government Decree to be issued soon."

See Also: from the Source Links section of intoeternitythemovie.com:

> Radiation and Nuclear Safety Authority is the organ of the Finnish state, which oversees the construction of ONKALO, approving it in it's different stages. It is STUK, which suggest the various legislation to be implemented by the Finnish Parliament concerning nuclear waste and nuclear safety: www.stuk.se.
>
> Swedish Radiation Safety Authority is the Swedish pendent to STUK: www.stralsakerhetsmyndigheten.se
>
> The Finnish Posiva OY is the company behind ONKALO. The technical concept behind ONKALO is called KBS-3, and is originally a Swedish concept, but now in collaboration with SKB [Swedish Nuclear Fuel and Waste Management Co], the Swedish pendent to Posiva. Various reports on conservation and knowledge transfer carried

out by SKB, see (PDF in Swedish) fx:
"Identitet och trygghet i tid och rum"
"Kunskapsbevarande för framtiden - Fas 1"

There is an English version of STUK and an English version of the Swedish Radiation Safety Authority (SRSA). In the SRSA website is a section entitled Final Repository which describes KBS-3:

> **Responsibility of industry**
> Sweden has made use of nuclear power since the 1960s. Today, nuclear energy represents nearly half of the country's production of electricity. In the mid-1970s, the Swedish Government determined that producers of nuclear power were to be responsible for the safe management of spent nuclear fuel, and in 1976, the Swedish Nuclear Fuel and Waste Management Company (SKB) was established. SKB is collectively owned by the Swedish nuclear power industry. One of SKB's tasks is to develop a method for the safe disposal of spent nuclear fuel for as long a period of time as is necessary to protect people as well as the environment.
> **SKB's proposed repository method**
> SKB's method is called 'KBS-3'. 'KBS' stands for 'nuclear fuel safety' in Swedish, and the number three designates this as the third and most recent version presented by SKB in its research programme.
> SKB plans to construct a final repository so that radiation safety is guaranteed by what are known as 'barriers'. The spent nuclear fuel will be placed in canisters with an external shell made of copper and an insert of cast iron. The canisters will be disposed of at a depth of approximately 500 metres in Swedish bedrock. These canisters will be surrounded by a special kind of clay that swells when it comes in contact with groundwater. The entire repository will ultimately be filled with clay.
> If you wish to know more about the method developed by SKB, please inquire at its website: www.skb.se.

7. A figure of 75,000 metric tons is cited in the document, "Nuclear Waste - Disposal Challenges and Lessons Learned from Yucca Mountain," published from the Government Accountability Office, GAO-11-731T, Jun 1, 2011:

> Nuclear energy generates about 20 percent of the nation's electric power and, as a domestic source of electricity with low emissions, is a critical part of our energy infrastructure. In addition, military use of nuclear material – in nuclear weapons and nuclear-powered warships – plays a vital role in our national defense. However, both of these activities generate nuclear waste – referred to as spent nuclear fuel in the case of fuel removed from a reactor and as high-level waste for material that is a by-product of weapons production and other defense-related activities. This nuclear waste has been accumulating since the mid-1940s and currently totals over 75,000 metric tons at 80 sites in 35 states, enough to fill a football field about 15 feet deep. Furthermore, this waste is expected to increase by about 2,000 metric tons per year, more than doubling, to 153,000 metric tons by 2055.
>
> The majority of this nuclear waste is expected to be spent nuclear fuel from commercial operators. An estimated 13,000 metric tons of this waste, however, is managed by DOE at five of its sites. Existing nuclear waste already exceeds the 70,000 metric ton capacity of the proposed Yucca Mountain repository.

8. The U.S. Department of Energy's Waste Isolation Pilot Plant site has a section on Passive Institutional Controls that includes a number of reports trying to address the question of how to communicate with the distant future. Of special interest to the makers of Into Eternity is a Los Alamos National Laboratory (PDF) report conducted in 1990 titled, "Ten Thousand Years of Solitude? On Inadvertent Intrusion into the Waste Isolation Pilot Project Repository." Quoting from the movie's Source Links section: "The only other substantial study in this direction, apart from work by Mikael Jensen, SKB, seems to be Roland Posners (editor) Warnungen an die ferne Zukunft (Warning for the distant future): Raben-Verlag 1990"

Also in this collection of reports is a copy of the First Web-page titled, WIPP Exhibit: Message to 12,000 A.D. used to explain warning messages and early concepts with the opening text stating:

This place is not a place of honor.
No highly esteemed deed is commemorated here.
Nothing valued is here.
This place is a message and part of a system of messages.
Pay attention to it!
Sending this message was important to us.
We considered ourselves to be a powerful culture.

9. Also included in the WIPP Exhibit Message to 12,000 A.D. web page are the original drawings of proposed markers used in Into Eternity as well:

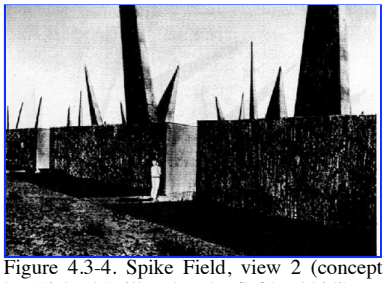


Figure 4.3-4. Spike Field, view 2 (concept by Michael Brill and art by Safdar Abidi).

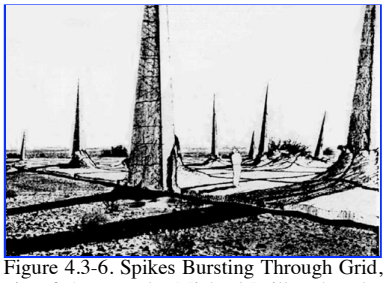


Figure 4.3-6. Spikes Bursting Through Grid, view 2 (concept by Michael Brill and art by Safdar Abidi).

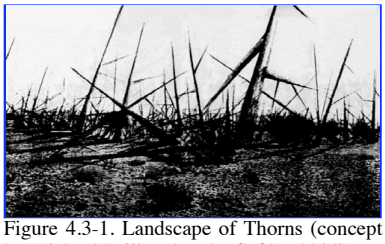
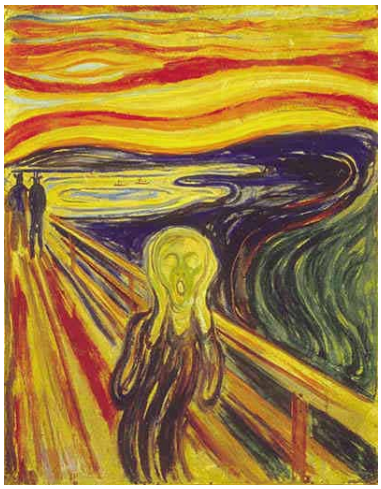
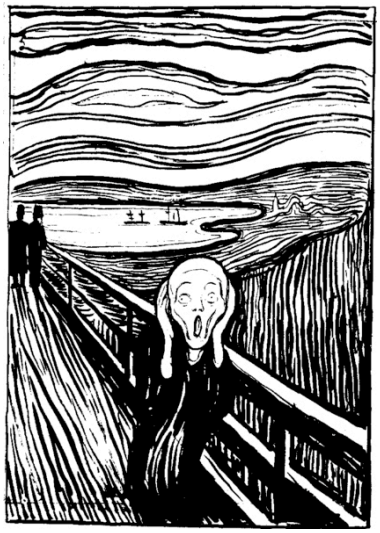
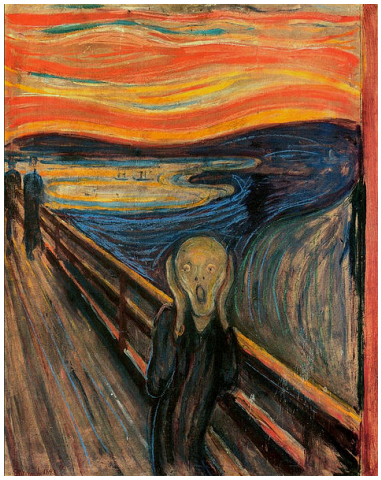


Figure 4.3-1. Landscape of Thorns (concept by Michael Brill and art by Safdar Abidi).

10. Edvard Munch created several versions of The Scream in various media. Copies of these are included in http://en.wikipedia.org/wiki/The_Scream and are reproduced below:







11. **See** The Problem: Nuclear Radiation and its Biological Effects, by Dr. Rosalie Bertell, Ph.D., G.N.S.H., *No Immediate Danger, Prognosis for a Radioactive Earth*, 1985, pp. 15-63.
See also: What Is Factually Wrong with This Belief: "Harm from Low-Dose Radiation Is Just Hypothetical — Not Proven", by John W. Gofman, M.D., Ph.D. Committee for Nuclear Responsibility, Fall 1995;
and A Troublesome Trio: Unrepaired ... Unrepairable ... Misrepaired Injuries, from Chapter 18, Disproof of Any Safe Dose or Dose-Rate of Ionizing Radiation, with Respect to Induction of Cancer in Humans of *Radiation-Induced Cancer From Low-Dose Exposure*, by John W. Gofman, M.D., Ph.D. 1990.

12. **See** "Asleep at the Wheel": The Special Menace of Inherited Afflictions from Ionizing Radiation, by John W. Gofman, M.D., Ph.D., Professor Emeritus of Molecular & Cell Biology, University of California at Berkeley, and Egan O'Connor, Executive Director, Committee for Nuclear Responsibility, Fall 1998.
and
A *Wake-Up Call* for Everyone Who Dislikes Cancer and Inherited Afflictions, by Gofman and O'Connor, CNR, Spring 1997.

13. See the on-going, longterm work being carried out by the Chernobyl Research Initiative (CRI) at the University of South Carolina. A significant member of this group is Timothy A. Mousseau, Associate Vice President for Research and Graduate Education, Dean of the Graduate School (Interim), Professor of Biological Sciences, University of South Carolina, Columbia. An extensive list of articles is available on the CRI's Publications Related to Chernobyl page [accessed 12 February 2012] including:
    1. Møller, A. P., and T.A. Mousseau. 2011. Conservation consequences of Chernobyl and other nuclear accidents. Biological Conservation, 144:2787-2798.
    2. Møller, A. P., A. Bonisoli-Alquati, G. Rudolfsen, and T.A. Mousseau. 2011. Chernobyl birds have smaller brains. PLoS One 6(2): e16862. doi:10.1371/journal.pone.0016862 (pdf)
    3. Mousseau, T.A., and A.P. Møller. 2011. Landscape portrait: A look at the impacts of radioactive contaminants on Chernobyl's wildlife. *Bulletin of the Atomic Scientists*, 67(2): 38-46. (DOI: 10.1177/0096340211399747)
    4. Møller, A.P. and T.A. Mousseau. 2011. Ten ecological and evolutionary questions about Chernobyl. *Bulletin of the Chernobyl Zone,* In press.
    5. Møller, A.P. and T.A. Mousseau. 2011. Rigorous methodology for studies of effects of radiation from Chernobyl on animals and humans. *Biology Letters* of the Royal Society.
    6. Galvan, I., T.A. Mousseau, and A.P. Møller. 2010. Bird population declines due to radiation exposure at Chernobyl are stronger in species with pheomelanin-based colouration. *Oecologia,* doi: 10.1007/s00442-010-1860-5
    7. Bonisoli-Alquati, A., A.P. Møller., G. Rudolfsen, N. Saino, M. Caprioloi, S. Ostermiller, T.A. Mousseau. 2010. The effects of radiation on sperm swimming behavior depend on plasma oxidative status in the barn swallow (Hirundo rustica). Comparative Biochemistry and Physiology – Part A – Molecular & Integrative Physiology, 159: 105-112 (DOI: 10.1016/j.cbpa.2011.01.018)
    8. Møller, A. P. and T.A. Mousseau. 2010. Efficiency of bio-indicators for low-level radiation under field conditions Ecological Indicators, doi:10.1016/j.ecolind.2010.06.013 (pdf)
    9. Møller, A.P., J. Erritzoe, F. Karadas, and T. A. Mousseau. 2010. Historical mutation rates predict susceptibility to radiation in Chernobyl birds. Journal of Evolutionary Biology, doi:10.1111/j.1420-9101.2010.02074.x (pdf)
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Majority of above article sources is from CRI Publications Related to Chernobyl, at the University of South Carolina's Chernobyl Research Initiative.

14. In the United States alone there are 80 such sites in 35 states as described in the June 1, 2011 document, "Nuclear Waste - Disposal Challenges and Lessons Learned from Yucca Mountain," published from the Government Accountability Office (cited above). A map of these sites is included on page 3 (click image to see high resolution version)

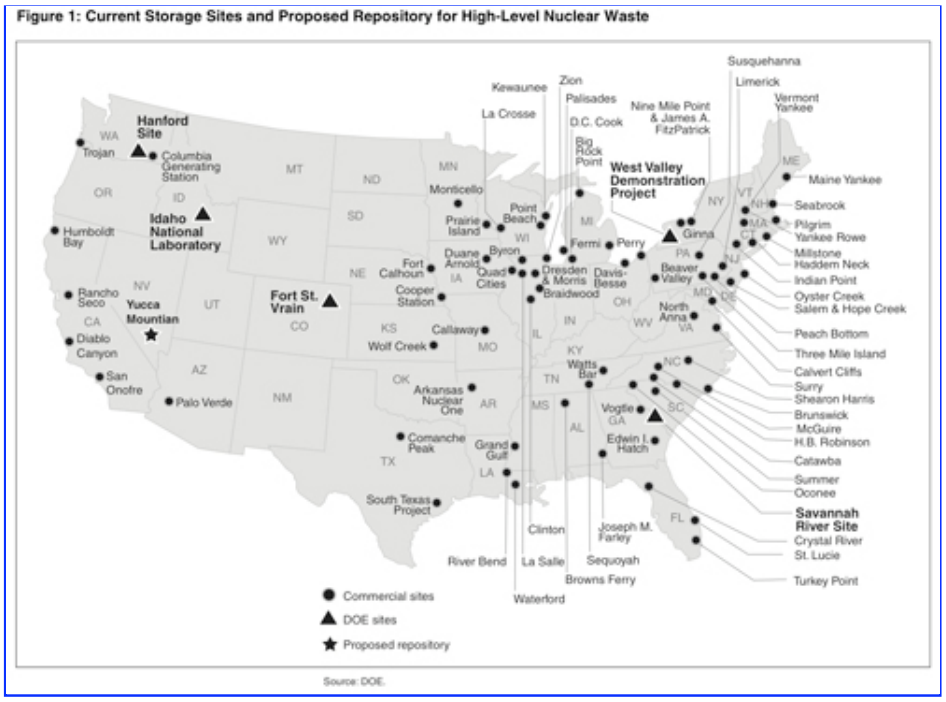

Figure 1: Current Storage Sites and Proposed Repository for High-Level Nuclear Waste

15. Links to where can buy a DVD copy of the film for $29.50 or see it on YouTube in 6 parts are presented at ratical.org/radiation/IntoEternity/index.html#SeeFilm

16. Olkiluoto 3 is to be the third reactor at the Olkiluoto Power Plant on Olkiluoto Island, on the shore of the Gulf of Bothnia in the municipality of Eurajoki in western Finland.

17. See "In Finland, Nuclear Renaissance Runs Into Trouble", by James Kanter, *New York Times*, 28 May 2009. See also the following film clips on YouTube:
    - Finland is Worried about Olkiluoto 3, Made in Germany | DW-TV EUROPA | 22.03.11 | 22:30 UTC (5:01)
    - FINLAND-OLKILUOTO 21.10.2009 ELEKTROWNIA ATOMOWA / NUCLEAR POWER STATION (0:48)
    - Olkiluoto 3: EPR(TM) dome installed (2:57)
    - AREVA Olkiluoto 3 EPR(TM) Reactor Primary Loop Completion, Uploaded by AREVAinc on Dec 7, 2011, (4:44)

18. The Posiva website describes its purpose – that includes a section on Onkalo – in the following terms:
    Posiva Oy
    Posiva Oy is an expert organisation responsible for the final disposal of spent nuclear fuel of the owners. Posiva has been established in 1995.
    Posiva's Owners
    Posiva is owned by Teollisuuden Voima Oyj (60%) and Fortum Power & Heat Oy (40%), both of which share the cost of nuclear waste management.
    Posiva's Role in the Nuclear Waste Management Sector
    Posiva is responsible for research into the final disposal of spent nuclear fuel of the owners and for the construction, operation and eventual decommissioning and dismantling of the final disposal facility. Additionally, Posiva provides expert nuclear waste management services to its owners and other customers.
    Extensive Co-operation
    Posiva works together with numerous Finnish and foreign expert organisations from a multitude of fields, and commissions studies related to nuclear waste management from universities and other institutions of higher education as well as from research institutes and consulting businesses.

Posiva's People
In 2011 Posiva employs around 90 people. The company had a turnover of some EUR 61 million in 2010 and is headquartered in Olkiluoto in the municipality of Eurajoki.
SEE ALSO more about Onkalo in footnote 4 above.

19. See In depth: Chernobyl's Accident Path and extension of the radioactive cloud. This is a graphic reconstruction of the path of the first 14 days of the 1986 Chernobyl radioactive plume, tracking the release of caesium-137. It was created by the Institut de Radioprotection et Sûreté Nucléaire (IRSN), the French Government's official agency on radiation and nuclear matters. It is a graphic illustration of the vast extent of radioactive contamination of Europe (and eventually the rest of the Northern Hemisphere) by the developing Chernobyl catastrophe.

20. See: "1945-1998" by Isao Hashimoto, A Time-Lapse Map of Every Nuclear Explosion Since 1945. Multimedia artwork. "2053" – This is the number of nuclear explosions conducted in various parts of the globe. The number excludes both tests by North Korea (October 2006 and May 2009).

21. From Wikipedia:

> Muckaty Station, also known as Warlmanpa, was a pastoral lease, now Aboriginal freehold land in Australia's Northern Territory, near Tennant Creek. . . . There are seven Aboriginal groups or clans who are traditional owners of the land and dreaming sites now known as Muckaty Station (and often referred to as just "Muckaty"): Milwayi, Ngapa, Ngarrka, Wirntiku, Kurrakurraja, Walanypirri and Yapayapa.

22. From Wikipedia:

> The Great Artesian Basin provides the only reliable source of freshwater through much of inland Australia. The basin is the largest and deepest artesian basin in the world, stretching over a total of 1,711,000 square kilometres (661,000 sq mi), with temperatures measured ranging from 30°C to 100°C. It underlies 23% of the continent, including most of Queensland, the south-east corner of the Northern Territory, the north-east part of South Australia, and northern New South Wales. The basin is 3,000 metres (9,800 ft) deep in places and is estimated to contain 64,900 cubic kilometres (15,600 cu mi) of groundwater.

In an e-mail response to a query about Muckaty Station and its proximity to the Great Artesian Basin (GAB), Dr. Caldicott wrote,

> Muckaty Station in the Northern Territory [is] where the government wants to store Australiaï¿½' radioactive waste but probably also foreign waste. There are aquifers underlying Muckaty station and no-one has accurately charted the extent and communication systems of the aquifers so it could well communicate with the GAB.

A map of Muckaty Station's location is shown with a drawing of the Australia's GAB:

See Also: PDF map of the GAB from www.environment.gov.au/ (local copy on ratical).

23. From Wikipedia,

> The International Framework for Nuclear Energy Cooperation (IFNEC) formerly the Global Nuclear Energy Partnership (GNEP) began as a U.S. proposal, announced by United States Secretary of Energy Samuel Bodman on February 6, 2006, to form an international partnership to promote the use of nuclear power and close the nuclear fuel cycle in a way that reduces nuclear waste and the risk of nuclear proliferation. This proposal would divide the world into "fuel supplier nations," which supply enriched uranium fuel and take back spent fuel, and "user nations," which operate nuclear power plants.

24. See Plans for Australia to become world's nuclear waste dump, by Sandi Keane, *Independent Australia*, 18 April 2011.

> Despite the Fukushima disaster, Alexander Downer has come out in support of Australia storing the world's nuclear waste. Sandi Keane looks at the secret plans developed by John Howard and George W. Bush to turn Australia into the world's radioactive waste dump, with healthy profits for all. Is this how Tony Abbott plans to pay for "direct action" on climate change?

25. Australia's New National Radioactive Waste Bill targets Muckaty Station, on Aboriginal land by Natalie Wasley, *Antinuclear*, 8 February 2012.

> As pointed out in the House of Reps debate, it bears uncanny similarity to the Coalition's legislation it purports to replace, the main difference being it specifically targets Muckaty – a site nominated in the Howard era. Mr Wroe's piece also ignores the ongoing opposition to the waste dump from the NT government and many Traditional Owners of the Muckaty Land Trust, who have built broad national support for their campaign and launched a federal court challenge against the nomination of the Muckaty site. If I was David's driving instructor, I would tell him to look more carefully at the traffic signals.

26. At 19:58 minutes, Timo Seppälä (Senior Manager, Communications, Onkalo, Posiva Oy) states,

> We have come to a conclusion that the bedrock, the Finnish bedrock, 1.8 billion years old, is the medium that we can predict, far to the future, at least 100,000 years ahead.

27. See the following for articles and information about what Michael Madsen has been engaged with since talking with Helen Caldicott:
    - Film maker Michael Madsen joins the Unknown Fields Summer 2011 Trajectory from Chernobyl to Baikonur Cosmodrome
    - Unknown Fields Division Part I: Chernobyl Exclusion Zone An architecture report from Pripyat, by Nelly Ben Hayoun, *Domus*, 3 August 2011
      An international, multidisciplinary team of researchers visits the zones where the myths of the near future are manufactured
    - Unknown Fields Division Part III: Baikonur Cosmodrome - An architecture report from Baikonur, by Nelly Ben Hayoun, *Domus*, 10 August 2011
      On hand for the launch of a space telescope, the UFD team completes its mission to technologically altered landscapes at the Baikonur Cosmodrome
    - KNOCK KNOCK
      10 November 2011, *Danish Film Institute*
      IDFA FORUM 2011. "A cosmic documentary comedy" is the tagline for Michael Madsen's next big film project "The Visit" which takes a close look at how we humans would react if – or when – we are approached by intelligent life from outer space. According to the United Nations Office for Outer Space Affairs the very first step in an alien emergency plan would be, quite simply, a phone call: "They have arrived."
    - VISITORS FROM OUTER SPACE
      21 November 2011 | By Annemarie Hørsman | *Danish Film Institute*
      INTERVIEW. How would we react if we were visited by aliens? Michael Madsen, who is delighted to see his award winning documentary "Into Eternity" moving into real political power forums, continues his speculative reflections in his next project which tests our imagination with a story of humanity's encounter with alien intelligent life.