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26 August 1998

Submission to the EIS on the Beverley Uranium Project

Foreword

Uranium mining is the first step towards

- **Nuclear weapons:** A global nuclear war could end life on earth.
- **Nuclear accidents:** The partial core melt down at Chernobyl may cost 1 million lives by the year 2030. A full core melt down may be 200 times worse.
- **Radioactive waste:** The worst kind of radioactive waste is the waste from uranium mining because it contaminates the biosphere forever. This makes uranium mining by far the most deadly aspect of the whole nuclear fuel cycle. The waste from fifty years of uranium mining will bring death and disease to our future generations for billions of years. It is estimated that over the next 500,000 years - a time span equivalent to the past human inhabitation - 200 million people will die here in Australia due to the waste from our uranium mining (tens of billions if the full time span of the risk is considered).

Uranium mining is an unprecedented crime against humanity. This crime, amounting to mass murder of our children's children and the potential extinction of life on earth, has been legalised by a succession of Australian governments. There is no constitutional protection of human life and health in Australia. This allows governments to pass laws permitting uranium mining, permitting mass murder.

Many scientists, politicians and bureaucrats have deliberately ignored the deadly consequences of uranium mining, even going to great extent to cover up the crime, to mislead the public and to stifle and intimidate those concerned. They have become the white-collar murderers of the nuclear age. More than ever before, Australia's destiny is influenced by such people.

The 30-year delay of the closure of our asbestos mines was a similar crime, just on a much smaller scale. Today, the victims and their families pay the price. If those responsible had been subjected to the criminal law we might not have to go through the same experience again, now with uranium mining. If those responsible were made liable for their actions the taxpayer would not have to pay the hundreds of millions of dollars for victim's compensation and clean-up measures.

A constitutional protection of human life - including the lives of our future generations - could void those laws legalising uranium mining and similar atrocities. This would bring an immediate end to uranium mining and allow the criminal prosecution of those responsible. A criminal investigation of Howard, Hill, Needham, Parer, Pittar, Kerin, Body, Chapman, Bishop, Ferguson, McDonald, Shirvington, Parbo, Morgan, Foldenauer and others is urgent to deter atrocities like uranium mining in the future. An immediate stop to uranium mining would be preferable though.

Australia is about to become the biggest supplier of uranium on the planet. Every year, we continue uranium mining at the currently approved rate, will cost an estimated 4 million lives from our future generations, and will further increase the risk of worst case accident and nuclear war.

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SUMMARY:

Uranium mining is in no way a sustainable development. It has no constructive balance between economy, environment and the welfare of the people. In the long term, uranium mining will destroy all three.

1. After uranium mining, at least 80% of the radioactivity of the original ore remains in the mining waste, be it ‘tailings’ or 'waste sludge' and 'waste solution'. This mining waste is usually dumped near the mine site, either on the ground or below ground.
2. Nearly all of the radiation of the uranium ore is alpha radiation. Alpha radiation is about 20 times more dangerous than beta and gamma radiation.
3. The alpha radiation of the natural ore has little effect on humans because an alpha-radiating substance needs to be inside the human body to be bio-effective. The uranium, being buried in the ground and being fixed in the mineral structure of the ore, has little chance to enter the human body. However, to extract the uranium, this changes dramatically:
    - During conventional uranium mining (at Olympic Dam, Ranger and Jabiluka) the ore is being finely milled -- to particle sizes, which easily can get inside the body via inhalation and ingestion. Also, the fine milling facilitates leaching, erosion and dispersion of the tailings. Fine milling increases the detrimental effect of the tailings radiation many million times.
    - During in-situ-leach mining (Beverley and Honeymoon) the uranium is extracted in the ground by pumping strong acids or alkaline reagents into the ground. Then the uranium leachate is pumped back up to the surface. Obviously, large quantities of dissolved uranium escape into the aquifer from where they will reach the surface, initially via water bores and later via springs and seepage. Dissolved uranium has a very high affinity to plants thereby entering the food chain and remaining there permanently.

    During conventional uranium mining as well as during in-situ-leach mining, the previously stable form and location of the ore's radioisotopes are being modified increasing their mobility and their ability to be assimilated by flora and fauna millions of times. This causes large scale human exposure in the future.
4. The most dangerous isotope in the mining waste is the gaseous radon-222. It is continually being produced in the waste as a decay product of radium and indirectly of thorium and uranium. It can carry four alpha decays of the uranium decay chain to distant locations. Uranium mining will facilitate the escape of this radioactive gas. Radon spreads the contamination over thousands of kilometres.
5. The radioactive contamination from uranium mining waste remains deadly for up to 30 billion years due to the extremely long half life of one of the two parent isotopes in the mine waste. Fifty years of Australian uranium mining will bring death for billions of years. For each year we continue uranium mining in Australia an estimated 4 million future Australians will die from radiation cancer.
6. Radioactivity can not be perceived with the senses. This makes us dependent on our knowledge and understanding of the dangers. Over the long time spans involved knowledge and understanding will be lost. Already today, the knowledge is not even passed on to those people most exposed. In the future, many people will be living and working in areas contaminated with radioisotopes. They will grow their food on contaminated soil and drink contaminated water. The tragic consequences (mainly cancers and genetic damage) appear only years after the exposure, thereby further obscuring the reasons for suffering and death.
7. While the radioactive hazard from uranium mining waste require safeguarding for billions of years the Australian regulations demand a life expectancy for a repository of 1,000 years only. However, after 1,000 years the uranium mining waste retains 99% of its initial radioactivity (this

is not an estimate but a scientific fact).

8. The various draft and final environmental impact statements for Jabiluka, Olympic Dam Expansion and now Beverley have again and again not addressed the main issues of uranium mining, the very issues that can not be resolved. The time scale of the contamination, the ever spreading contamination, the impossible task of our children to recover the waste and to properly contain it, the cost of future life and health. This perverts the very purpose of the Environmental Impact Assessment process.
9. Several claims have been made, which further question the integrity of the EIS provided, which would require independent investigation and public scrutiny. An example is the highly contradictory baseline study. How are those people concerned about the environment meant to test the baseline data when not even access to the site is permitted, when the Field Leach Trial has already severely contaminated the aquifers, when no funds are provided?
10. By now, Australia has accumulated some 60 million tonnes of radioactive uranium mining waste, a waste that should never be in contact with the biosphere for infinity. The creation of another 600 million tonnes has already been approved - enough to cover the whole of Victoria 1.3 mm high. Also, trillions of tonnes of soil and ground water have been contaminated by now.
11. The cost of recovering and relocating the waste to a safe repository (as safe as something can be stored for billions of years, away from groundwater, away from wind and weather, away from possible human interference) will be many thousand times the total income of those mining ventures. The regulations provide for the government to resume responsibility and bear costs shortly after mine closure.
12. Recently, nuclear energy and uranium mining have been promoted as Greenhouse-friendly. It is neither ethical nor possible to combat our Greenhouse problems with a ‘nuclear solution’ which will be borne by our future generations with disease, genetic damage and billionfold death from radiation cancer. Greenhouse emissions have to be reduced <u>and</u> uranium mining has to end.

This submission further provides comparisons of various waste storage options and estimates of the future death toll based on a study by the US Environmental Protection Agency. Also attention is given to the regulatory, political and ethical aspects, including concepts for a revised EIS process.

1 The three main dangers arising from uranium mining and the severity of those dangers

Uranium mining is the first step towards

- **Nuclear Weapons:** 200,000 humans died in Hiroshima. A 'modern' nuclear bomb can kill millions. A global nuclear war could end life on earth.
  Since 50 years we have had to live with the ever-present threat of a nuclear war, be it initiated by accident or by insanity. In 1996, the International Court of Justice has ruled against the use and threat of use of nuclear weapons. The United States declared the verdict irrelevant. Since then, more countries have followed their example and have become nuclear powers. There are many more countries keen to develop their own nuclear weapons, mainly in Asia. While nuclear reactors in Europe and US are gradually being phased out, the Asian market remains the last expanding market for uranium. Australian uranium mining expansion is largely designed for this Asian market. When India recently performed its first nuclear weapons test, the staunch friend of uranium mining John Howard called out: "It is madness."
  The Nuclear Safeguards Agreements, intended to restrict the use of uranium for nuclear weapons, have been incapacitated by a wide range of exceptions and shortcomings (obligation swaps, origin swaps, lack of controls, and even lack of power to control). Australian uranium is obviously able to end up in nuclear weapons, be they French, Indian or Pakistani. The state-owned French company Cogema - the main uranium supplier to the French nuclear weapons program - is actually one of the major shareholders of ERA (Ranger, Jabiluka). The owner of the proposed Beverley uranium mine, General Atomics, has supplied the Romanian dictator Ceausescu with a nuclear research reactor, a precondition for a nuclear weapons program. The US complemented the deal with 16 kg of weapons-grade uranium (Moody, 1992, p.390).

- **Nuclear Accidents:** The worst case accident in a nuclear reactor, a core melt down, is the second ever-present threat to everybody on this planet. The first big warning, the near core meltdown at the Three Mile Island reactor (US) was ignored. The second warning, the tragic partial core meltdown of the nuclear reactor at Chernobyl will cost several hundred thousand if not millions of lives over the next 40 years as the radiation cancers develop.

  Instead of heeding the warning, the nuclear establishment tries to fake the numbers. The Australian Uranium Information Centre breaks all records by claiming only 31 deaths from the Chernobyl accident. The International Atomic Energy Commission concedes 600 deaths while the Ukrainian Health Department already recorded 125,000 deaths by 1995 in the Ukraine alone. A complete release of the reactor's radioactivity may have been 200 times worse.

  More than half of the death toll from the Chernobyl accident is actually expected in Europe, some 2000 km away from the accident site. This means that the proposed new nuclear reactor at Lucas Heights, Sydney, and the planned reactors in Indonesia - all to be fuelled by Australian uranium - are a threat to all Australians. The Federal Government promotes both projects.

  There are daily incidents and accidents in nuclear reactors. Most of them are being kept secret, some become public months or years later. The nuclear reactor at Lucas Heights, Sydney, had several severe incidents, the most recent one the corrosion and leakage of the underground storage tubes for the spent fuel rods - kept secret for a long time.

- **Radioactive Waste:** There are many types of radioactive wastes from uranium mining, nuclear weapons production and nuclear reactors. The worst type is the radioactive waste from uranium mining because it contaminates the biosphere forever. This waste is being produced in vast quantities in Australia – 14,000 tonnes each day. It is estimated that the Australian uranium mining waste will cost billions of lives in the future, the lives of our future generations. This waste remains dangerously radioactive for up to 30 billion years. This submission and my study "Long-term consequences of uranium mining", July 1998, further analyse these hazards.

2 *The effects of the radioactive waste from uranium mining*

2.1 Health effects of radiation

The most commonly known health effect due to uranium mining is lung cancer. It is triggered by the inhalation of airborne isotopes. These are gaseous (radon) and fine dust particles (uranium and its radioactive decay products). Inhalation is the main pathway for the radiation hazard. Where the radioactive contamination has spread from the uranium mine into the water, soil, vegetation and fauna of the region, ingestion of tailings material becomes another important pathway of contamination.

The health effects from exposure to the radiation also include birth defects, still births, leukemia, gastro-intestinal cancers (and many other cancers), Downs Syndrome, premature aging, heightened susceptibility to diseases...

Where the mining operations are very messy, such adverse health effects can already appear during mining, even though on a smaller scale.

2.2 Why is the mining waste much more dangerous than the original uranium ore?

The main radiation hazard of uranium mining comes from the powerful alpha radiation. Unlike beta and gamma radiation, it can not penetrate the skin due to the large size of the emitted particle (the 'ray'). It is only when alpha radiating material is inhaled or ingested that it becomes dangerously bio-effective, many times more than beta or gamma radiation.

The uranium, being buried in the ground and being fixed in the mineral structure of the ore, has little chance to enter the human body. "Uranium is present in the Beverley ore zone primarily as coffinite, a uranium mineral insoluble under normal conditions" (BevEIS, 1998, p.4-28). The alpha radiation of the natural uranium ore has little effect on humans because an alpha-radiating substance needs to be inside the human body to be bio-effective.

However, when alpha radiating ore is milled into small particles or when the radioisotopes are leached out of the rock with strong chemical reagents, a completely new situation arises: the radioisotopes become mobile. They can become airborne and inhaled or they can reach via the groundwater roots of plants to become assimilated and enter the food chain. Now the alpha radiation becomes many million times more detrimental to human health than the alpha radiation from the original uranium ore sitting in the ground.

2.3 Pathways of contamination

There are three severely hazardous radioactive waste categories from uranium mining at Beverley: fine solids, dissolved radioisotopes and the radioactive gas radon. Their exact proportionment depends on the mining process used and on the geochemistry of the deposit.

The **fine solids** in the mine waste include:

1. Pond sludge due to settlement and evaporation
2. Bore and process sludge from filtration, scale formation …
3. Fine particles in aquifer onto which some of the previously leached radioisotopes have precipitated
4. Fine ore particles mobilised by the leaching process

After an initial period the time span of the contamination from the fine solids will be determined by the half life of uranium-238 (the parent isotope of the uranium decay chain) and the half life of thorium-230 (parent isotope of the incomplete uranium decay chain). These half lives are 4.5 billion years and 76,000 years respectively. Integrated over the time spans involved (up to 30 billion years), uranium-238 determines the contamination to 99%. However, for the first 300,000 years thorium may be more important (this can only be guessed as data on thorium content of the wastes have not been released in the EIS).

The company proposes to bury some of the fine solids in 5m deep trenches and cover them with 2 metres of unspecified materials. Others are to be injected into the local aquifers for disposal or are simply to be dumped into pits and covered with soil.

The fine solids are highly mobile in the environment. They are subject to water erosion, wind erosion, dispersion over thousands of kilometres by the wind, entry into aquifers, movement within aquifer, (re)surfacing via springs, seepage and water bores, leaching of isotopes, assimilation by plants and animals, ingestion and inhalation by humans.

The **dissolved radioisotopes** in the mine waste include

1. Uranium leachate not recovered from underground
2. 'Lixiviant bleed'
3. 'Spent eluant'

Again, the dominant half life of those wastes is 4.5 billion years.

Nearly all of the dissolved radioisotopes are intended to be injected of into the local aquifers. Some of them will be sufficiently diluted to allow them to remain dissolved. They will eventually reach the biosphere via springs, seepage and boreholes. The western region of Lake Frome is already today used agriculturally. Future climatic changes, and in particular the pending Greenhouse Effect could bring intensive agriculture to this region. More rain would also flush the dissolved radioisotopes more rapidly out of the aquifer and into the biosphere. There they are ready to be assimilated by plants, animals and humans to cause genetic defects and cancers forever.

Those wastes, which are too concentrated to remain dissolved, will precipitate in various forms, especially onto humates, organic matter and clays. Their new fixation is nearly always much weaker than the original mineral compound. This means that they are available for re-dissolution into the groundwater as soon as the groundwater consistency becomes more favourable for this. The groundwater is subject to many influences, and therefore often changes its nature over the long time spans involved. Once re-dissolved these radioisotopes are again ready to reach the biosphere and food chain.

Also, the presence of organic matter and humates in the ground water provides usually a more attractive bond than the clay for the isotopes. This fixation does not inhibit the mobility of the isotopes in the ground water. The underlying Namba formation is described to be rich in organic matter which may affect the mineralised aquifer.

The **radioactive gas radon** emanates from all the above wastes. Radon is an indirect decay product of uranium and of thorium, and is continually produced as long there is any uranium or thorium present (up to 30 billion years). Radon has a half life of about 3.8 days. This means that the radon has only a limited time to reach the atmosphere and the lungs of any breathing being.

If the radon emanating isotopes are covered by several metres of soil or water, then hardly any radon can reach the atmosphere, as is the case with the original uranium ore and with the radioactive wastes dumped into the aquifer. However, as the dissolved wastes in the aquifer re-enter the biosphere (see above) and as the buried solids become eroded and dispersed, radon can easily escape and travel up to some 3000 kilometres within its half-life. After 3 half lives (11 days) there are still some 12.5% of the radon left which makes the radon emanation from each uranium mine a global cancer risk.

Therefore the radioactive wastes from the Beverley mine will eventually contaminate the very large floodplain of Lake Frome via dispersion by water, and the whole of Australia via wind dispersion of fine particles and radon gas.

2.4 Quantities of contaminants

For the radioactive solid wastes the Beverley EIS states "there will be only small amounts of [solid] radioactive wastes requiring management" (p.4-33). These 'small amounts' are not any further quantified. According to my estimates they could be anything between 500 tonnes and 10000 tonnes annually, largely depending on the evaporation rate versus aquifer injection rate of the liquid wastes.

The radioactive liquid wastes are according to the EIS 33,000 tonnes of lixiviant bleed and 5000 tonnes of discarded eluant annually, equivalent to some 50,000 kg of dissolved uranium (see BevEIS, 1998, p.4-35).

The quantities of non-recovered uranium leachate is unknown and can not be determined in advance with any certainty. The proponent has every reason to keep the losses secret just like they kept the spillage of 500 litres of uranium leachate during the field leach trial secret.

If 5% of the uranium leachate are not recovered then 380 million litres of uranium leachate will be retained in the aquifer system annually, equivalent to some 80,000 kilograms of dissolved uranium.

If uranium leachate escapes through the Poontana fault into the Great Artesian Basin or to the springs in the western region of Lake Frome, the escape of uranium leachate could be significantly higher.

2.5 Time spans of contamination

The time span of radioactive contamination depends on half life and concentration of the isotope involved. A half life of an radioisotope is the time span after which half of the isotope has decayed into another element. After 2 half lives 25% of the isotope remain, after 4 half lives 6.25%, and after 10 half lives 0.1%. If the concentration of an isotope is relatively low, 4 half lives may be required to reach reasonably safe radiation levels. In the case of a high isotope concentration 10 half lives may be required to reach reasonably safe levels.

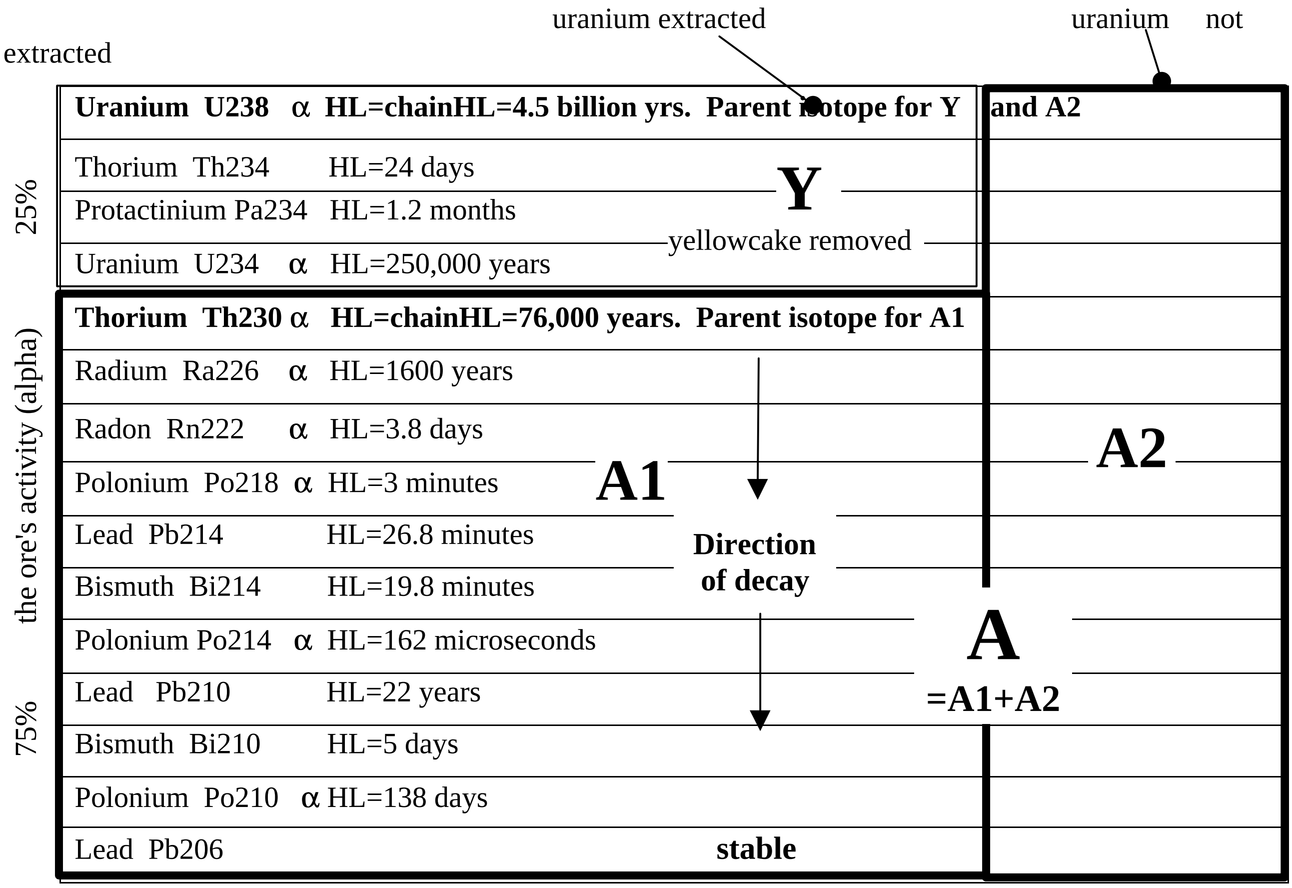

Fig.1: Isotope balance in mined aquifer

"Y"=radioisotopes removed as a consequence of uranium extraction (chainHL=4.5billion y)
"A" = "A1" + "A2" = radioisotopes in aquifer
"A1"= Radioisotopes with thorium 230 as parent isotope (chain half life = 76,000 years)
"A2"= Radioisotopes with uranium 238 as parent isotope (chainHL = 4.5billion y)

In the case of uranium ore there is a decay chain of 14 radioisotopes involved, with uranium-238 being the parent isotope, the longest lived isotope at the beginning of the decay chain. The parent isotope's half life becomes the half life of the decay chain: the activity of each isotope is halved after 4.5 billion years regardless of the individual isotope's half life (due to the ongoing re-supply of new isotopes from the large 'reservoir' of the parent isotope).

After uranium has been extracted from the ore, thorium-230 becomes the new parent isotope for the shortened decay chain. Thorium-230 has a half life of 76,000 years. The Beverley EIS does not provide any data on thorium. Data from another acid in-situ-leach mine suggest that very high levels of thorium 230 are being dissolved from the ore. These high thorium levels were largely retained in the aquifer, even after major restoration efforts (1 year of continuous treatment). If this applies to Beverley as well, thorium-230 would become the dominant parent isotope during the first 300,000 to 500,000 years, and thereafter uranium-238 would become the parent isotope for infinity (see Fig.2).

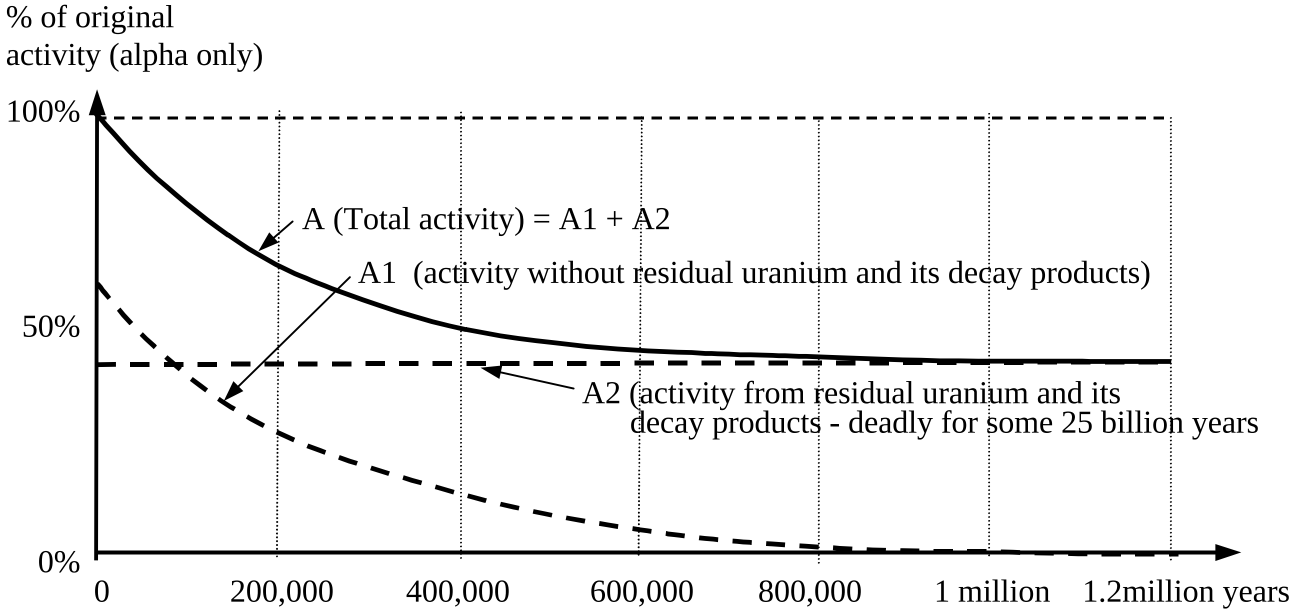

Fig.2: The aquifer's activity after mining (uranium extraction rate: 60% of the ore's uranium) - simplified due to lack of data -

After 600,000 years the radiation levels in the aquifer remain nearly constant for billions of years. In reality, the radioisotopes do not simply remain in the aquifer but will reach in substantial quantities the biosphere - where they should never be.

2.6 The lost knowledge

The knowledge and understanding of the situation will certainly be lost within a few thousand years if not much earlier:

At some stage in the future, people will forget the locations of radioactive contamination because of other problems and issues, which consume all their attention, like extended periods of famine, war, plague, of low levels of culture and science or because of migration. Then it can be expected that people not only work, grow food and live near the contaminated areas, but do all these right on top of the contamination.

Similarly, at some stage in the future the understanding of the radiation hazard will be lost just like the Egyptians lost the understanding of their ancient culture. People will forget how the contamination can spread via the groundwater, via release of radon gas into the atmosphere and via erosion by wind and water. Also they will forget how to measure radioactivity and how the radiation affects health.

In Australia, we currently live in an extended period of migration - or occupation - where the culture of the Aboriginal people is being gradually destroyed. With this cultural destruction we loose the knowledge of the land including the knowledge of those danger spots of radiation which Aborigines described as sickness country and punishment areas. While some of these ancient legends are still being told and while we are warned not to dig in the soil of those areas, while the pending destruction is foreshadowed, the white invaders are busy digging and leaching out every bit of the most dangerous metal uranium. How can we expect that the people of the future will safeguard the consequent contamination for billions of years?

Today we are digging out the uranium despite our advanced scientific knowledge about these dangers, despite our vivid experience of some of the consequences, of the nuclear bombs at Hiroshima and Nagasaki, and the partial core meltdown at Chernobyl. How could anybody claim that the people of the future will become and remain aware of the tailings hazards to such an extent that they abide by the restrictions - for billions of years into the future?

Already today, the information is not passed on, not even to those most affected, but rather encrypted into some scientific reports. Consequently, children have been playing and swimming in tailings dams at Port Pirie in South Australia for years. The government had to be forced by repeated public pressure to erect fences and to cover the tailings. There is still no ongoing health observation for those exposed.

In an example from Bulgaria, the tailings radioactivity got into the food chain: a farmer grew wheat on contaminated soil near a uranium mill. Regular consumption would have lifted the dose 74 times above the legal limit (see section 3.3.2 of my study "Long-term consequences of uranium mining" for more details).

This future loss of understanding of the situation will be inevitably combined with a lack of perception for the dangers. No human senses can detect radiation. Alpha radiating dust either inhaled with fresh air or ingested via the food chain will have no immediate effects. The most common consequence, cancer, becomes apparent only after some 10 to 50 years. Other effects like genetic damage and slightly increased ageing are even more subtle.

2.7 The future death toll

In my previous submissions to the Olympic Dam Extension and the Jabiluka proposal, and in my study "Long-term consequences of uranium mining" (1998), estimates of the future death toll from uranium mining have been provided. These estimates are based on estimates by the U.S. Environmental Protection Agency, and they have been adopted to the Australian situation with particular consideration of the long-term effects. Also a comparison with the results of the OECD and UN-SCEAR has been provided. Most of these estimates and comparisons are being included in this submission in section 5 and in Appendices 5, 6 and 7.

A specific estimate for Beverley has not been provided, largely due to a lack of data in the EIS. However, this section intends to provide some sort a comparison of the long-term effects of Beverley with those from Jabiluka.

The most fundamental difference is the mining method: Jabiluka intends to apply the conventional mining method of digging out the ore and extracting the uranium in a plant above ground. This leaves a very large amount of finely milled mining waste, the tailings. At Jabiluka, these tailings are to be buried in a purpose built mine pit from where they will eventually, over various pathways, reach the biosphere.

At Beverley, it is proposed to extract the uranium with the in-situ-leach process. This involves the leaching of uranium from the ground by pumping large volumes of acid (or alkaline reagents) into the ore deposit and pumping the uranium leachate back above ground for further processing. This process leaves large amounts of dissolved radioisotopes in the aquifer. It is also proposed to pump the radioactive waste solutions created above ground, back into the aquifer.

The perceived 'advantages' of the Beverley process are

- that a certain proportion of those dissolved isotopes dumped into the aquifer may never come up to the biosphere again.
- that a certain proportion of the ore's radioisotopes are not dissolved or moved in the first place (the exact proportion is unknown as the released field trial data do not contain any information on the majority of those isotopes). However, this advantage is very limited due to the fact that those isotopes which are possibly not dissolved in the process have a much shorter half life than those which are certainly dissolved. The longest lived isotope possibly not dissolved (lead-210) has a half life of only 22 years. This means that within a few decades the advantage has disappeared while the problems from the longer-lived isotopes remain for billions of years.

The clear disadvantages of the Beverley proposal are

- That the waste consists mainly of easily soluble and dissolved isotopes instead of finely milled tailings particles. Dissolved isotopes have a much larger affinity to plants and animals, to the permanent inclusion in the biosphere and food chain than the finely milled tailings from conventional mining.
- That the most important isotope, uranium-238, is specifically targeted with the leaching chemicals and therefore dissolved in very large quantities. Uranium-238 is so important because it is the parent isotope of the decay chain and therefore continually creates all the other isotopes of the decay chain as its direct or indirect decay products, including the most dangerous isotope radon. Also, dissolved uranium-238 has a very high chemo-toxicity with a limit for inhalation and ingestion of 7 nanogram per day per kilo body weight being currently discussed for a new threshold (about 70 times lower than the threshold value used in the EIS).

Due to a lack of data and research in the EIS it is not possible to provide definite results for the hazard of ISL mining. However, it appears that the in-situ-leach process is at least as bad as the conventional uranium mining.

Considering in a very simplistic approach only the proposed quantity of yellowcake to be produced over the lifetime for each mine (16,300 tonnes at Beverley and 90,400 tonnes at Jabiluka) and, leaving all other factors to balance each other out, would result in the following death toll for Beverley: 900,000 over 500,000 years, and 360 million lives over the next half a billion years (derived from an estimated death toll for Jabiluka of 5 million / 2 billion).

However, if the difficulty of recovering the isotopes dumped into the aquifer (see section 5.2) is also to be considered, then the ISL process appears to be much worse than the conventional process.

3 *In-situ-leach (ISL) mining*

3.1 The process and its hazard

The ISL uranium mining involves the pumping of strong acids or alkaline reagents via a series of boreholes some 100 metres below ground into the uranium rich formation. From there the chemicals are forced some 40 metres through the aquifer with the uranium mineralisation to reach another row of bores. On their way the chemicals leach the uranium from the deposit - in the case of Beverley some 60% of the uranium. From the second row of bores the uranium leachate is then pumped up to the surface and back to the processing plant, where the yellowcake extraction is completed.

For the ISL process to work without very large-scale contamination of the local aquifer system, the mineralised aquifer has to be enclosed by impermeable formations (see section 3.2.3). Also, the mineralised aquifer has to allow the flow of the injected reagents to the extraction bores. If the flow is obstructed by impermeable sections or becomes obstructed by clogging or congestion then uranium leachate can escape into the aquifer.

3.2 Beverley specifics

3.2.1 Location of deposit

The Beverley uranium deposit is located some 100 metres below ground. According to the surveys provided it enclosed by clays above and by alpha mudstone, a particular type of hard clay, below. Some 150 metres below the mineralised aquifer we find an aquifer associated with the Great Artesian Basin, the biggest underground water body in Australia underlying about one-fifth of the land mass of mainland Australia.

On the surface, Beverley is located on the western side of Lake Frome. The region is characterised by a mean annual rainfall of 222 mm (1948 - 1996) and occasional 'extensive' and 'widespread' floods (most recent ones in 1989 and 1997). The mine site itself is subject to potential flooding.

The drainage for surface and underground water is into Lake Frome.

The land use of the region is mainly tourism (2 National Parks and Mt.Painter Sanctuary) and pastoral (mainly cattle). Agricultural use could be more intensive with more rainfalls which may be a consequence of the Greenhouse Effect. Over the last 50 years the average rainfall has increased by 15%.

3.2.2 Wastes

The most critical aspect of uranium mining is the radioactive waste to be left behind in extremely large amounts for billions of years.

The Beverley EIS provides no adequate data despite a Field Leach Trial. Among others, the data for thorium-230 has not been published in the EIS. This is of severe concern as another acid ISL mine showed extremely high concentrations of this radioisotope in all liquids including the restored aquifer. This isotope has a half life of 76,000 years and one of its indirect decay products is the most dangerous radioactive gas radon. The other data provided comes from various stages of the protracted mine development and is highly contadictory: baseline data provided in Table 4.1 contradicts baseline data in Table 6.18. This becomes obvious when the values, provided here in Bq, are converted to milligram for comparison with Table 4.1. One milligram of uranium is equivalent to 25 Bq of uranium.

Even less attention has been given to research into the long-term aspects of the radioactive mining waste. This is despite the requirement in the Guidelines for the EIS (section 10) to address "**stability and erosion control measures including stability of tailings and other waste disposal structures for the duration of risk to the surrounding environment.** The EIS does not even establish the duration of risk for the radioactive waste. For the most important radioisotope, uranium-238, the half life is 4.5 billion years, and the risk could persist for up to 30 billion years (by then about 1% of the isotope has not decayed yet).

Because uranium-238 is the parent isotope of the decay chain, all 14 radioactive isotopes will - regardless of their individual half lives - be present with the uranium for the full time span involved (Fig.1 and section 2.5).

The proposal involves the disposal of very large quantities of uranium-238 in various ways:

- Disposal of liquid wastes with dissolved and suspended radioisotopes into the mine aquifer: see section 3.2.3
- Disposal of solid contaminated wastes in solid waste trenches: over the lifetime of the mine several 10,000 tonnes if not 100,000 tonnes would be dumped into trenches 5 metres deep. These trenches would be filled with wastes to a depth of approximately 2 m below grade, then covered, backfilled and signposted. Again, the main waste is uranium-238 and its 14 radioactive decay products. The duration of the risk is billions of years as discussed above. The disposed wastes are subject to leaching into the groundwater from day one, emanation of the radioactive gas radon, uptake of radioisotopes by the plants growing on the rehabilitated trenches, transmission of buried radon to the atmosphere via plants (this has been found to double the emanation rate), gully erosion and wind erosion within a few decades. The signposts might last for twenty years if not collected earlier by scavengers. Even if they were made from stainless steel in a couple of hundred years the writing may not understood any longer. Also, scavengers and farmers can be expected to sift through the disposed solids which include plant, pipes, valves and other contaminated equipment. The hazard from the disposed solids is such that the meer standing on the waste could expose the uninformed peasant or tourists of the future above the legal dose limit within a day. For somebody actually sifting through the waste an hour might be too much. For a detailed description of the hazards involved, see my paper "Long-term consequences of uranium mining".
- Disposal in mud pits with soil cover: this is proposed for contaminated mud at bores. Their dispersed locations all over the mine area will even further increase the risks for the people of the future.
- Surface disposal: as the current operation of the trial mine has shown, surface disposal of uranium-238 is also intended. A 500-litre spill occurred during the field leach trial. The spillage, containing approximately 105 grams of uranium-238, was kept secret from the public until the mining company was confronted with the leaked information at a public meeting several months later. The contaminated area had been cordoned off but not cleaned up. This has left the contaminants available for wind erosion. Inhaled uranium dust is extremely dangerous both because of its radiotoxicity and its chemotoxicity.

  Such surface spills are a major feature of any ISL operation, but in particular where acid leaching is used as proposed for Beverley (see section 3.2.4).

3.2.3 Aquifers

Contained within the wastes, 50,000 kilograms of uranium annually are to be injected into the mine aquifer for disposal. A presumably even larger quantity of uranium will simply left dissolved in the aquifer as the recovery of uranium leachate is not 100%.

The claimed isolation of the mine aquifer may be a requirement for ISL but it is not a fact: cross section A, Fib.6.5 (BevEIS) shows that the western end of the mine aquifer (Namba formation: Beverley sands sequence) is connected with the Willawortina formation. It has to be assumed that there are many more such connections to the north and to the south. Similarly, the eastern end of the mine aquifer is bound to have connections to the Willawortina aquifer allowing easy discharge towards Lake Frome when the mine aquifer is under pressure. Also, the very thin band of Beverley clay sealing off the mine aquifer from above can not be expected to be continuous over the whole mine aquifer. Even if it was continuous, the 1200 boreholes (and more to come) through the Beverley clay would have brought an end to it. The pumping tests were far too short (1 and 3 days) and many more spots would have been needed to be tested to give any indications, let alone proof. On a couple of occasions, the Beverley EIS actually acknowledges that the mine aquifer is not completely isolated, without ever discussing the long-term consequences of this.

Also, the location of the Poontana fault across the mine aquifer opens up a further connection to another aquifer, the Great Artesian Basin (GAB), the largest and most important Australian underground water body. Such a connection, even if not active in the moment, may become active soon when the pressure in the Great Artesian Basin aquifer changes due to the draw of a proposed 57 Megalitres of water from the GAB. It might appear that 57 Megalitres of water are insignificant for the GAB and would therefore have no influence on the pressure. However, the fault line is located near the rim of the GAB where the water volume is much smaller and where speed of recovery from draw down is much lower. To propose the location of the GAB water supply bore right at the fault is indicative of the lack of foresight, understanding and concern of the proponent.

The connection of the mine aquifer to the GAB via the Poontana fault is further indicated by the prevalence of springs at other fault locations in the region. The reason why there is no spring at this fault may actually be that the Willawortina aquifer allows horizontal movement of the rising water.

So far only the existing situation has been investigated yet. However, the mine aquifer would have to remain isolated for billions of years to safely contain the injected and abandoned radioactive wastes. Even if the mine aquifer was completely isolated today, a climatic change with higher rainfalls would certainly force connections between the aquifers due to the increased pressures. Also, the 1200 plus boreholes will further deteriorate over the years to come, however well they may be sealed today. Movements at the existing fault have to be expected.

The installation of bores for agricultural or even domestic uses can be expected. Even the existing bores might be used. The EIS goes to great detail to show that the aquifers are not suitable for stock purposes because of their salinity ranges "to more than 12,000 mg/l", while a level of 10,000 mg/l is the upper limit for stock water supply. However, a closer look shows that most of the bores show actually salinity levels well below 10,000 mg/l. The above phrasing of the salinity may have to be considered as misleading throwing severe doubts onto rest of the EIS.

The salinity of a given aquifer is variable depending on the charge rate. As soon the rainfall increases - especially the intensity of rainfalls, which is responsible for the recharge of aquifers - the salinity goes down. The aquifer is then purged onto the surface via springs, seepage and capillary flow. Together with the salts, the dissolved isotopes will reach the biosphere. Over the last 50 years the rainfall has increased by more than 15%, and in particular the intensity of rainfall events has increased. With the Greenhouse Effect pending further increases can be expected. Within a few years or decades many of the aquifers could reach drinking water quality, the area could become fertile and populated. Simultaneously, the radioisotopes would spread death and disease over the region. Such change of climate with consequent change of land use, ground water quality, and population density is a likelihood rather than a faint possibility.

I feel reminded of the original Olympic Dam EIS which provided scientifically tested claims that the carbonates in the formation would react with any leaking tailings liquor to form gypsum which would then "create a seal limiting further advance of the wetting front" (S.OD-EIS, p.18). A few years later a major leakage of tailings liquor was discovered, possibly in the order of 1 Gigalitre, an extremely large amount. It seems that neither the proponent nor the South Australian government nor the Federal government are interested in the Precautionary Principle which requires to use the more cautious approach if there is doubt. This principle does not apply to games and gambling but it does apply where human lives are at stake. For example, our traffic rules are a reflection of the precautionary principle. Those responsible for the decision on the Olympic Dam Expansion and those responsible for the Beverley EIS have not applied the precautionary principle in the most important issues. If the used a similar approach to their car driving they would not survive a hundred kilometre trip on a normal highway. Yet they are in charge of protecting the environment, an essentially precautionary aspect of our society.

[The mobility of the radionuclides in the ground water has been discussed in section 2.3.]

3.2.4 Leaching agents (acidic)

Essentially there are two groups of leaching agents for ISL mining: acidic and alkaline.

The proponent intends to use acidic leaching (sulphuric acid), environmentally certainly the worst choice. Acid leaching causes severe disruption of the aquifers chemistry and massive dissolution of heavy metals from the ground. The dissolved heavy metals further increase the toxicity of the uranium leachate and any accompanying sludges.

In acid ISL the uranium leachate is accompanied by considerable amounts of sludge clogging up filters, pipes, valves and even the aquifer itself, which can cause massive excursions of uranium leachate. The frequent cleaning and exchange of filters, pipes, pumps and valves causes further surface contamination.

Also, acid ISL causes extreme corrosion of the equipment, again including valves, pipes and plant. Spillage from broken pipes is common. And again, the exchange of damaged equipment creates further spillage.

Acid ISL stands for Accidents, Incidents, Spills and Leakage.

3.2.5 Restoration

Restoration involves the removal and precipitation of the dissolved radionuclides and heavy metals left in the mine aquifer. There are severe limits to the restoration outcome: firstly, it is impossible to remove the dissolved radioisotopes to a satisfactory extent. To overcome this limitation the precipitation of many of the remaining dissolved isotopes is undertaken as a second stage of the aquifer restoration process. This two-stage approach eventually produces a significant improvement of the aquifer's water quality.

However, the precipitation does not produce a bond for the uranium-238 as strong as the original bond (in the case of Beverley the mineral coffinite). This means that the uranium will be subject to future re-dissolution according to the variation in the ground water chemistry. For example a simple heavy rainfall bringing fresh water into the aquifer will cause renewed dissolution with its dire consequences (increased mobility, assimilation by plants, retention in the biosphere …). Dissolved uranium is the most dangerous form of uranium.

Acid ISL is not suitable for restoration. For this reason there has not been a commercial acid ISL mine in the USA, quite contrary to the impression the EIS repeatedly tries to create. There have been acid ISL trials, but the environmental results have been catastrophic. General Atomics, a nuclear multinational based in the USA, the 100% owner of Heathgate / Beverley, would certainly know about these problems. They have decided to ignore the environmental issues and to go for the acid ISL process because it is cheaper. This analysis does not mean that I consider alkaline ISL a viable alternative. This would be like saying it is not acceptable to kill four million people for General Atomics profit, but it could be OK to kill 2 million.

3.2.6 Long-term behaviour of radionuclides and heavy metals in the aquifer

This issue has largely been covered in the previous section.

3.2.7 Inversions

The climate at Beverley involves regular low-level inversions during the night time. This is known to substantially increase the radon concentration during the night.

3.2.8 Lake Frome depression

Lake Frome is the endpoint of the regional drainage system. Lake Frome lies below sea level and has no established overflow path towards the ocean - all water collected in Lake Frome evaporates. When a climate change brings more rain the water level of Lake Frome will rise until it reaches sufficient height to overcome the surrounding obstacles on its way to the ocean. A brief study of the atlas suggests that the new river could flow first north and then west around the Flinders Ranges and down to Port Augusta via Lake Torrens. What does the proposed Beverley mine mean for the current and future drainage area?

Discounting any major geological changes for the region, the main motor of change will be rainfall. Rainfall will successively flush soluble and dissolved radioisotopes from the mine aquifer. The heavier the rainfall the more isotopes will be flushed out. As long there is no river established to drain the water from Lake Frome to the ocean, the radioisotopes will be dispersed over the floodplain of the Lake and will largely be taken up by the vegetation, thereby entering the food chain. There will be a continuous increase of the radioactive contamination of the biosphere.

Without uranium mining, this dispersion would happen as well, but to a much lesser degree, maybe by a factor of thousand. This factor could actually be determined to some extent as it reflects the solubility of the radioisotopes before mining versus the solubility of the isotopes after mining. The geological disturbance by the introduction of strong chemicals and also by the thousands of boreholes will further increase this dispersion.

If the rainfall in the region increases to such an extent that a river forms to drain the water into the ocean then essentially the whole flood plain of the river will become contaminated. Some isotopes will reach the ocean and be included in the biosphere there. The strong affinity of uranium to vegetation (ERA,1995) will make this a secondary effect.

3.2.9 Flash floods

The region west of Lake Frome is known to experience severe flash floods. The EIS has actually provided some details of flood levels for the 1 in 100 year flood. However the potentially very grave effects of a flood at the mine site have not been discussed: A flood could obviously break any solution pipes crossing the flood ways. These pipes connect the extraction and injection boreholes with the processing plant and could spill large amounts of highly concentrated radioisotopes into the biosphere. Also, a flood could breach any containment structures for solid or liquid radioactive wastes like the trenches for the solid wastes and the various holding and evaporation ponds for liquids if they are situated in an inundated location.

Fig.4.7 shows that the design of the plant and bore field facilities - to the very limited extent they are shown on this map - are out of reach of a 1 in 100 year flood. However, a comparison with Fig.6.20 shows that the facilities are not necessarily out of reach of a 1 in 1000 year flood. Certain structures like the northern wellfield header unit or the stage 1 plant could well be within the reach of a 1 in 1000 year flood. Flood contours for such a flood have not been provided, possibly because of a lack of data. The risk of a 1 in 1000 year flood for a 25-year duration of the mining venture would be 2.5%. The resultant contamination of the Lake Frome flood plain would be prohibitive. The 2.5% probability does not yet include the consideration of the Greenhouse Effect. It appears that this additional risk factor has increased during the last decade by a few percentage points annually.

Conveniently, the problems posed by the Greenhouse Effect to the mining venture have not been mentioned in the EIS.

3.2.10 Poor design of field leach trial

The field leach trial has not been used to establish the essential data on the concentration, chemical form and dissolution / bond strength of the radioisotopes for baseline, injection and extraction streams, waste liquids, of the mine aquifer before and after mining, and after restoration. Consequently, modelling of the future isotope behaviour under various conditions of the aquifer was also not possible.

One might be inclined to believe that this negligence was a prudent move because the mine could not possibly be approved because of its dire consequences in any case. However, the South Australian and the Federal government have proved before that they are willing to approve a uranium mine without the discussion of the long-term effects bringing death to hundreds of millions of people in the future. This mine is Olympic Dam in South Australia, arguably the biggest death factory in the Southern Hemisphere.

3.2.11 Monitoring

The proposed development is so negligent in its design - principle and details - and so detrimental in its effects on the innocent people of the future that a discussion of the monitoring features appears akin to contributing to the smooth and environment friendly operation of mass murder. Therefore I will just address the long-term monitoring: We read that a seven-year monitoring program is planned (BevEIS, p.13-3), which mentions groundwater sampling only. No mention is made as to which groundwater is to be sampled and what is to be analysed - just two words, "groundwater sampling".

The section further states that any further activities required "'will be determined and addressed with the concurrence of the appropriate regulatory authorities". This has to be seen in the context of the 'performance bond' (BevEIS, p.13-2), which protects General Atomics from any unwelcome or unexpected costs: The rehabilitation bond has to be determined every year in advance for the expected disturbance to be caused by the mine. This allows General Atomics to opt out whenever the proposed costs appear too high. Obviously, the costs of cleaning up of a major spill, being unexpected, would not be included in this bond.

The short section also acknowledges that after those seven years the effects of the Beverley mine on the mine zone aquifer may not be mitigated. Then, the death factory has been developed to such an extent that it can work in 'automatic mode' for billions of years.

4 The operators credentials

4.1 Secret deals and inappropriate actions

The Beverley proposal is already now, even before the completion of the Environmental Impact Assessment, marred by irregularities and secrecy.

Firstly, the field leach trial has been approved by the South Australian government without an EIS. An EIS has to be provided for projects with potentially severe environmental impacts. The severe environmental impacts of the field leach trial are the same as those for the mine though at a smaller scale. Massive ground water contamination, eventually to be dispersed over the Lake Frome region, surface spills and release of heavy metals are certain to cause birth defects, cancer and death for many people of our future generations.

Also, the lack of public discussion of the proposal ensured that the relevant data have not been collected during the field leach trial, like the concentration of all the radioisotopes in the various process and waste streams under various treatment processes, or the effects of various restoration procedures, or the modelling of the isotope and aquifer behaviour for the duration of the risk.

Also, the lack of public scrutiny allowed the trial mine to operate with the lowest environmental parameters:

- acid leaching of the mine aquifer has been used despite the well established knowledge that this process dissolves many heavy metals from the ground, that it guarantees a messy operation with massive corrosion of pipes, valves, machinery, plant and equipment with consequent pipe breakage and many spills.
- The restoration of the aquifer has not even been attempted, leaving large amounts of dissolved isotopes in the aquifer.
- The disposal of the radioactive solids in trenches in no way provides a safe storage for even a fraction of the duration of the risk.
- No due care has been ensured by adequate working procedures
- Monitoring of the aquifer with just two monitoring boreholes is completely inadequate considering the many and varied risks. Some 200 monitoring boreholes and continous monitoring of some 20 of those would be more appropriate.

Not only has the field leach trial been approved without an EIS, also the Declaration of Environmental Factors (DEF) was declared a secret document by the South Australian government - for reasons of commercial confidentiality. Obviously, the South Australian government values business interests of the US-based nuclear multinational General Atomics higher than the lives of our future generations.

Again and again, the South Australian government has been seen to act in the interest of the General Atomics rather than in the interest of people and environment. How is this government meant to reach a reasoned decision on the proposal? Considering last year's approval of the Olympic Dam expansion project, the credentials of this government - and of the Federal government - are as bad as those of the proponent.

4.2 Irresponsible proposals - the proponent should know better

An ISL mine using the acid leach process is contrary to any other commercial ISL mine in the western world - for environmental reasons: acid ISL mining is plagued by spills and accidents, and leaves the mine aquifer unsuitable for restoration. The proponent not only ignores this well established knowledge but even refers to advances in the USA to underpin their sound ISL practice.

The proponent appears to misrepresent the facts and deliberately mislead the public.

A similar approach has been taken by the proponent in regards to claims about the quality of the groundwater (see section 3.2.3). It is misleading to suggest that the groundwater is useless because of its high salinity when a closer scrutiny of the data proves that most of the bores show usable groundwater.

Further, the proponent intends not to restore the mine aquifer. This again is a very exceptional approach. The reason given - the groundwater is useless anyway - is completely inappropriate because the quality of the groundwater is highly variable in tune with varying climatic and other factors. The groundwater recharge / discharge sequences flush the aquifer and periodically reduce salinity. The main problem from the groundwater contamination arises actually when the contaminants are flushed to the surface as a consequence of the recharge / discharge cycles as discussed earlier in this submission (the radioisotopes enter the biosphere, are assimilated by plants and animals thereby entering the food chain, and radioactive radon gas can become airborne). Again, the proponent should be familiar with such simple hydrogeological and radiological facts.

4.3 Irresponsible action

It is impossible to know what happened over the last eight months at the site. A huge spill of contaminated water, obviously caused by the previous owner of the mining lease, was only now detected - by coincidence. At the time, the public was not informed, the government was not informed or, if it was informed, was not interested in clean up and protection of the public and of future on-site workers.

Now General Atomics has started operations. The spills will not be just radioactive water. Now uranium leachate is to be spilled. The first (?) spill, 500 litres of uranium leachate, happened in March, within less than three months from start of operation (see section 3.2.2). Three months later the site of the spill had still not been cleaned up, the public had not been informed, and if the government had been informed it obviously couldn't care less. The spill was only admitted when the company was confronted at a public meeting. Has the South Australian government withdrawn the permit for the field trial? Have the South Australian and Federal governments cancelled the Environmental Impact Assessment process? Since, the spilled isotopes were subject to wind dispersion and, most likely, water erosion, making the clean up ever more limited.

The company is also said to not properly seal equipment from the ground causing further contamination.

4.4 Litigation, litigation: the past history of the proponent's parent company

Roger Moody's "The Gulliver File" has devoted a chapter to General Atomics (p.389-390). The report is dominated by law suits the company was involved in. The question arises whether Australia and South Australia will be faced one day with massive law sutes as well. The EIS contains some proposals seemingly limiting the liability of the company. The liability for the long-term consequences of the mine appears to be passed on to the State government after decommissioning.

4.5 Nuclear weapons connection

The founder of General Atomics was Frederic de Hoffman, a former member of the Los Alamos team which constructed the Hiroshima and Nagasaki bombs. One of the ventures of the company was the sale of a 'research' reactor, precondition of a nuclear weapons program, to the then Romanian dictator Ceaucescu. Later on, this sale was complemented by the US government with the supply of 16 kg of weapons grade uranium to the notorious dictator. Before his downfall, Ceausescu had boasted that his country had the capacity to manufacture nuclear weapons (Moody, 1992, p.390).

Also, in 1980 General Atomics offered the now disposed Indonesian dictator Suharto the supply of a nuclear reactor. Recently, the Australian government wanted to supply the dictator with the uranium for his nuclear program. Fortunately both the nuclear program and the dictator have now been disposed off (Moody, 1992, p.389).

4.6 Aboriginals misled

Several members of the Aboriginal communities were taken on a tour of overseas ISL mines to convince them of the safe operation of the ISL process. Little would they have known of the hazards connected with the proposal. This tour and the eventual agreement happened while the spill of 500 litres of uranium leachate was kept secret. Such an approach disqualifies the proponent as trustworthy enough to run an operation of the most deadly industry in Australia. It further questions the validity of the agreement reached with the Aborigines.

5 Comparisons

5.1 Comparison of radioactive waste storage options in uranium mining

The deadly hazard from the uranium mining waste persists for some 25 billion years. It is compounded by the very large quantities of tailings, their susceptibility to erosion, dispersion, leaching into groundwater, radon release, future re-use of tailings for building material by ignorant humans, the inability of our senses to detect radioactivity and the difficulty of associating radiation cancer to an exposure due to its long latency period. In ISL mining the radioactive waste is to be dumped partly into the aquifer, mainly in dissolved and soluble forms, and partly into totally inadequate storage facilities akin to the tailings storage of conventional uranium mining. To which extent the tailings radiation becomes harmful to future humans depends on the capability of the storage facility to prevent the escape of the tailings isotopes into the biosphere. However, there is no storage option which could achieve this sufficiently for the time spans required.

The storage options are:

1. Dumping the waste material next to the mine: this is the historic and, more recently, the Third World approach. Here the tailings material is exposed to erosion by water and wind right from day one. The dashed line of refusal to accept responsibility in Fig.1 in "Long-term consequences of uranium mining" moves right to the beginning of the time scale. The environmental and health effects become measurable already during the mine’s operation.
2. Storage in a tailings dam: this option is seemingly much cleaner and better controlled than the simple dumping of the waste next to the mine. A delay of the onset of the large-scale contamination by tens or hundreds of years is achieved, bringing an initial improvement of the environmental and health situation. After this the death toll rises steeply – for hundreds of thousands of years. If the initial improvement would not actually save perhaps a thousand human lives, one could be forgiven to say that it is purely cosmetic and totally insignificant in the face of the long-term death toll. Compared with the plain dumping of the tailings next to the mine, the storage in a tailings dam might reduce the death toll by about 0.01 to 0.5%.

3. Dumping of radioactive mine waste into aquifer (as used by ISL mines): This storage option has been discussed earlier in the submission. The improvement in comparison to the first option depends on many factors like the depth, location and geochemistry of the aquifer, local climate, acid or alkaline leaching, restoration, the mobility and potential mobility of the radioisotopes. ISL mine waste has a very high content of soluble and dissolved radioisotopes, which very much increases the mobility and also the affinity to the biosphere. The death toll with this storage option may be reduced by 20 - 70% in comparison to the first storage option. [The storage of tailings in an aquifer is discussed in the next paragraph]
4. Storage in open mine pit: this storage option prevents a large proportion of the tailings from entering the biosphere and therefore significantly reduces the long-term death toll from the tailings. The weakest aspects of this storage option are the leaching of isotopes into the ground water and human interference - the ignorant mining of the rock powder for all sorts of purposes as happened in the past. At a later stage erosion becomes a major factor. There are many parameters making a big difference in the performance of this storage option:
   - can the tailings be recovered for eventual disposal in better containment?
   - the depth of the deposit below ground (obviously, the deeper it is buried the better),
   - the compaction and solidification of the tailings material,
   - the acidity of the tailings (acidic tailings increase the dissolution of the isotopes U-238, Th-230 and Ra-226 in the ground water).
   - the design of the cover of the deposit,
   - the location in regard to flood plains,
   - watercourses,
   - climate
   - geological composition and instabilities,
   - aquifers (such a major cut through the geological layers is bound to intersect or at least to create major aquifers).
   - height above sea level

   The death toll with this storage option could be very significantly reduced, maybe by 60 - 95%. Nevertheless, for mines like Ranger and Jabiluka the estimated death toll would be still several millions (over 500,000 years) or several billions (over 500 million years).
5. Storage in old or specifically built mine shafts: this is the safest storage option. Compared with the open mine pit it provides greater depth and better ways of sealing the deposit off. The death toll would be reduced by perhaps 90 - 99%. The only remaining transport mechanisms for the transfer of tailings particles and dissolved isotopes into the biosphere are the aqueous transport and human interference. This storage option still involves the death of many thousands if not millions of future humans and is therefore not a suitable storage proposal for any further mining. However, purpose-built mines sited in suitable rock formations of a very dry region seem to be the best options available for dealing with the tailings that already exist at various dumps, in tailings dams and in mine pits.
6. Synroc and similar technologies: Synroc is very well known and therefore often thought to be a good storage refinement for underground storage of tailings. However, Synroc is only adequate for small quantities (kilos rather than millions of tons). The only related storage technology for low-level high volume waste is the addition of cement to the tailings and the mixing of the tailings into concrete. However, the required long-term success for hundreds of thousands of years is a thousandfold beyond the reach of concrete.

5.2 Suitability of waste storage options for later remediation

One of the most important criteria for tailings storage options is whether they permit the complete recovery of the contaminated materials for an improved storage in a purpose-built mine sited in suitable rock formations of a stable and very dry region. Such relocation is many times more expensive than any profits, taxes and wages paid by the unscrupulous uranium mining ventures today. However, it will save billions of lives, reduce further genetic damage to humans and any other species, and is infinitely cheaper than the ongoing surveillance, monitoring and maintenance of the disposal facilities for billions of years. Therefore, as humanity fully recognises its mistake - hopefully in the near future - the tailings will be relocated.

How detrimental are the above listed storage options from the aspect of eventual tailings recovery? Assuming that the tailings will be recovered within the next 10 to 50 years and placed into better storage facilities, an investigation of the short-term releases and their potential of recovery is important:

- A tailings dam releases radioactivity in the form of radon gas into the atmosphere, dissolved and suspended isotopes into the ground water and via wind erosion and surface water erosion. The potential of recovery for those released substances is either nil or minimal. While the bulk of tailings would still be recoverable after some 10 to 50 years, a large quantity of the dissolved and easily soluble isotopes in the tailings dam would have entered the groundwater already during the operational phase of the mine. The only suitable interim above-ground storage for tailings would have to be completely covered by a roof to prevent the entry of water and would need to be completely sealed against the release of the radioactive gas radon, which may not be possible. Furthermore a suitable barrier to the ground would need to be installed like a concrete slab sandwiched between two thick HDPE foils. Obviously, such above-ground storage is economically not viable. Also, from the aspect of long-term storage a tailings dam is the worst option. As there is no certainty that the tailings from a tailings dam will be relocated in the near future, it has to be considered as the worst storage option.
- Dumping of radioactive mine waste into aquifer (as used at ISL mines): This is the method discussed in this submission. The potential for recovery of the isotopes from the aquifer depends on many complex chemical factors. It appears to be even lower than the potential for tailings dam and in-pit storage of conventional mining, due to the high mobility of dissolved isotopes and their consequent migration into other aquifers and to the biosphere where they could remain permanently.
- In-pit storage allows at a first stage the release of dissolved and suspended isotopes into ground water. Therefore from the aspect of potential future recovery of the waste, interim in-pit tailings storage is only an improvement (in comparison to a tailings dam) in climates with extremely low rainfall and in locations with impermeable ground. Considering that even the Simpson Desert is underlain by aquifers, such locations might be very rare.
- An old mine shaft or backfill into a current mine shaft provides a storage from which the recovery of tailings is nearly impossible. Therefore the long-term suitability of such storage is of paramount importance.

To order the storage options from the aspect of suitability for future waste recovery, bad to worst:

- purpose-built deep mine shaft in impermeable rock, in dry climate
- in-pit storage in desert
- tailings dam in desert
- in-pit storage
- tailings dam
- aquifer

- wild waste dump next to mine

Please note that there is no a safe storage for long-term radioactive waste, and the above investigation of the potential for recovery does not at all imply that uranium mining is acceptable in any way. Uranium mining implicitly involves mass murder on our future generations. The current legalisation of such activity does not lessen the crime but rather indict those politicians responsible. There is no certainty that the next generation will have the understanding, ability and willingness to relocate mountains of tailings to a thousand metres below ground. While our generation has the knowledge of the consequences of uranium mining and the ability to simply stop uranium mining - those politically responsible in Australia do not have the will.

5.3 Greenhouse Emissions Versus Nuclear Energy

Frequently, nuclear energy production is praised as being free of Greenhouse emissions. Summit Resources, Paladin Resources, Southern Cross Resources and Uranium Australia all claim zero Greenhouse gas emissions for nuclear energy. Nuclear energy is therefore claimed to be environment friendly. Nothing is further from the truth:

1. As outlined in this paper, radioactive uranium tailings or ISL wastes are being produced in enormous amounts without a solution for their long-term storage. It is not ethical – apart from not being possible – to combat our environmental problems from Greenhouse emissions with a nuclear 'solution' which will be borne by our future generations with disease, genetic damage and billionfold death from radiation cancer.
2. In an article by Nigel Mortimer 'Global warming and the nuclear power debate' it is further described that there are not enough viable uranium deposits to make a switch to nuclear power, far from sustaining such a switch. As the uranium resources become more marginal, more energy is needed for the uranium extraction, reaching an energy cut-off point within a few years.
3. The economic cut-off point, making nuclear energy unviable, is obviously reached much earlier. This point has already been reached in the US where several reactors are about to be closed soon.

   If the long-term costs of radioactive waste storage had been considered nuclear energy would never have been viable.
4. There are considerable Greenhouse emissions from the nuclear fuel cycle during it's stages of:
   - mining and milling,
   - uranium extraction,
   - fuel fabrication,
   - enrichment and reprocessing,
   - construction of the various plants and reactors,
   - demolition of the contaminated plants and reactors after their design life (or after accident),
   - transport of radioactive materials and other equipment,
   - emergency measures and clean-up after severe accidents like Chernobyl,
   - construction of storage facilities for the radioactive waste (so far only temporary), for example the US site at Yucca Mountain, Nevada (now considered unsuitable, after an expense of $US 2.4 billion), or the Chernobyl sarcophagus (now in need of replacement).
   - maintenance and repair of the waste storage facilities for thousands to billions of years. The uranium tailings and ISL wastes constitute the largest quantity of radioactive waste from the nuclear fuel cycle. Their safe storage has to be guaranteed for billions of years as outlined above. Obviously, the Greenhouse emissions from this gigantic task, mainly earthworks, will be larger than the emissions from the current fossil fuel energy production.

   The Greenhouse emissions from the nuclear fuel cycle have been recognised many years ago, before Chernobyl, before the tailings problem was fully recognised, and before the ISL wastes had to be considered. As long the Greenhouse emissions due to the ongoing task of securing, recovering, relocating this radioactive waste were not factored in, the emissions from the nuclear fuel cycle appeared to be rather low. This approach is no longer acceptable.

5. A study by Bill Keepin and Gregory Kats (1988) – without even considering the Greenhouse emissions due to the ongoing task of waste mangement and due to emergency measures and ongoing clean-up after Chernobyl-type accidents – came to the conclusion
   - that a transition to nuclear power would consume tremendous amounts of fossil energy (Greenhouse emissions)
   - that energy efficiency measures created several times less Greenhouse emissions than such a switch to nuclear power production.
6. Before, the Greenhouse emissions as a indirect consequence of Chernobyl-type accidents were mentioned. The human cost of such accidents is an even more severe consequence. As we know from the Hiroshima statistics, the radiation cancer fatalities in areas with low-level contamination will not be known for some twenty to fifty years due to the slow progression of this disease. Most of the Chernobyl victims are of this category. The more credible estimates of the Chernobyl death toll range from 250,000 to 1,000,000. Many of the Chernobyl fatalities will never be known because of the way the clean up operation was conducted, for example the near total lack of information about the identity of the more than 500,000 emergency workers from all over the USSR who received the highest doses. There have been several near-meltdowns at other reactors. Can we resolve our environmental problems with Greenhouse gases at the expense of the lives of others?
7. Nuclear reactors were originally designed to produce the material for nuclear weapons. While this motive has largely vanished from the public perception, the eager attempt by third world countries -- including some dictatorships – to acquire nuclear power plants, can only be seen in this light. Nuclear power includes the risk of nuclear war.

The very reason for the Greenhouse convention is the protection of human life and health. How could a technology involving the death of billions of human lives be praised as a solution?

Greenhouse emissions have to be removed <u>and</u> uranium mining has to end.

5.4 Comparison of the operating and proposed uranium mines in Australia

Roxby Downs is claimed to be the mine with the world's biggest uranium ore reserves.

The approved expanded project will result in about 569 million tonnes of tailings. The ore grade (vastly differing figures) is assumed to be 0.06%, a low-grade ore. The tailings disposal in a dam is discussed in my study "Long-term effects of uranium mining. Supervision of the mine is poor, mainly by the S.A. Health Commission.

Ranger is one of the world's biggest uranium mines. The mine will eventually produce some 42 million tonnes of tailings. Due to the high ore grade (0.29%) the radiation hazard from the tailings is particularly serious. The future death toll depends largely on the tailings storage:

The tailings dam, currently filled to its capacity with some 16 million tonnes of tailings, has been designed, approved and built as a temporary storage facility. After the completion of mining, these tailings together with the balance of the total tailings quantity are to be backfilled into the two mine pits. These mine pits are unsuitable for tailings disposal (many aquifers, proximity to Magela creek, proximity to floodplain, etc.). In a recent EIS the operator proposed to have the tailings dam declared permanent and to use the surplus space in the mine pits for Jabiluka tailings. This would have even further aggravated the situation because of the use of a tailings dam and because of the acid-forming nature of some of the Jabiluka tailings. Currently it seems in-pit storage will be used.

The residual uranium content of the tailings, originally claimed to be 1% is now admittedly rather 10%. While this increases the death toll for the next 500,000 years 'only' by some 10%, for the very distant future this alone may increase the death toll by a factor of 10.

Jabiluka is a proposed new uranium mine adjoining the Ranger mine. The very high ore grade of 0.46% and the acid forming nature of some of the resulting tailings (20 million tonnes of tailings at a first stage) would make this proposal very problematic. A residual uranium content of 4%, as quoted in the PER, has been used.

Using our estimates of the future death toll (appendix 5) and our comparison of different storage options and correcting for the respective ore grades, for the tailings quantities and residual uranium content we may have to expect a death toll for the next 500,000 years

for Ranger, if continued as approved with eventual in-pit storage (correction factor 0.20), of 9 million humans (127 million x 0.29 / 0.06 x 0.20 x 42 / 569 x 1.1 / 1.23),

for Ranger, if the current tailings dam were to be retained (one third of tailings total), of 19 million humans

for Jabiluka, if tailings are to be deposited in Ranger pit (see Jabiluka draft-EIS, section 4.13.2), of 9 million humans (127 million x 0.46 / 0.06 x 0.35 x 19.5 / 569 x 1.04 / 1.23)

for Jabiluka, if fine tailings sections are to be stored in own tailings dam according to section 5.5.6 of the Jabiluka draft-EIS, of 13 million humans.

for Jabiluka, if 50% of the tailings are to be deposited in pit at Jabiluka and the rest is backfilled into the mine stopes (see JMA-PER, Chapter 4) of 5 million humans (127 million x 0.51 x 0.46 / 0.06 x 0.35 x 19.5 / 569 x 1.04 / 1.23)

The estimated 500,000-year death toll for the two linked mines Ranger and Jabiluka, if approved, could be between 11 and 24 million humans, depending on the tailings storage options chosen. Taking into account the full time span of the hazard from the residual uranium content, the tailings from these two mines would cost billions of human lives.

Uranium mining has to be stopped as a matter of urgency.

6 Economics (cost / benefit, rehabilitation, reclamation, compensation, mine closure, liability)

The EIS promises "under full operation", ie. at the second stage, "royalties, payroll tax and indirect taxes to the State government of up to $1.1 million per year." (BevEIS,p.3-4)

For 25 years of operation this would be at the most 28 million dollars, but rather considerably less because the lower production level of the first stage is not yet discounted, and because the 1.1 millions are the maximum yearly figure. There might be years with losses. Maybe a figure of 10 million in royalties, payroll tax and indirect taxes is the total for the projects operational life of 25 years.

What costs does the South Australian government incur in return? It will take on the responsibility for the mine after decommissioning. As the submission has shown, the negative consequences come mainly after the mine has been closed. A major clean up program for the aquifer system of the western Lake Frome region and of the flood plain of Lake Frome might cost billions - and still could not resolve the problems created to any satisfactory extent. Where should the recovered sludge and the millions of tonnes of (by then) contaminated soil be safely stored? If an area of 100 square kilometres was contaminated and would require 20 centimetres of soil to be removed then 20 million cubic metres of soil would need to be removed and safely stored. The Lake Frome flood plain is several 1,000 square kilometres in size, and potentially several 10,000 square kilometres if the current increase in rainfall continues. Wherever this material is to be stored, it would again contaminate an aquifer, again reach the biosphere and again require remedial action at some future stage.

This experience has already been encountered to some extent. For example in Germany the reclamation of uranium mining tailings costs considerably more than all the yellowcake produced there would return on the market. Now we are not comparing taxes received with expenses incurred by the government but the whole income of the companies over their operational life with the government's consequent expense.

This so costly reclamation is assumed to be sufficient for 1000 years. However, after 1000 years the tailings have 99% of their original radiation left due to their long half-life. A renewed reclamation program would be considerably more expensive because the contamination will have affected larger areas, more aquifers.

This assessment made for tailings from conventional uranium mining would be rather worse for the ISL wastes because of their higher mobility, their greater affinity to assimilation by plants and animals and their consequent permanent inclusion in the biosphere.

Uranium mining may not be viable much longer: overseas, many millions of dollars are being paid out to uranium mine workers to compensate them for the health effects (mainly cancers) just like our government pays currently many millions of dollars to those affected by the mining and use of asbestos.

Another indicator of the hazards involved is that insurance policies generally exclude damages due to radiation. Nor are governments very willing to accept the responsibility for their nuclear ambitions: Britain’s Prime Minister, Tony Blair, is refusing to award compensation to veterans of nuclear test explosions for the illness they have suffered, despite Labour’s support for their cause while in opposition.

A new study, ’Chromosomal aberrations with Namibian Uranium Mine Workers’ (Zaire, 1995), indicates the extent of the genetic damage caused by radiation exposure (the highest dose of those workers was only 5 mSv which compares with 20 mSv and 50 mSv permitted for Australian workers) far beyond the known increase in birth defects and still births. Much of this genetic damage will be passed on from generation to generation to leave a permanent mark on humanity.

However, the study may indicate some new avenues to prove health damages from radiation exposure. This might be an incentive for government and uranium industry to adequately consider those to be exposed to radiation from the tailings.

The decommissioning and clean-up costs for uranium producing projects in Australia is currently estimated to be some 70 cents per pound of uranium produced. However, a different approach is shaping up with Sweden spending some $AUS 50 per pound of uranium (Diehl, 1996, p.2).

The increasing public awareness of the tragic long-term consequences of uranium mining may at any moment lead to an end of uranium mining. The enormous costs of constructing a new mine appear to be an outrageous gamble with shareholder's money. Those shareholders would largely not be aware of the problems. The responsibility lies foremost with board and management of the company. It can not be expected nor accepted that the public will again accept arrangements similar to those for the asbestos mining companies. As Peter Jelinek-Fink, scientific secretary of this year's conference of the International Atomic Energy Agency said: "We are only one accident away from being dead." Do not misunderstand, he is not concerned about human life or his life but the nuclear industry's life.

7 International and national framework of the proposal

7.1 The international regulatory body (ICRP)

The 'International Commission on Radiological Protection'(ICRP) is widely accepted as the authoritative body to analyse the available data on the health effects of radiation and then to issue non-binding regulations. These regulations are then expected to become incorporated into the laws and regulations of the various nations.

Originally, the ICRP was actually attached to a medical congress, and the members of the commission were mainly radiologists and medical scientists. For these reasons and probably because of its innocent name, the ICRP is still today credited with some mistaken trust into their motives.

During the Second World War the ICRP meetings ceased. After the war, a certain Lauritzen Taylor, former member of the Manhattan Project (development of the first nuclear bomb) initiated the ICRP anew according to his liking: the ICRP members were to be chosen by its own members who were originally largely chosen by him. Accordingly ICRP members are usually close to the mining industry or other factions of the nuclear establishment. The ICRP is undemocratic, unrepresentative and has no legitimacy whatsoever. The professions represented on the ICRP are rather related to industry than to human health which they are supposed protect. The relevant fields of epidemiology, genetics and pathology are under-represented. The biologist R. Blackith from Dublin points out that scientists criticising the ICRP activities are outcast from the ranks of serious scientists. To differ from the majority opinion is seen as proof of scientific incompetence.

The Report from the Session of the Permanent People's Tribunal on Chernobyl writes about ICRP, IAEA (International Atomic Energy Commission) and UN-SCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation): "This system of agencies is very tightly knitted, with many overlapping memberships. It has been effectively isolated from normal channels of occupational and public health … this small group of scientists has full control of policy making, and of recognition given to "outside" research, which may challenge its findings and decisions. All who disagree with the recommendations and policies, are labelled either ignorant, emotional or nonscientific. There is no international forum in which disputes can be resolved, either for scientific questions or for policy decisions." (PPT 1996, pages 216 and 217).

The ICRP recommendations provide the best indication of their motives: when it comes to the consideration of the rights and the suffering of the human beings of the distant future the most tragic atrocity of the ICRP comes to light. In ICRP46, Chapter 7.3 'Time-scales' on page 13/14 the ethical aspects of 'man-made' radiation are discussed as vaguely as possible. In a roundabout way the ICRP offers two options to the governments on how to disregard those future humans:

- To 'truncate' the dose assessment from a time the governments can determine (i.e. not to worry about health and lives of those who live after that date). Obviously, this is the approach the Australian government has chosen: those humans living in Australia after 1000 years from now are disposables for our mining industry.
- To time-weight the value of the future detriment (for example a government could choose that the lives of future generations count for each hundred years into the future 1% less. Therefore, those to die in 5,000 years due to the tailings radiation would then count only half, whereas the lives of those to die after 10,000 years are not to be counted at all.)

The whole chapter 7.3 (ICRP46) is bathed in vagueness and nice phrases (eg. 'For careful judgement by national authorities' or 'is an issue of an ethical and political nature to which there is no simple answer'). [Obviously, the simple answer is: "You shall not kill."]. However, looking at the regulations of the various governments involved with the nuclear industry they have understood the message: nearly all decided to 'truncate' somewhere between 1000 and 10,000 years without ever spelling out the consequences of their decisions. To discuss such a decision and the implications publicly would make the decision an obviously deliberate one – possibly an act of mass murder even though legalised for the time being.

In Australia, in line with these ICRP recommendations, the structural life expectancy of a tailings storage facility has to be 1000 years at least. The graph on the front page shows how such regulations receive their deadly implementations: during those thousand years the radiation dose is reduced to a low (comparatively only) value, and afterwards the contamination rises steeply to result in the deaths of many millions, if not billions.

Coming back to the ICRP: historically the ICRP dragged its feet in regard to dose reductions needed in response to any new data and statistics on radiation effects. Usually, the dose limits were reduced only after considerable delay. At the moment there is already a ten-year delay between the new statistical evidence requiring a lowered worker's dose limit and the ICRP amendment.

Even worse, since the last lowering of the dose limit (frowned at by the mining industry but forced onto the ICRP by statistical evidence and critical scientists) several of the individual dose conversion factors for the uranium decay chain have been changed, thereby mitigating some of the effects of the dose reduction for the mining industry. In Appendix 2 it can be seen how the critical values for worker's protection – permissible inhalation of ore dust and product dust – have gone up by a factor of about 2 to 10 despite the reduction of the general dose limit. The limits in App.2-1 are based on the ICRP recommendations of 1978 whereas the limits in App.2-2 are based on the ICRP recommendations of 1990 to 1995.

After nearly half a century, the ICRP has developed an extremely complex dose assessment system which inhibits public scrutiny. Even the national radiation research bodies are currently not able to make exact determinations. This will eventually lead to the so-called computer modelling by consultancy firms, which removes the last bit of transparency and is wide open to fraud. Obviously, Third World countries will be completely at the mercy of the multinational mining giants.

In the published proceedings on 'Chernobyl – Environmental, Health and Human Rights Implications', the 'Permanent Peoples Tribunal' states: "The Tribunal condemns … the International Commission on Radiological Protection (ICRP), whose policy is clearly inspired by the promotion of the nuclear industry, instead of being aimed at the protection of the potential victims" (PPT, 1996, p.229).

7.2 The Australian regulations

Some 10 years ago a nuclear consultant with international experience told me that Australia has good regulations (obviously by ICRP standards) for radiological protection, but supervision was on a Third World standard. Good regulations without adequate supervision are useless except if some concerned citizens take those responsible to court.

However this last loophole for humanity is to be closed as well: now the Australian standards do not even match the ICRP recommendations. The Australian recommendations for the implementation of the new (1990) outdated ICRP dose limits have watered down those limits even further: ICRP60 recommends for workers a 5 year cumulative dose limit of up to 100 mSv. The Australian recommendations provide for exceptions up to 250 mSv. Australia is one of the firsts, if not the first, country to provide a Third World template for ‘no worries’ regulations. Despite this, at a recent Senate Select Committee Hearing I heard representatives from ARL and from ANSTO declare that Australian regulations were top in the world.

7.3 OSS / SSG

The current environmental supervision of uranium mining and milling in Australia is totally inadequate. Naturally there is a limitation in the case of uranium mining and milling: ‘adequate’ supervision of something ‘that should never happen’ is mutually exclusive, just like adequate supervision of genocide. Here it is futurecide.

In the case of the proposed Jabiluka mine, the supervision rests with the SSG (formerly OSS). The OSS relies to a large extent on the data and scientific guidance from ERA. I received fundamentally wrong information from the OSS on such essential data as the tailings composition. The source of the information - before I found out that it was wrong`- was as a matter of cause declared to be ERA. Several other examples could be given of inappropriate reliance on information by the stake holder ERA.

Even worse, there are severe accusations about faked research results like the comparison of upstream (relative to Ranger) contamination at the end of the dry season with downstream contamination at the end of the wet season to create the impression that there is no contamination of the Magela Creek wetlands from Ranger. Also, the radon dose is said to be one order of magnitude higher than declared.

The 'wetlands filtration' of radioisotopes at Ranger is another example of environmental vandalism orchestrated by ERA, OSS and CSIRO (please refer to my paper "Wetland filtration at the Ranger Uranium Mine, Dec.1997). Its breach of all scientific and ethical reason is a very severe crime against the future generations.

The permission to store tailings without the initially required water cover (2 metres minimum), the many water releases from the mine site into Kakadu National Park and the cascading of tailings down the pit wall at Ranger are other examples of inadequate supervision and guidance.

7.4 Nuclear industry and society

The nuclear industry is often seen as antagonistic to democracy and human rights. A free society is a big threat to this industry which is so dependent on cover-up and disinformation. This is because of

- its horrific threat against future generations
- its ongoing polluting work practices (most contamination testing is being conducted by the companies themselves)
- its disastrous long-term effects on the national economy
- its dependence on a silent scientific and academic community

- its potential exposure to astronomical damages claims

The ever-expanding scale of potential destruction is so far-reaching that the signature of the ICRP on the 'truncation' rules (see section 7.1) might cost many times more future lives than there are currently on our planet.

Our society has a criminal law to deter and punish those which cause the death of a human. This is a generally accepted means of protecting human lives. However, a short reflection on history makes it clear that most killings have not been caused by individuals but by governments.

Governments can commit crimes by legislative processes. Laws that permit uranium mining are laws that commit crimes against present and future generations. Therefore we need to work for the national and international protection of the dignity of human life.

On the national level such a protection within the constitution could override acts and laws by government and parliament. The deterrent function of criminal law has to be extended to those scientists, politicians and bureaucrats who facilitate such crimes by bending the truth, by manipulating or just by being silent in the face of such pending crimes.

To deal with the multinational uranium mining companies and their international regulator, an international trial on the uranium-mining holocaust similar to the Nuremberg Trials may be needed.

7.5 The ethical background

This most important issue has been addressed in the foreword of this paper. I would like to add some considerations.

During my research I came across many instances where essential information has not been brought out to the public, and instances where wrong information or lies were served to the public. The most striking example is the long-term tailings issue: the half life of the two tailings sections is 76,000 years and 4.5 billion years - yet in Australia the tailings need to be safeguarded for one thousand years only at the expense of millions or rather billions of future lives. This issue, the gravest environmental issue of the nuclear age, has been raised in public submissions many times and has never received consideration - neither in EIS or PER nor in the Environment Assessment Reports of the Department for the Environment. The best the Department for the Environment (supposed to protect the Environment) could do is a 7-sentence statement on the tailings issue in a 140-page Environment Assassination Report (see Environment Assessment Report - The Jabiluka Proposal, 1997). The sentences are so vague as if they came from high school students grabbling to come to terms with this physics issue while there interest was really music only - or perhaps as if they were the muffled words of somebody strangulated with a retrenchment threat. While I don't know where the interest of those scientific watchdogs of our environment rests, they certainly lost their human core i.e. their ethical approach to the challenges of life. If the matter is really so hard to understand for them one would have expected that they seek some advice from myself or enter some discussion of the issues. Even my repeated offer to explain and to provide further information was never accepted. Instead, the seven sentences were dropped in a later report.

The hiding of information about the tailings reminds me of the general dishonesty in government and industry. Dishonesty is a near total blanket over our society, and nearly everybody is aware of this. Dishonesty is required where responsibility is discarded. In contrast, for a responsible society, speaking out the truth becomes a major responsibility for everybody.

Confronted with a technology which expands into ever more risky dimensions, the only society capable of handling such challenge would have to be based on truth and a caring attitude.

8 The inadequate EIA process

This chapter has originally been written in response to the Environmental Impact Assessment (EIA) for the Olympic Dam uranium mine expansion. However it largely applies to the EIA for Beverley as well.

Currently the EIS process consists of 6 stages:

1. The Environment Department provides the 'Guidelines' for the EIS after public consultation
2. The proponent prepares a 'Draft Environmental Impact Statement' which explains the environmental problems of the project and details the proponent's concepts of how to deal with the problems.
3. The public writes submissions to the draft EIS
4. The proponent prepares a Supplement to the EIS, which considers the concerns raised in the submissions
5. The Department of the Environment prepares an 'Environment Assessment Report" for the project based on the information provided in the EIS and the concerns raised by the public.
6. The Minister for the Environment gives consent to the project under certain conditions or rejects the project.

In the case of the Jabiluka proposal and of the Olympic Dam Expansion the EIS process failed in all stages. This chapter will mainly consider the stages 2, 3, 4, 5 and 6 of this process.

8.1 Environmental Impact Statements omit the essential information

An Environmental Impact Statement is meant to explain the environmental problems of a project, and then to detail the proponents concepts of how to deal with the problems.

The Environmental Impact Statement is to show that the project is ecologically sustainable, that there is a balance between economy, environment and the welfare of the people.

In the case of uranium mining, some of the environmental impacts are so severe and unavoidable that their explanation and discussion would make uranium mining outright unacceptable. How did the proponents of the Jabiluka mine and of the Olympic Dam Expansion Project deal with this dilemma? They simply omitted the consideration of those impacts, in particular they did not even mention

- That 80% of the radiation of the uranium ore remains in the tailings
- The millionfold increased radiation hazard from the tailings – compared to the original ore – due to the fine milling.
- That the small particle sizes of the tailings allow the tailings
    - to become widely dispersed into the environment via wind and water
    - to become airborne and inhaled
    - to enter the food chain
- The time spans of the future radiation hazard
- The long-term stability (or lack of stability) of the tailings deposits
- The consequent emissions of the radioactive gas radon
- The effects of the residual uranium content of the tailings
- The costs of containing many millions of tonnes of powdery tailings for millions of years
- The limitations of this task and the devastating consequences for the Australians of the future

- The past failures of tailings management which show unwillingness and incapability to deal with the problems even in the very short-term.

Not only the discussion of those principal environmental problems has been omitted from the EIS but also many details required for an independent assessment. These include important measurements available to the company. Even such essential details as the particle size distribution of the tailings and their respective radioactivity or the residual uranium content of the tailings have not correctly been specified if at all.

Where it matters most, the very purpose of an EIS has been ignored.

8.2 The submissions to the EIS

The submissions to the draft EIS are meant to provide the public and any other interested parties (competitors, government departments etc) with an opportunity to raise concerns about the proposal. There are severe limitations to this stage where the environmental impacts of the proposal are not obvious or not easy to assess. This is particularly true for uranium mining: the long-term environmental impacts are not easily understood by lay persons; they will not be obvious in the immediate future and are therefore not obvious at existing mines, and their extent is difficult to assess even for scientists, especially when the required information is not provided.

The Environmental Impact Statements for the Jabiluka mine and for the Olympic Dam Expansion Project have both not provided this information. This is even more tragic as the issues raised in this paper cover only the minute 'visible' fraction of the details which can be researched just with commonsense – without the data, without the information, and in particular without all the instruments and dozens of scientists and technicians to check those millions of measurements.

Even access to the mines is denied. The EIS could claim just about anything. In the light of these considerations, the omission of those extremely tragic aspects of the projects leads to daunting suspicions about the credibility of all the other data and statements in the EIS which can not be checked independently. Hardly any details are given on radiation measurements, past or proposed (measurement principles, techniques, instrumentation, independent (?) consultants / engineers employed, baseline studies).

8.3 The role of the consultancy firm (Kinhill)

The EIS's for Jabiluka and for the Olympic Dam Expansion as well as the JMA-PER have all been prepared by the consultancy / engineering firm Kinhill. Why can Kinhill completely ignore the basic facts?

After 1000 years, the tailings retain 99% of their current radioactivity – this is a scientific fact. If they need to be kept meticulously out of the biosphere for now, then obviously they need to be kept out of the biosphere in 1000 years and then also for millions of years thereafter. One might ask what else are they prepared to ignore? The ICRP (ICRP 46) employs similar disregard for the lives of future humans. However, a crime cannot be justified because a similar crime is being committed by somebody else.

These concerns about Kinhill have to be seen in context of the regulatory framework of the EIS process: the consultants for the preparation of the environmental impact statement are chosen and paid for by the company. Considering the effect of competition from other consultants wanting to get the job, who could expect the consultant to be simply concerned with the potential environmental impact?

The EIS consultancies undergo a negative selection process with potentially dire consequences for all humankind. The EIS process needs to be overhauled.

8.4 The Supplement to the EIS can ignore the main concerns in submissions

The EIS Supplement is the last opportunity for the proponent to address environmental concerns, in particular those raised in submissions.

In the case of the Jabiluka proposal as well as in the case of the Olympic Dam Expansion Project, the supplements did not address the severe concerns about the long-term effects of the uranium tailings raised in several submissions. Even the prospect of millions of projected deaths did not motivate the companies to discuss the issues. There are no solutions for those problems. Consequently, the discussion of those problems would lead to a stop of uranium mining. In particular the Olympic Dam Supplement addressed many of the less important, misunderstood and mistaken details raised in public submissions without facing up to the main concerns. This can only be seen as an admission of those environmental impacts. The list of items not addressed in the Supplements is essentially identical to the list in section 8.1 (above).

8.5 The role of the assessing and supervising authorities (OSS and Environment Australia)

As detailed before, the Environmental Impact Statements are compromised by the interests of the proponents / consultants; the public is limited by its lack of information, its inability to check up on measurements and claims. This leaves the supervising and assessing government authorities as the last hope for an assessment of the environmental impact. Their contribution to the EIS process comes as the ‘Environmental Assessment Report’ which is supposed to investigate the environmental impact on the basis of the draft EIS, the public submissions, the Supplement to the EIS, and their own research.

In the case of the Jabiluka proposal, the Commonwealth Department of the Environment wrote a 141-page ‘Environment Assessment Report’ (1997) with exactly one paragraph (7 sentences) devoted to the assessment of the long-term tailings hazard. Considering that many millions of future lives are endangered, this issue should have taken up at least half of the report. While those few sentences provide some acknowledgment of the impacts, each and every one of those sentences contains gross distortions and / or diminishment of the facts. The very approach in writing those sentences shows the bias of the authors for the mining company and against the lives of the future humans. It is impossible to know where this bias comes from. Certainly, a lot of independent character is required (see chapter ‘A Law unto Themselves’ in Quentin Dempster’s book “Whistleblowers”).

The ‘Assessment Report’ (1997) for the Olympic Dam EIS avoids the investigation of the long-term tailings issue altogether.

8.6 The political decision

The last stage of the EIS process is the decision by the politicians, here mainly the Minister for the Environment, Robert Hill, and the Minister for Resources and Energy, Warwick Parer.

After the derailment of the EIS process up to this stage, a tremendous responsibility rested with those ministers. The public still had the informal opportunity of writing letters to those ministers, and this has certainly been done.

Unfortunately, the ministers appear to have reached their decision a long time ago. Even worse, they appear to be at the source of the derailment of the previous stages of the EIS. As several ministerial advisers and government scientists indicated, the political will to address the issues was not there.

8.7 Concepts for a revised EIS process

The long-term consequences of the uranium mining will cost many millions (if not billions) of future lives. How is it possible that the EIS process failed those humans so miserably?

- Managers of mining companies feel obliged to pursue the interests of the shareholders. They may not understand or may not want to understand the issues involved. Certainly, they would be aware of the indirect consequences of uranium mining, of Hiroshima and Chernobyl, and of the potential for a nuclear holocaust.
- The consultants would certainly understand the environmental implications very well. The skilful reply in section 10.3 of the Olympic Dam Supplement (1997) shows the ability to find any mistaken claims while skipping over those essential concerns as if they had not been raised. In several cases, obviously deliberate misunderstandings have been used to avoid the issue and mistakes favouring the mining company were even used to further diminish dose estimates even though an increase was appropriate. Obviously, the author of the EIS Supplement was willing to do his job.
- The authors of the Assessment Reports would have been able to judge the consequences. In the case of the Jabiluka report they actually indicated the problems. They may have feared repercussions with their career or even the loss of their jobs, or they did not consider it realistic to expect from the current government consideration of future generations.
- The ministers concerned appeared to be single-minded in pursuing uranium mining as their Prime Minister had promised. The EIA process gives all the responsibility for the final decision to the minister - death verdict for many millions.

If we talk about the death of many millions, even billions of future humans from cancer, about birth defects and ongoing genetic damage, we are facing one of the biggest crimes in human history, however legal it may be today. An EIS process permitting such crimes urgently needs review.

For proposals with high environmental risks like nuclear and chemical plants, mines and heavy industries, a different approach is required: the EIS has to be compiled by independent consultants. The disclosure of the environmental impacts and risks in the EIS has to be a legal requirement backed by criminal law. Non-disclosure or misleading description of severe impacts or risks have to be penalised like the corresponding crimes, for example as ‘accessory to murder’, and have to automatically trigger the dismissal of the proposal. In the current EIS process the consultant has not much choice but to become an accomplice to the crime, if he wants to get the job.

Similarly, those assessing the EIS and submissions, as well as the decision-bearing politicians, have to be exposed to the deterrent function of criminal law. Murder and manslaughter are not acceptable, not for greed, not for job security, not in exchange for party donations etc.

Also, the companies and their managers have to be made liable for the long-term consequences of their activities.

A society largely based on the pursuit of self-interest cannot deal with the excesses of modern technology without the use of the criminal law to protect the fundamental rights to life, health and environment. This protection has to include future generations. Obviously, it would be preferable to have a common appreciation of these values as the base of our society’s functioning, making the threat by criminal law a secondary recourse. However, as our economy, politics and media are now structured and as we humans have developed our ethical framework so far, the deterrent function of criminal law has a very important role, which we urgently have to utilise.

Conclusion

'No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes' (ICRP - Principle). The most important detriment from the proposed Beverley mine (the radioactive contamination by tailings for billions of years) has not even been mentioned in the Beverley EIS.

In the past, the long-term tailings issue has been addressed in single sentence remarks:

- In the Ranger inquiry / Fox Report, II, p.141: "The time taken for radon output to dwindle to insignificant levels could be 100,000 years or more (perhaps up to a million years)."
- Annual Report of the Supervising Scientist 1988/89: "Almost all of the radioactivity will be con-tained in the tailings and … a potential health hazard remains for several hundred thousand years"

This applies similarly to ISL waste.

There are several government radiation research bodies in Australia. One would assume that their foremost task is to investigate these issues of public interest. However, they obviously prefer to keep the issues quiet so the industry remains viable.

The recent Senate Report (SSCUMM) chooses to state: "The Committee, whilst not necessarily sharing the more pessimistic forebodings about management of tailings, nonetheless views tailings management as among the most serious challenges…" Obviously, the committee could not tell the reasons why it does not share those 'pessimistic forebodings' nor did it take up this 'most serious challenge'. All it recommended was reliance on future research. How would you feel if you and your family were to be deep-frozen, with the hope that one day the iceblocks could be revived – just because it suits the business interests of some company? While there may be a hope that you could be revived one day, there is no justified hope that the radioactive waste from uranium mining could be made safe - and this waste will affect billions of humans in the future.

The tremendously destructive potential of our technology (and the tailings issue in particular) challenge us to rethink our ethical and legal framework. This should be addressed in a future revision of the constitution. By now, 'Crimes against Humanity' and the 'Dignity of the Human Life' are well-established legal terms in other countries and in international courts (constitutions of various countries, Nuremberg Trials, Bosnian War Crimes Tribunal) however limited their current application

If we had suitable legal protection, our scientists, bureaucrats and politicians would have learnt their lessons after the asbestos affair when disinformation, academic silence and manipulation caused a 30-year delay to the mine closures. Instead, we are facing the same difficulties again – now with uranium mining. The stakes have increased a thousandfold – or perhaps a millionfold.

While research for this submission has been conducted with inadequate funds and personnel, it certainly provides sufficient information

- for the immediate closure of all uranium mines and outright rejection of any new mine proposals
- to conduct a thorough research project by nuclear and environmental scientists into the issues raised with the participation of environmental groups.
- to halt all asset transfers of companies previously or currently involved with uranium mining to secure some of the costs
- to investigate why ANSTO, ASTEC, OSS/SSG, ARL, Environment Australia and other related scientific and environmental research and control bodies have not provided clear information to date, and to then press criminal charges against those responsible to prevent future repetition.
- To contact all current and past workers at uranium mines for a thorough dose assessment and health examination, to inform them about their medical and legal situation.

Appendices:

The calculations and estimates in the appendices have been made for various Australian mines (mainly Olympic Dam, with the results for Jabiluka added in brackets). A comparison of the mines is provided in sections 2.7, 5.4 and in App.6.

App. 1: Activity calculations (values in brackets […] for Jabiluka:

The specific activity of U238 is 12,330 Bq/g and the U238 content of U_3O_8 (yellowcake) is 84.8%.

Therefore the specific activity of U238 in yellowcake is 1.045 x 10^4 Bq/g (alpha only). Considering the two other uranium isotopes in yellowcake as well, U234 and U235, the total activity of uranium in yellowcake is 2.1 x 10^4 Bq/g (alpha only).

With an Olympic Dam ore grade of 0.065% [Jabiluka 0.46%] the specific activity of U238 in the original ore is 6.79Bq/g [48 Bq/g], which represents the current chain activity both in the uranium ore and in the tailings. The total uranium activity in the original ore would be 13.6 Bq/g [96 Bq/g](alpha only).

The tailings contain 6 alpha decays, each having the same activity, therefore the total specific activity (alpha only) for the tailings is 6 x 6.79 = 40.8 Bq/g [6 x 48 = 288 Bq/g], and for uranium ore 10 x 6.79 = 67.9Bq/g [10 x 48 = 480 Bq/g].

App. 2: Dose limits for inhalation of tailings particles:

1. According to the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores', 1987, Commonwealth of Australia:

For designated radiation workers an annual dose limit of 50 mSv applies. For members of the public a dose limit of 1mSv per year applies (with a subsidiary dose limit of 5mSv per year, as long the average annual dose over a lifetime does not exceed 1 mSv). The conversion factors for ore dust, product dust and tailings dust are 0.021, 0.034 and 0.017 [mSv/alpha disintegration per sec.] respectively. The maximum quantity of dust [grams] to be inhaled per year is therefore:

	Ore dust	product dust	tailings dust
For workers	35.1	0.07	72
For members of the public, ongoing exposure	0.70	0.0014	1.44
For members of the public, single accident	3.5	0.007	7.2

2. According to ICRP's 60, 68 and 72

For designated radiation workers an annual dose limit of 20 mSv applies with a subsidiary dose limit of 50 mSv per year as long the average annual dose over 5 years does not exceed 20 mSv. For members of the public a dose limit of 1 mSv applies with a subsidiary dose limit of 5 mSv per year as long the average annual dose over 5 years does not exceed 1 mSv. The conversion factors are detailed for each isotope separately requiring lengthy calculations and uncertain assessments. Considering for each dust category only the two isotopes with the largest conversion factors we arrive at the following maximum quantities of dust [grams] to be inhaled per year:

	Ore dust	product dust	tailings dust
	Th230, Ra226	U238,U234	Th230, Ra226
For workers, ongoing exposure	74	0.17	74
For workers, single accident in any 5 years	370	0.8	370
For members of public, ongoing exposure	1.3	0.006	1.3
For member of public, single accident in any 5 years	6.5	0.03	6.5

The maximum quantity of Olympic Dam tailings dust to be inhaled per year by a member of the public is 1.44 g. With a spec. gravity of 1.75, this would be equivalent to a half teaspoon.

All the above inhalation limits would have to be set much lower as other pathways and other sources of man-made radiation apply as well, both for workers and the public. In a practical situation, perhaps some 2 – 100 times less dust is allowable to be inhaled.

App. 3: External radiation, gamma dose (values in brackets […] for Jabiluka):

The two main gamma-radiating isotopes in the tailings are Bi-214 and Pb-214 with a dose factor of 2.81E-04 resp. 4.69E-05 [Sv/a per Bq/cm^3]. With a spec. activity of 6.79Bq/g [48Bq/g](see App.1) and a tailings density of 1.9 we arrive at an activity/vol of 12..9 Bq/cm^3 [91 Bq/cm^3].

For somebody living on exposed tailings this results in an annual dose of $(2.81 + 0.469) \times 10^{-4} \times 12.9$ = 4.23mSv [29.9 mSv] for a thickness of the tailings deposit of 1 centimetre. For a 15 centimetre thick deposit the annual dose would be 19.7 mSv [139 mSv].

App. 4: Radon emanation and annual dose (values in brackets […] for Jabiluka):

In the O.D.EIS (1982, p.9-26) [JMA-PER, Appendix L.6.2] the radon emanation rate for the tailings during mine operation is specified as 0.6 and 3.2 Bq / (m^2 x s) [19.4 Bq / (m^2 x s)]. While this might be correct for the partly saturated tailings during mine operation, the long-term emanation rate after erosion of the cover and dehydration of the top strata of the tailings would rather be 7.3 Bq / (m^2 x s) [50 Bq / (m^2 x s)]. This assumes a radium 226 content of 7.3 Bq/g (O.D.EIS, 982, p.9-26, adapted to the higher ore grade) [49 Bq/g] and an emanation constant of 1Bq/ (m^2 x s) per Bq/g of radium 226 (ARL TR 43) [0.8Bq / (m^2 x s), considering the effect of the rain season].

For the members of the 'critical group' we assume that they live in buildings which tend to accumulate the radon gas emanating from the ground. If a person lives in a 10-squaremetre / 20 cubic metre hut, tent or similar structure erected on the ground without much cover of the ground, and keeps doors and windows closed during the night (8 hours), then the radon accumulation (in a night) is 7.3Bq/(m^2xs) x 8h x 3600s x 10m^2 = 2,102,400 Bq [11.520,000 Bq] and the average radon concentration during the night is then 52,560 Bq/m^3 [288,000 Bq/m^2] The exposure time is 365 x 8 = 2920 hours. This results in a dose of 300 mSv [1600 mSv].

While this calculation considers a rather theoretical situation (no radon losses from the building and unobstructed radon emanation), this is more than compensated by not considering the daytime exposure to radon in the calculation.

I assume a radon dose of 300 mSv [1600 mSv] per year for members of the 'critical group'.

App. 5: Estimates of future radiation cancer deaths from current Australian uranium tailings:

It has been estimated by the US EPA that, without control, the radon emissions from all tailings in existence at licensed US sites in 1983 would cause about 500 lung cancer deaths per century (EPA 1983a), and that, without remedial action, the radon emissions from all tailings at inactive US mine sites would cause 170 - 240 deaths (EPA 1983b).

For our estimates we use the figures from the inactive mine sites as they more closely reflect the condition of the Olympic Dam tailings deposit over the future millennia, when the tailings will be exposed and spread around (the US study does not include the long-term aspects of the tailings).

Considering the very slowly diminishing radioactivity of the tailings the 170-240 death per century (205 deaths used for calculations) would result in about 228,000 future lung cancer deaths from radon emissions alone.

We assume the average dose distribution model for uranium tailings to be 80% radon, 12% inhaled tailings dust, 8% ingested tailings and 0.2% external radiation (see chapter 3.6 of my paper 'Long-term Consequences of Uranium Mining'). This would result in 284,000 future cancer deaths from the combined pathways.

The US EPA estimates have been made for the situation in the US in 1983. How do they compare with the future situation in Australia?

a) Population density of Australia: Our estimates are made for today's Australian population density which is 10.67% of the US reference population density. This figure is based on the current estimate of the Australian population (18.2 million). Correction factor(C/f): 0.1067

b) Population density in the region of mine site: Olympic Dam is located in a remote area, even more than the US reference mines. This is somewhat mitigated by the fact that a variety of climatic conditions can be expected over the long time spans involved – as happened in the past. Higher rainfall would make the prevalent soils much more fertile. This would increase the average future population density of the area as well as the contaminated food supply from the area. C/f: 0.5

c) Tailings quantities: In 1983 there were some 26 million short tons (23.6 million tonnes) of tailings at inactive mine sites in the US. Proposed Olympic Dam tailings: 569 million tonnes. C/f: 24

d) The ore grade directly determines the radioactivity of the tailings. Unfortunately there are very contradictory statements about the Roxby Downs ore grade. In the original EIS an ore grade of 0.05% was stated and since widely used. A recent report to the Senate (Leigh, 1997) states an ore grade of 0.15% -- 3 times higher!! An investigation of this discrepancy might be of interest. The new O.D.ExpEIS, gives in Table 3.2 values between 0.069% and 0.087% for the years 1996 to 2010 and in Table 3.1 a value of 0.06% for the total deposit. We assume an ore grade of 0.06%. The average ore grade of the reference US tailings is 0.227%, resulting in a reduction of the detriment. C/f: 0.26

e) The effects of those American tailings were only considered for a time span of 100 years into the future. After 1000 or 10,000 years the situation will be substantially different -- tailings will be an intrinsic part of the human biosphere. Then, the detriment will be much higher than during the 'foreseeable' next hundred years considered in the US study. For the long-term situation, four main differences have been identified:

- The tailings deposits will increasingly deteriorate causing higher erosion rates than assumed in the reference US-study. C/f: 2
- The loss of knowledge and understanding of the dangers will result in people living, working and farming right on top of deposited and eroded tailings. C/f: 5
- The ongoing erosion of tailings will result in a substantial accumulation of tailings particles in the biosphere. While a considerable proportion of the eroded and dispersed tailings will leave the biosphere in various ways (buried under sediment on land or in the ocean), substantial quantities will remain in the topsoil from where they can release radon and enter the human food chain again and again. Some of the tailings covered by sediment will again become exposed by erosion. Even those tailings covered by sediment will largely stay connected to the biosphere for 2 reasons: firstly, several of the radioactive isotopes in the tailings are water-soluble (OECD, 1984, p.38 ff.). The fine particle size of the powdery tailings permits the leaching of those isotopes. Secondly, radon gas continues to escape: A cover of half a meter of sand will reduce the radon emanation from the tailings into the biosphere by 29% only, a cover of three metres by 88% (EPA 1986). Initially, the tailings leaving the biosphere each century may be 10% of all tailings in the biosphere, the tailings re-entering the biosphere may be 0.5% of all tailings outside the biosphere earlier. These rates would gradually decrease eventually moving very close to zero. C/f: 15
- Also, the loss of knowledge and understanding of the dangers will see the people of the future mining the tailings for land fill, concrete admix or for their garden beds as it happened some 30 years ago in the US when we had all reason to know better. C/f: 2 .. 5 .. 10

f) Since the first recommendation of a radiation dose limit in 1902, the dose limits had to be reduced again and again as the evidence of the hazard mounted. The last major push for such a dose reduction occurred in the eighties when new statistical data from Hiroshima further revealed the long-term consequences of uranium mining. Each reduction in the dose limit increases the costs of uranium mining considerably, and reduces the viability of the whole nuclear industry. As usual, the International Commission on Radiological Protection (ICRP) resisted the required changes for a long time and eventually introduced a half-hearted dose reduction with a 10-year delay. This reduction granted a 2.5 times lower dose limit for workers and a 5 times lower dose limit for members of the public. Since, the ICRP modified the individual conversion factors for the most critical isotopes in the uranium ore and tailings effectively increasing the maximum exposures for the most common situations some 2 to 6 times. This effectively inverted the dose limit reduction (see App.2 and chapter 6.1). Considering that the dose limit reduction was in the first place not adequate to the statistical evidence from Hiroshima and that not even the basic principle of a linear 'dose – effect relationship' has been applied to the calculation even though accepted in principle, the maximum exposures limits may be another 2 to 10 too high. For most practical situations, the combined effect of these flaws might result in a radiation exposure limit some 4 to 60 times too high. For various reasons these distortions of the exposure limits had only a limited influence onto the US study (eg. radon research is not based on Hiroshima data). C/f: 1.5 .. 10

These assumptions would suggest 106 million future cancer deaths from the proposed Olympic Dam uranium tailings (284,000 x 0.1067 x 0.5 x 24 x 0.26 x 2 x 5 x 15 x 5 x 1.5 = 106 million) for the scenario considered most likely (underlined correction factors). With the above assumptions the death toll could range between 42 million and 1.41 billion! These estimates do not yet include the effect of the residual uranium content, which increases the death toll over the next 500,000 years by about 20% (in the very long term this aspect will increase the death toll perhaps several hundred times, which is not yet considered here). The estimate of the death toll from the Olympic Dam tailings over the next 500,000 years is therefore 127 million ranging from 53 million to 1.7 billion.

Obviously these estimates come with big uncertainties which could increase or decrease the estimates considerably. However, we do not have the right to give the credit of the doubt to the mining companies. This is not a trial where the crime has already happened, where we have to give the credit of the doubt to the accused. This is rather a proposal for the future to indirectly inflict death and disease. The credit of the doubt has to be given to those potentially affected.

Please note: For the calculations of the future death toll in App.5 very small doses (minute fractions of a mSv) have been included into the statistical cause of cancers. The consideration of annual doses below 1mSv (the maximum dose for members of the public) is often rejected as insignificant. However, there is a natural background dose of about 2 mSv providing already a high base level. Therefore these minute additional levels have to be included.

The other argument made is that these smaller man-made doses are insignificant compared to the natural background. While it is true that a dose of 0.1 mSv adds only 5% to the average background radiation, it is as well true that the natural background radiation costs many lives (some 1800 deaths per year in Australia). The fact that nature causes deaths does not give us the right to add to this. Over the very long time spans involved vast numbers of people (perhaps 50% of the above estimates) will die due to those 'insignificant additions' to the natural background radiation. The sanctity of human life can not be abolished because nature causes deaths. Nature provides for the eventual death of each of us. This does not give mining companies the right to request a share in killing rights.

App. 6: Estimates of radiation dose to 'critical group', required time span for safe storage of the tailings and of future radiation cancer deaths from proposed Jabiluka uranium tailings:

In chapter 3 of my study "Long-term Consequences of Uranium Mining" (July 1997) estimates have been made for the Olympic Dam uranium mine. The result was a 400 mSv maximum dose for the members of the 'critical group' resulting in a safe storage requirement for some 20 billion years. For the Jabiluka tailings several parameters have changed:

a) The ore grade: Jabiluka: 0.46%, Olympic Dam: 0.06%, Correction factor (C/f): 7.67

b) The quantities: Jabiluka: 19.5 million tonnes, Olympic Dam: 569 million tonnes.

For the maximum dose to a member of the 'critical group' the difference in the tailings quantity is less relevant: C/f (death toll): 0.034 C/f (critical group, max.dose): 0.9

c) The residual tailings content: Jabiluka: 4%, Olympic Dam: 23%, C/f (death toll,500,000y): 0.95 C/f (death toll, after 500,000y): 0.2 C/f (critical group, max.dose): 0.95 C/f (critical group, hypothetical): 0.04

d) The storage factor: In section 5.1: 'Comparison of radioactive waste storage options' it was stated that in-pit tailings storage would reduce the future death toll by 65 - 95% (resulting in a correction factor of 0.05 to 0.35). The in-pit storage of cement-enriched tailings at Jabiluka is presented as rather safe and reliable. Unfortunately, this is not at all the case. Close investigation of the site characteristics and of the cement-enriched paste technique reveals very serious concerns. A further problem arises with the 'human interference' risk as outlined earlier. Human interference brings the tailings contamination not only into the biosphere in general - like erosion does - but also into the human habitation in particular (as building material) where radon emanation is most detrimental. C/f (death toll): 0.35 C/f (critical group, max.dose): 0.7

e) Tailings distribution: Jabiluka: 50% in-pit, 50% in mine shaft C/f (death toll): 0.51 C/f (critical group, max.dose): 0.99

f) Time factors: In comparison to a tailings dam the in-pit storage brings a larger improvement in the first 500,000 years while the effects over the remaining 20 billion years are ever decreasing. C/f (500,000years): 0.8 C/f (after 500,000): 1.6

Using these conversion factors the maximum dose to the 'critical group' due to Jabiluka tailings is estimated at 1744 mSv (400 mSv x 7.67 x 0.9 x 0.95 x 0.7 x 0.99 x 0.8 = 1817 mSv).

The death toll due to the tailings over a period of 500,000 years is estimated at 4.6 million (130 million x 7.67 x 0.034 x 0.95 x 0.35 x 0.51 x 0.8 = 4.6 million).

The required time span for safe storage is mainly dependent on the residual uranium content, ore grade and the long-term effects. To calculate this time span a hypothetical maximum dose (due to the residual uranium and its decay products only) to the 'critical group' is required: Hypoth.Dose = 400 mSv x 7.67 x 0.9 x 0.04 x 0.7 x 0.99 x 1.3 = 100 mSv. This dose requires 29 billion years or some 6.5 chain half lives (tailings section "A2", see Fig.1) to diminish to the legal limit of 1mSv and therefore 29 billion years of safe storage for the tailings. This assessment requires further investigation. However, even if the 'Hypothetical Dose' was only half of the calculated 100 mSv, ie 50 mSv, the tailings would still require 25 billion years for safe storage (non-linear half life curve).

App. 7: Other studies and estimates

So far the estimates have been based mainly on data of the US Environmental Protection Agency. There have been several other studies on the future effects of uranium tailings:

- In 1984 a **report by the OECD** has been published under the title ‘Long-Term Radiological Aspects of Management of Wastes from Uranium Mining and Milling’. One of its four case studies conducted was for the Ranger uranium mine and tailings dam. By limiting the study to 10,000 years and proclaiming a safe performance for most of the investigated tailings dam options for this time span, the study avoided to really look into the long-term consequences of uranium mining. Unfortunately, there are two problems with this approach: Firstly, after 10,000 years the tailings retain 92% of their original radiation. Secondly, the described tailings dam options in the described climate would never last for 10,000 years as a civil engineer with some honesty and related knowledge may easily confirm.

  The estimates of the collective dose commitment (equivalent to death toll) are similarly biased towards the industry and appear several thousand times too low. In Table 3.8 of the OECD report a collective dose commitment between 780 and 3000 man-Sievert has been claimed for the 10,000-year period, which is equivalent to a death toll of 40 to 150.

  The study does not always provide sufficient detail to show where it went wrong in its estimates.

However, there are a few examples where the mistake can be shown:

In section 3.4.1. (par.98) the radon exhalation rate from tailings / waste rock is assumed to be 0.4 Bq/(m^2xsec). Considering the seasonal variation of the radon release this figure appears at least 20 times too low and should be <u>at least</u> 8 Bq/(m^2xsec). Using the dose distribution shown in Fig.3.2 of the OECD report, the collective dose would increase by a factor of 10, ie. 400 to 1500 deaths.

The study assumes that by the end of the 10,000-year period the surface erosion of the tailings has just started (see Table 3.7, OECD report). Therefore, the death toll estimate for the second 10,000-year period has to be increased, perhaps by a factor of 20, and for the third 10,000-year period [Estimate(3)] perhaps by a further factor of 1.5. This means a death toll 12000 to 45,000 for the third 10,000-year period and also for the following 10,000-year periods.

The tailings particles eroded in a particular 10,000-year period will not all have left the biosphere by the end of that period. Also, the dissolved isotopes entering the biosphere are not very likely to ever leave the biosphere. Consequently there is an ongoing accumulation of radioactive tailings particles / isotopes in the biosphere as long as the tailings erosion proceeds (for some 200,000 years according to the study). Afterwards the death toll estimate is mainly determined by the half lives of the parent isotopes in the tailings. In the long term the tailings find ever more stable places inside and outside the biosphere. There is still movement, mainly of dissolved isotopes into the biosphere (due to ongoing leaching of the finely milled tailings) and - to a lesser extent - of particles out of the biosphere. For the estimation it is conservatively assumed that these movements are in balance.
The initial accumulation of tailings in the biosphere during the first 200,000 years requires the above death toll estimate to be further increased, perhaps according to the formula $\text{Estimate}(n) = \text{Estimate}(3) \times (1.05 + 0.01 \times n)^{(n-3)}$ with n = 4 to 20 for the fourth to the twentieth 10,000-year period.

Considering the effect of the slowly diminishing tailings radiation according to the half lives and the effect of the ongoing dispersion of the eroded tailings, this could result in a death toll from the tailings stored in the Ranger tailings dam (if it were to be retained) of 5 million to 20 million people over 200,000 years equivalent to 10 million to 40 million over 500,000 years.

Understandably, the report by the mining friendly committee is limited to 10,000 years. Page 90 of the report defends: “such integration [‘to and beyond 100 million years’] is not technically sup-portable”. However, after 10,000 years some 92% - and after 100 million years 4% of the tailings radiation persists - a scientific fact!

- The periodic **‘Reports by the United Nations Scientific Committee on the Effects of Atomic Radiation’** are another source of estimates:

Paragraph 61 of the 1988 report states that “over 1 million years, assuming a world population of 10 billion persons, the collective dose from the long-lived radionuclides was estimated at about 3,400 manSv/Gigawatt-year.” 95% of this dose is due to uranium tailings (see same paragraph of the report). The production of one Gigawatt-year requires about 230 tonnes of natural uranium (see 1993 report, Annex B, Table 16). The proved and probable uranium ore reserves at Olympic Dam are estimated (30 June 1996) at 569 million tonnes with an ore grade of 0.06% (see O.D.ExpEIS, Table 3.1). This results in 314,000 tonnes of uranium oxide -- enough to produce 1480 Gigawatt-years. For the above assumptions, the collective dose from the Olympic Dam uranium tailings is therefore 4.78 million manSv (.95 x 3400 x 1480), which is equivalent to a future death toll of 239,000.

Paragraph 32 of Annex B, 1988 report, details that the radon release “as a function of time is assumed to be constant, and given the very long duration of the source, the normalized collective effective dose equivalent commitment is proportional to the duration considered reasonable for assuming the release.” This statement shows that various factors increasing the radiation hazard from the tailings in the long-term (see this paper Appendix 5e) have not or not adequately been considered. Using the four correction factors outlined in App.5e, the above death toll estimate increases to 179 million. Considering the very slowly diminishing radioactivity of the tailings and the different integration periods for the estimates, the result confirms my estimates.

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