Response to the Tentative Findings of the Nuclear Fuel Cycle Royal Commission.

Friday 11th March 2016

The Honorable Rear Admiral (Rtd) Mr Kevin Scarce

Your Excellency

I urge the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

South Australia can not safely increase its participation in nuclear activities through the storage and disposal of used nuclear fuel. In the event of an accident such as fire or explosion, highly radioactive particles and gases would be widely dispersed. A breech or leak in storage containment could result in radiation entering the environment through ventilation systems and groundwater.

Claims by the nuclear industry that it is safe to place a spent nuclear fuel (SNF) repository near population centres are misguided. Radiation, carried by particles and gases and inhaled or ingested by the human body are far more dangerous to human health than industry models will credit. The work of Alexi Yablokov et al 2009[1.] show that the consequences of exposure to radiation and fallout from the Chernobyl reactor explosion are orders of magnitude worse than the World Health Organisation (WHO) figures.

A determination of the safety of a spent nuclear fuel repository in South Australia cannot be made without accurate scientific analysis of the human health consequences of accidental radiation release. Plutonium for example is highly reactive chemically and may spontaneously ignite in air. Industry know that Plutonium may rapidly oxidise in moisture-accelerated runaway reactions leading to rupture of containment. (John M. Haschke et al 1991)[16]. Radioactive nanoparticles are readily transported.

The ICRR model of radiation risk used by the industry worldwide to determine safety has been shown to under-estimate the detrimental health effects of ingesting or inhaling radioactive particles and gas. The ICRR model does not properly recognise the chemical affinity of radionuclides for DNA and the spectrum of consequent illnesses are ignored. This is the reason the WHO estimate of casualties from the Chernobyl explosion are two orders of magnitude low. The ICRR model was never intended to be used to determine the safety of widespread accidental radiation release. (Busby et al 2006)[2]

I urge the Royal Commission to recognise the possibility of accidental radiation release, to recognise the detrimental health impact of the Chernobyl accident upon millions of human beings and to conclude that a Global SNF repository in South Australia cannot safely contain a thousand times as much radiation as was lost from Chernobyl, for two hundred thousand years.

I urge the Royal Commission to find that South Australia cannot safely increase it's participation in nuclear activities through the storage and disposal of spent nuclear fuel, that the integrated storage and disposal facility is not proven technology and presents an unacceptable risk to the health and welfare of South Australians.

The following responses address Tentative Findings of the Royal Commission in the order in which they are presented :

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

WHAT ARE THE RISKS?

64.

Australia holds a manageable volume of domestically produced low and intermediate level radioactive wastes. These low level wastes comprise contaminated soils, decommissioning waste from research reactors, and equipment and laboratory items from the operation of Australia's research reactors and medical facilities. The intermediate level wastes include vitrified (glass) waste from reprocessed research reactor fuel and some materials from the decommissioning of research reactors. The wastes result from science, medicine and industry, the products of which have served current and past generations of Australians.

The vitrification process for intermediate waste is not proven. Nuclear waste glasses may corrode in actual conditions both via ion exchange/interdiffusion and hydrolysis depending on the temperature of the disposal environment. The wide range of chemistries found in intermediate level waste make each vitrification a process of experiment.

- The Royal Commission is urged to amend the findings in this section to conclude that the long term stability of vitrified waste remains in question.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

WHAT ARE THE RISKS?

65.

Low level waste mostly contains radionuclides (an atomic nucleus that emits radiation) with short half-lives. This means it requires containment and isolation from the environment for up to a few hundred years to reach background (natural) levels. Low level waste does not generate heat. Intermediate level waste needs a greater degree of containment and isolation than low level waste due to its higher radioactivity and possible higher proportion of long-lived radioactive materials. It requires shielding during storage and transport. It does not generate significant quantities of heat. Both types of wastes are solids at the point of disposal.

Low level nuclear waste can include any type of radionuclide it includes everything from slightly radioactive trash such as mops, gloves, and booties to highly radioactive activated metals from inside nuclear reactors. It includes both short-lived and long-lived radionucldes.

- The Royal Commission is urged to amend the findings in this section to recognise the long lived components of "Low Level" radioactive waste and to conclude that this waste must be handled appropriately and contained for thousands of years.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

IS THE ACTIVITY FEASIBLE?

68.

Repositories have been developed on a range of sites and in a variety of climates—many of which are much less favourable than conditions in South Australia. The designs of those facilities have been adapted to suit those conditions. There is substantial experience in their design, management and operation, and in the case of France, their closure, which has informed applicable international standards. The performance of those facilities in providing long-term isolation and containment is assessed during their operation.

The past performance of existing repositories should alert the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

Germany's Asse 2 nuclear waste repository has failed. ""It is a disastrous situation", says Jochen Flasbarth, state secretary at the Federal Ministry of the Environment."[7.] The Asse repository holds 126,000 drums containing enough plutonium bearing waste to fill 20 Olympic swimming pools. "But now, the walls of the Asse mine are collapsing because of pressure from surrounding rocks and brine is seeping in at a rate of around 12,000 liters a day." "In 2011, the BfS (Federal Office for Radiation Protection) ruled that the waste had to be removed. But the task is so difficult that it is likely to take decades."[7]

The US Department of Energy (DOE) Waste Isolation Pilot Project (WIPP) nuclear waste dump in Carlsbad New Mexico has also failed. On 14th Feb 2014 radiation detectors detected radiation in the exhaust air being released from the mine. On 15th February, authorities ordered workers to shelter in place at the facility. Later, traces of airborne radiation consisting of americium and plutonium particles were discovered half a mile from the facility. On 26th February 2014, the DOE announced that thirteen WIPP above–ground workers at the time had received internal radiation exposure and that additional testing would be done on employees who were working at the site the day after the leak. On February 27, the DOE announced it had sent out a letter to tell people in two counties what they knew so far. (Gundersen A. 2014)[19.]

The cause of the contamination was a barrel that exploded on 14th February because it had been packed with organic cat litter. Contaminants were spread through more than 910m of underground tunnels leading to the 660m exhaust shaft into the surrounding above ground environment. Radiation was also detected off site as far away as the surrounding communities. Given workers and land far outside the mine were contaminated, the underground portions of the mine were more than likely severely contaminated. (Gundersen A. 2014)[19.]

- The Royal Commission is urged to acknowledge the high number of failed nuclear waste repositories around the world.

- The Royal Commission is urged to find that from past industry experience, long term containment of nuclear waste cannot be guaranteed.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

IS THE ACTIVITY FEASIBLE? 69.

The disposal of low level and short-lived intermediate level waste need not rely on the technical characteristics of the site. There is no need for a perfect site; rather, a sufficient one. The emphasis is placed on a facility design that is engineered with sufficient barriers that, in combination, provide for long-term containment and isolation of radionuclides. When disposed of in near-surface facilities,

the risks of migration of such radionuclides into the natural environment is managed by

a.

disposing of the waste in solid and insoluble form

b.

containing the waste in a purpose-built package

c.

adding a further steel or concrete barrier around the waste container

d.

designing and building the facility in a way that retains the waste and prevents moisture ingress from the natural environment. Modern waste facilities incorporate such controls.

This approach should be seen for what it is. It is Design-On-The-Run. The original hope for a deep geological repository was containment through the impervious nature of the surrounding bedrock. When it is realised that water moves through bedrock, reliance on the geological barrier has to be abandoned. This should cause the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

The Finnish facility at Onkalo has run into these problems. The bedrock repository was intended to act as a barrier to migration of radio nuclides by restricting groundwater flow. But groundwater is entering the facility at a rate of twenty liters a minute. Posiva have been forced to abandon reliance on the granite to restrict groundwater and have fallen back onto engineering barriers of bentonite packing and copper capsules to provide the environmental isolation.

This water leakage directly threatens the copper containment capsules. Water reaching the canisters, may contain corrosive minerals and bacteria which seep through the clay and erode the metal containers. The fuel rods would become exposed to the clay, and the water would carry harmful radionuclides into the ground water.

Groundwater may chemically react with the plutonium in the SNF in a more catastrophic manner.

- The Royal Commission is urged to find that the engineering barriers were originally intended as the last line of defence and never as the the primary isolation.
- The Royal Commission is urged to find the corrosion threat to containment from corrosive water and bacteria is significant.
- The Royal Commission is urged to find that long-term containment and isolation of

radionuclides in copper cannisters is doubtful.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

IS THE ACTIVITY FEASIBLE?

74.

There is international consensus that geological disposal is the best technical solution for the disposal of used fuel. Two countries, Finland and Sweden, have successfully developed long-term domestic solutions. That success has been both in gaining social consent for a facility and in developing an engineering and technical solution that has been licensed to safely provide for disposal over a long period. The more advanced of the two projects will start receiving used fuel early in the next decade.

Describing the Finnish and Swedish geological disposal facilities as successful is premature.

The Finnish facility at Onkalo has problems. The bedrock repository was intended to act as a barrier to migration of radio nuclides by restricting groundwater flow. But groundwater is entering the facility at a rate of twenty liters a minute. Posiva have been forced to abandon reliance on the granite to restrict groundwater and have fallen back onto engineering barriers of bentonite packing and copper capsules to provide environmental isolation.

This water leakage directly threatens the copper containment capsules at Onkalo.

- The Royal Commission is urged to find that the technology utilised at the Onkalo repository in Finland is unproven.
- The Royal Commission is urged to find that South Australia's unique geology presents a whole new set of challenges to the Finnish and Swedish containment technology.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

IS THE ACTIVITY FEASIBLE?

75.

In these facilities, the risk of the radionuclides migrating into the environment is managed by the geology in which the facility is situated as well as its engineered barriers (see Figure 5).

A research group at the Royal Institute of Technology in Stockholm, Sweden, published research that suggests that the copper capsules of KBS-3 are not as corrosion-proof as Svensk Kärnbränslehantering AB (SKB) and Posiva claim.[8.] The research group led by Peter Szakálos found that the copper capsules would last only about 1,000 years, instead of the 100,000 years claimed by the companies. According to the research results, corrosion in pure copper advances at about one micrometer a year, whereas KBS-3 depends on a rate of corrosion that is a thousand times slower. In response, STUK (the Finnish nuclear safety office) has asked Posiva for further explanation, and independent research conducted in Finland has supported the results of Szakálos's group. However, in public, Posiva dismissed the independent research in Sweden and Finland, referring to its own safety studies.

CuOFP has been selected as corrosion resistant material for the overpack in the KBS-3 concept. The capsules are hot. Copper alloys which contain oxygen as an impurity in the form of residual oxides present in the metal matrix, can be embrittled if exposed to hot hydrogen. The hydrogen diffuses through the copper and reacts with inclusions of Cu2O forming H2O, which then forms pressurized water steam bubbles at the grain boundaries. This process can cause the grains to be forced away from each other, and is known as steam embrittlement.

- The Royal Commission is urged to acknowledge the corrosion threat to the copper containment capsules due to hydrogen embrittlement.

- The Royal Commission is urged to find that that the technology utilised at the Onkalo repository in Finland is unproven.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

IS THE ACTIVITY FEASIBLE?

76.

Each facility is sited in geological conditions that naturally limit the potential pathways for migration. While it is not possible to know the geological and climatic conditions in the distant future, reasonable predictions of such future behaviour have been made from careful study of the particular geological formations over much longer periods in the past. Safety analysis has included an assessment of the barrier performance in a range of scenarios of possible future events over one million years. Geological analogues or observed natural conditions in similar ore bodies or materials provide additional confidence.

Moisture directly threatens containment at Onkalo. The bedrock was intended to act as a barrier to migration of radio nuclides by restricting groundwater flow. But groundwater is entering the facility at a rate of twenty liters a minute. Posiva have been forced to abandon reliance on the granite to restrict groundwater and have fallen back onto engineering barriers of bentonite packing and copper capsules to provide environmental isolation.

- The Royal Commission is urged to acknowledge the threat to containment capsules in deep geological repositories from moisture.

- The Royal Commission is urged to acknowledge the effect of rock fractures, greatly increasing radionuclide mobility.

- The Royal Commission is urged to find that the Finnish and Swedish containment technology is not proven.

AUSTRALIAN LOW LEVEL AND INTERMEDIATE LEVEL WASTE

IS THE ACTIVITY FEASIBLE?

77.

Engineered barriers are designed to work in combination to greatly delay the exposure of the fuel to groundwater and ensure that if the radionuclides migrate into the natural environment, the level

of radioactivity would be below that produced by natural sources. Engineered barriers include:
a.
waste being in solid form—either retained in the original spent fuel ceramic or incorporated into a solid matrix. This could be a glass structure (known as vitrified waste), a ceramic or a synthetic rock (such as Synroc)
b.
solid waste being contained inside a purpose-built package to protect it from mechanical loads
c.
the package being deposited inside an additional container to prolong containment
d.
the use of a buffer to impede moisture ingress and thereby reduce corrosion
e.
the use of backfill and plugs to provide structural support to the tunnel and impede groundwater flow
f.
the facility being designed and constructed in a way that acts as a geological barrier.

Water is the one agent that seriously threatens this design. Impeding moisture ingress is not sufficient. Groundwater in South Australia is highly mineralised, containing ions of iron and sulphur and frequently is highly corrosive. Synroc is not a proven technology. From the chemistry of the waste being vitrified to the chemistry of the surrounding geology, Synroc is unproven.

The geological barrier concept is meaningless when fractured rock allows rapid migration of radionuclides.

- The Royal Commission is urged to acknowledge the risk of accidental radiation release from fire, explosion or natural disaster during operation of the repository.

- The Royal Commission is urged to acknowledge the threat to long term containment from corrosion of containment capsules.

- The Royal Commission is urged to acknowledge the effect of rock fractures, greatly increasing radionuclide mobility.

- The Royal Commission is urged to find that the risk of radiation release during long term operation of the repository is unacceptably high.

Nuclear Fuel Cycle Royal Commission Tentative Findings
MANAGEMENT, STORAGE AND DISPOSAL OF WASTE
80.
The time frame for the development of a geological disposal facility for used fuel on the Finnish and Swedish models is long. These successful projects have taken more than 30 years to develop—although the facilities were not required before that time and the disposal methods and technology were being investigated concurrent with implementation. Any future proposal could draw on these experiences to reduce licensing and construction time frames.

Describing the Finnish and Swedish geological disposal facilities as successful is premature.

The Finnish facility at Onkalo has already run into problems. The bedrock repository was intended to act as a barrier to migration of radio nuclides by restricting groundwater flow. But groundwater is entering the facility at a rate of twenty liters a minute. Posiva have been forced to abandon reliance on the granite to restrict groundwater and have fallen back onto engineering barriers of bentonite packing and copper capsules to provide environmental isolation.

This water leakage directly threatens the copper containment capsules at Onkalo. The groundwater will corrode the capsules. The fuel rods will become exposed to the clay, and the water will carry harmful radionuclides from the SNF into the biosphere.

A research group at the Royal Institute of Technology in Stockholm, Sweden, published research that suggests that the copper capsules of KBS-3 are not as corrosion-proof as Svensk Kärnbränslehantering AB (SKB) and Posiva claim.[8] The research group led by Peter Szakálos found that the copper capsules would last only about 1,000 years, instead of the 100,000 years claimed by the companies. According to the research results, corrosion in pure copper advances at about one micrometer a year, whereas KBS-3 depends on a rate of corrosion that is a thousand times slower. In response, STUK (the Finnish nuclear safety office) has asked Posiva for further explanation, and independent research conducted in Finland has supported the results of Szakálos's group. However, in public, Posiva dismissed the independent research in Sweden and Finland, referring to its own safety studies.

CuOFP has been selected as corrosion resistant material for the overpack in the KBS-3 concept. The capsules are hot. Copper alloys which contain oxygen as an impurity (in the form of residual oxides present in the metal matrix) can be embrittled if exposed to hot hydrogen. The hydrogen diffuses through the copper and reacts with inclusions of Cu_2O forming H_2O, which then forms pressurized water steam bubbles at the grain boundaries. This process can cause the grains to be forced away from each other, and is known as steam embrittlement.

- The Royal Commission is urged to reserve judgment on the success or otherwise of the Finnish and Swedish geological disposal facilities.

- The Royal Commission is urged to find that the copper capsules may only last about 1,000 years, instead of the 100,000 years as claimed.

NUCLEAR FUEL CYCLE ROYAL COMMISSION TENTATIVE FINDINGS

MANAGEMENT, STORAGE AND DISPOSAL OF WASTE

IN WHAT CIRCUMSTANCES IS THE ACTIVITY VIABLE?

81.

Globally, there are significant quantities of used fuel from nuclear reactors in temporary storage awaiting permanent disposal, including in the Asia-Pacific region, for example, in Taiwan, Japan and Korea. In 2015, there were global inventories of 390 000 tonnes heavy metal (tHM) of used fuel and reprocessed waste, and about 9.9 million cubic meters (m) of intermediate level waste in storage. The quantities will grow as these countries continue to rely on nuclear power as a source of generating low-carbon energy. By 2090, the amount of used fuel is projected to be more than 1 million tHM.

Reprocessing waste often exists in liquid form and typically presents as a heavy metal sludge containing plutonium and uranium and extremely mobile salts such as cesium in solution. The technology to safely isolate the salt solution or heavy metal sludge from the environment has not been proven. Proposals to dry and vitrify this material do exist however the long term stability of the vitrified material is not proven. There is a risk because it is cheaper, to dump this material in it's existing form as liquid sludge or salt solution and systems for the long term containment of liquid waste from the environment are totally unproven.

- The Royal Commission is urged to find that the risk to public public safety of storing reprocessing waste in South Australia is unacceptably high.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

116.

The national radiation safety regime in Australia sets annual limits on the amount of ionising radiation that can be absorbed (in 'doses') by workers and the public. For the public, the limits are significantly lower than what an average Australian might expect to receive from natural sources in any year or from certain medical procedures, such as CT scans and xrays. Background radiation relates to the natural and artificial sources that all people are exposed to on a daily basis. These exposures can vary greatly depending on an individual's location. Projects or activities that have the potential to result in radiation releases to the environment are also assessed for their potential impact, and protective requirements imposed where a potential release may exceed a threshold.

An important clarification to include here is the type of exposure expected from radiation releases to the environment. Doses from inhaled or ingested radio-active particles are far more damaging than external doses from distant sources. Gaseous or particulate radionuclides may be taken up by the body and accumulate over many years. Certain radionuclides have affinity for various parts of the body such as strontium, which is a calcium analog and will be taken up by bone. Iodine is taken up by the thyroid, sulfur by the testes, cesium is an iron analog taken up by muscle tissue and so on.

There is concern in the scientific community that the health impacts of particulate or gaseous radiation incorporated into the human body are not being properly assessed.

This concern is voiced by seventeen doctors and professors of science from the European Committee on Radiation Risk (ECRR) in a statement titled "The Lesvos Declaration" which in part states that:

"...the International Commission on Radiological Protection (ICRP) has promulgated certain risk co-efficients for ionizing radiation exposure,"... (and these) "… ICRP radiation risk coefficients are used worldwide by federal and state governmental bodies to promulgate radiation protection laws and standards for exposure to workers and the general public from waste disposal, nuclear weapons, management of contaminated land and materials.....and all stages of the nuclear fuel cycle."[17.]

"..by common consent, the ICRP risk model cannot validly be applied to post-accident exposures, nor to incorporated radioactive material resulting in internal exposure,"[17.] And

"...the ICRP risk model was developed before the discovery of the DNA structure and the discovery that certain radionuclides have chemical affinities for DNA, so that the concept of absorbed dose as used by the ICRP cannot account for the effects of exposure to these radionuclides,".

- The Royal Commission is urged to acknowledge that the health impacts of particulate or gaseous radiation incorporated into the human body are not being properly assessed under the ICRR radiation risk model.

- The Royal Commission is urged to recognise that the ECRR 2003 model of radiation risk is the only accurate method for assessing the potential health effects of radiation releases to human health and that this model is not used by the nuclear industry.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

117.

This regulatory regime is underpinned by the precautionary principle that any increase in radiation exposure, even at very low levels, may increase the risk of cancer. At very high levels of exposure, adverse health impacts can be directly observed or inferred from statistical analysis. However, at low levels (in the range of ordinary exposures from natural sources) there is ongoing scientific debate on the extent of any health risk that radiation exposure might create. Despite that debate, for the purpose of reducing potential occupational and public risk, a precautionary approach is appropriate.

There is concern in the scientific community that the health impacts of particulate or gaseous radiation incorporated into the human body are not being properly assessed and a frustration at regulatory authorities over tardiness in accepting findings after the Chernobyl nuclear accident. It is not the case of debate within the scientific community but more a tardiness of regulators to update their modelling.

The ICRP accepts that it's radiation risk model cannot validly be applied to post-accident exposures, nor to incorporated radioactive material resulting in internal exposure. An accurate model does however exist, the ECRR 2003 model, but it is not being used by the industry.

This concern is voiced by seventeen doctors and professors of science from the European Committee on Radiation Risk (ECRR) in a statement titled "The Lesvos Declaration" which in part urges that :

"the ICRP has not taken into consideration new discoveries of non-targeted effects such as genomic instability and bystander or secondary effects with regard to understanding radiation risk and particularly the spectrum of consequent illnesses," [17.] And

" there is an immediate, urgent and continuing requirement for appropriate regulation of existing situations involving radioactivity, to protect the human population and the biosphere". [17.] Because of the immediate, urgent and continuing regulatory requirement,

- the Royal Commission is urged to require the nuclear industry to adopt the ECRR 2003 radiation risk model [17.] or a model of equal accuracy to determine impacts of radiation release upon human health.

- The Royal Commission is urged to find that risk of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia is significant and unacceptable.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

118.

Any new nuclear facilities in South Australia would need to be designed and operated in a way that ensures the regulatory limits are not exceeded and that any human exposure is as low as reasonably achievable. The greater the risk, the greater the level of engineered barriers, automation of processes and protective work practices required.

An important addendum in this section are the exact regulatory limits to apply and the scenarios in which they are to be applied. The analysis of public exposure must include accident scenarios and accident scenarios must in fairness draw from past experience such as fuel fire, fuel detonation and chemical explosion and the consequences analysed with accurate models. Chernobyl data has shown that the ICRP radiation risk model under-estimates the health effects of radiation by an order of magnitude or more. This has important ramifications in terms of engineering operations, public exposure, decisions on evacuation etc.

The concern is voiced by seventeen doctors and professors of science from the European Committee on Radiation Risk (ECRR) in a statement titled "The Lesvos Declaration" which in part urges that

"..the responsible authorities and all those responsible for causing exposures, to adopt a generally precautionary approach, and in the absence of another workable and sufficiently precautionary risk model, to apply without undue delay the provisional ECRR 2003 risk model, which more accurately bounds the risks reflected by current observations'". [17.]

- The Royal Commission is urged to examine the impact of accidental radiation release in South Australia upon public health.
- The Royal Commission is urged to require the nuclear industry to adopt the ECRR 2003 model of radiation risk[17.] to determine the impact of radiation releases upon human health.
- The Royal Commission is urged to find that risk of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia is significant and unacceptable.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

119.

Data from modern nuclear fuel cycle facilities demonstrates they operate well within the applicable regulatory limits for workers, the public and the environment. The levels of exposure to the public are in the vast majority of cases lower than what might be expected from natural sources.

Public health and environmental data collected after the Chernobyl accident has shown the inadequacy of the ICRP radiation risk model used by government and industry worldwide for radiation safety analysis.

These concerns are voiced by seventeen doctors and professors of science from the European Committee on Radiation Risk (ECRR) in a statement titled "The Lesvos Declaration" which in part contains the following:

"...the International Commission on Radiological Protection (ICRP) has promulgated certain risk co-efficients for ionizing radiation exposure,"... (and these) "… ICRP radiation risk coefficients are used worldwide by federal and state governmental bodies to promulgate radiation protection laws and standards for exposure to workers and the general public from waste disposal, nuclear weapons, management of contaminated land and materials.....and all stages of the nuclear fuel cycle."[17.]

The ECRR "assert that the ICRP risk coefficients are out of date and that use of these coefficients leads to radiation risks being significantly underestimated,

and the ECRR "assert that employing the ICRP radiation risk model to predict the health effects of radiation leads to errors are at a minimum 10 fold while we are aware of studies relating to certain types of exposure that suggest the error is even greater," [17.]

The ECRR urge responsible authorities not to rely on the ICRP radiation risk model in determining radiation protection standards and managing risks but to "apply without undue delay the provisional ECRR 2003 risk model instead, which more accurately bounds the risks reflected by current observations." [17.]

- The Royal Commission is urged to find that an accurate model of radiation risk assessment covering ingested and inhaled radionuclides is required to establish applicable regulatory limits for workers, the public and the environment in South Australia.

- The Royal Commission is urged to require the nuclear industry to adopt the ECRR 2003 model of radiation risk[17.] to determine the impact of radiation releases upon human health.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

120.

Doses of radiation to the local community from any new nuclear facilities in South Australia can be expected to be in the range of those estimated from the international nuclear facilities set out in Figure 7. Doses of radiation to the public are calculated based on a representative person who is exposed to radiation by living near, or eating food sourced from around, a particular facility. To give an Australian example, the maximum annual effective dose of radiation that a member of the public would receive by continuously standing on the edge of the buffer zone around the Australian Nuclear Science and Technology Organisation (ANSTO) facility at Lucas Heights in

New South Wales would be an additional 0.0026 millisievert (mSv), or about three-tenths of one per cent of average annual background sources. In the case of the Finnish deep geological disposal facility, which will be subject to an annual regulatory public dose limit of 0.1 mSv during normal operations, the annual dose to the most exposed members of the public has been modelled
to be one hundred thousandth of that limit.

This finding does not consider scenarios of accidental radiation release. Modelling of radiation dose from a normally operating nuclear facility is expected to be well within safe exposure limit. It is the modelling of radiation exposure from scenarios of accidental radiation release which is critical to the safety analysis. A complete and accurate safety analysis should cause the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

Consideration of the safety consequences of potential accident scenarios has to be included in the safety analysis. The consequence of water, foam or mist reaching fuel assemblies in dry storage for example, could be a criticality accident, explosion or fire, spreading radioactive contamination over a huge area.

Accident scenarios may be drawn from previous accident experience:

- The chemical explosion at the Kyshtym spent nuclear fuel waste facility in Russia is one example. “The explosion, on 29 Sept 1957, estimated to have a force of about 70–100 tons of TNT threw the 160-ton concrete lid into the air. There were no immediate casualties as a result of the explosion, but it released an estimated 800 Pbq of radioactivity. Most of this contamination settled out near the site of the accident and contributed to the pollution of the Techa River but a plume containing 80 Pbq of radionuclides spread out over hundreds of kilometers.”[14] Communities are having to be evacuated because of the spreading waste even today.

- The accident at the US Department of Energy (DOE) Waste Isolation Pilot Project (WIPP) nuclear waste dump in Carlsbad New Mexico is another example. This facility was designed for the permanent disposal of transuranic nuclear waste including plutonium and americium. On the evening of 14th Feb 2014 there was a nuclear safety failure at the site. Radiation detectors detected radiation in the exhaust air being released from the mine. On 15th February, authorities ordered workers to shelter in place at the facility. Later, traces of airborne radiation consisting of americium and plutonium particles were discovered half a mile from the facility. On 26th February, the DOE announced that thirteen WIPP above–ground workers at the time had received internal radiation exposure and that additional testing would be done on employees who were working at the site the day after the leak. On February 27, the DOE announced it had sent out a letter to tell people in two counties what they knew so far.[15,16]

- The fire at the St Louis Westlake nuclear waste landfill is another example. Over time, nuclear waste found its way to this landfill and now the landfill is on fire. When uranium waste decay into their byproducts, one of the things it decays into is radon, gas. Radon is already being vented from various places but if the fire reaches the waste, that venting is going to increase. The release of uranium and decay product nanoparticles into the atmosphere is a significant risk. EPA have been on the site for a few years trying to mitigate the impact of both the waste and the fire but the situation is barely under control.

- The explosion at South Australia's own nuclear waste burial site at Maralinga is a home grown example. The explosion occurred during vitrification of the plutonium burial pits causing the process to be abandoned.

A fire, explosion or natural disaster could conceivably involve the same quantity of radioactive material or more, as was released in the Chernobyl accident. This should cause the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

- The Royal Commission is urged to find that risk of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia is significant and unacceptable.

- The Royal Commission is urged to find that the human health consequences of a nuclear waste fire, explosion or natural disaster in South Australia are significant and unacceptable.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

121.

For workers at nuclear facilities, the annual dose of radiation received will vary depending on the nature of the tasks that are performed. The range of occupational exposures which might arise in South Australia from nuclear fuel cycle activities can be expected to be in the range of those recorded at the international nuclear facilities set out in Figure 8. Cumulative doses of radiation received by relevant workers are continuously measured by personal dosimeters attached to clothing. In Australia in 2014, the average annual dose (in addition to background radiation) received by a uranium mine worker was less than 1.5 mSv, or just below the level of average annual background radiation.

There is concern in the scientific community that the health impacts of particulate or gaseous radiation incorporated into the human body are not being properly assessed. This concern is voiced by seventeen doctors and professors of science from the European Committee on Radiation Risk (ECRR) in a statement titled "The Lesvos Declaration" which in part states that:

"...the International Commission on Radiological Protection (ICRP) has promulgated certain risk co-efficients for ionizing radiation exposure,"... (and these) "… ICRP radiation risk coefficients are used worldwide by federal and state governmental bodies to promulgate radiation protection laws and standards for exposure to workers and the general public from waste disposal, nuclear weapons, management of contaminated land and materials.....and all stages of the nuclear fuel cycle."[17.]

"..by common consent, the ICRP risk model cannot validly be applied to post-accident exposures, nor to incorporated radioactive material resulting in internal exposure,"[17.]

- The Royal Commission is urged to find that the human health consequences of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia would be significant and unacceptable.

- The Royal Commission is urged to require that the 2003 ECRR radiation risk model covering ingested radionuclides be used to establish applicable regulatory limits for workers, the public and the environment in South Australia.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

122.

The more significant radiation risks are created in the event of an uncontrolled release of nuclear or radioactive material, for example, in the event of an accident at a nuclear power plant such as occurred at Chernobyl in 1986 and Fukushima Daiichi in 2011. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and World Health Organization (WHO) have evaluated the independent and peer-reviewed epidemiological studies undertaken by medical doctors and other scientists into the health effects of each accident. These investigations are ongoing.

It is not illustrative to conclude that these investigations are simply ongoing. Complete analysis of the data available from Japan should cause the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

In the aftermath of Chernobyl not only was there an increase in the incidence of stillbirths and malformations in Europe, but there was also a shift in the ratio of male and female embryos. Significantly fewer girls were born after 1986. A paper by Kristina Voigt, Hagen Scherb[18.] showed that after 1986, in the aftermath of Chernobyl, around 800,000 fewer children were born in Europe than one might have expected. Scherb estimated that, as the paper did not cover all countries, the overall number of “missing” children after Chernobyl could be about one million. Similar effects were also observed following above-ground nuclear weapons tests.

In Belarus alone, over 12,000 people have developed thyroid cancer since the catastrophe. According to a WHO prognosis, in the Belarus region of Gomel alone, more than 50,000 children will develop thyroid cancer during their lives. If one adds together all age groups then about 100,000 cases of thyroid cancer have to be reckoned with in the Gomel region.

After Chernobyl, infant mortality rates in Sweden, Finland and Norway increased by a significant 15.8 percent compared to the trend for the period 1976 to 2006. Alfred Körblein calculated that for the period 1987 to 1992 an additional 1,209 (95% confidence interval: 875 to 1,556) infants had died.

A paper published by the Chernobyl Ministry in Ukraine registered a multiplication of the cases of disease of the endocrine system (25-fold from 1987 to 1992), the nervous system (6-fold), the circulatory system (44-fold), the digestive organs (60-fold), the cutaneous and subcutaneous tissue (50 times higher), the muscular-skeletal system and psychological dysfunctions (53-fold). The number of healthy people among evacuees sank from 1987 to 1996 from 59% to 18%. Among the population of the contaminated areas from 52% to 21% and – particularly dramatic – among the children who were not directly affected themselves by Chernobyl fallout but their parents were exposed to high levels of radiation, the numbers of healthy children sank from 81% to 30% in 1996 .

According to figures given by the Russian authorities, more than 90% of the liquidators have become invalids; i.e. at least 740,000 severely ill liquidators. They are aging prematurely, and a higher than average number have developed various forms of cancer, leukemia, somatic and neurological psychiatric illnesses. A very large number have cataracts. Due to long latency periods, a significant increase in cancers is to be expected in the coming years.

According to UNSCEAR between 12,000 and 83,000 children were born with congenital deformations in the region of Chernobyl, and around 30,000 to 207,000 genetically damaged children worldwide. Only 10% of the overall expected damage can be seen in the first generation.

- The Royal Commission is urged to acknowledge the epidemiological data and conclusions of Professor Alexey V. Yablokov[1.] on the health effects of the Chernobyl meltdown and the difficulty this scientist has experienced presenting his findings to the Western World.

- The Royal Commission is urged to question the large discrepency between the data published by UNSCEAR and WHO and that published by independent scientists such as Yablokov on the public health consequences of the Chernobyl nuclear meltdown.

- The Royal Commission is urged to conclude from the Chernobyl experience that an accident releasing a similar quantity of radionuclide particulates, such as a chemical combustion of spent nuclear fuel, would have disastrous public health consequences to South Australians.

- The Royal Commission is urged to find that the human health consequences of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia would be significant and unacceptable.

Nuclear Fuel Cycle Royal Commission Tentative Findings

RADIATION RISKS

123.

Based on UNSCEAR and WHO reports, the observed health effects in people who were exposed to radiation as a result of the Chernobyl accident are as follows:

a.

Of the plant staff and emergency workers who received very high doses of radiation, 134 people developed acute radiation syndrome (ARS), which caused the deaths of 28 of those people.

b.

Of the ARS survivors, a further 19 had died by 2006 (two decades later), although their deaths were

not directly attributable to radiation exposure. The remaining ARS survivors experience skin injuries

and cataracts as a result of radiation exposure.

c.

For the public, who received much lower doses of radiation than the plant staff and emergency workers, there were no cases of ARS or associated fatalities.

The data presented in finding 123 on the observed health effects in people who were exposed to radiation as a result of the Chernobyl accident is substantially incomplete. It is not an accurate summary. Complete analysis of the data available should cause the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community. Acute Radiation Syndrome (ARS) casualties were only the tip of the iceberg. ARS results from extreme exposure to ionising radiation. Far more people are ill or have died from exposure to much lower doses of radiation and inhalation or ingestion of radionuclide particles.

Populations exposed to the Chernobyl radiation include 830,000 clean-up workers (Liquidators), 350,400 evacuees from highly contaminated zones, 8,300,000 population in the heavily irradiated irradiated areas in Russia, Belarus and Ukraine and 600,000,000 European population exposed to minor radiation.(Yablokov 2010, Fairlie 2007)[1.]

According to Yablokov et al [1.] "In the contaminated territories of Belarus, Ukraine, and European Russia, the additional Chernobyl death toll for the first 15 years after the catastrophe amounted to nearly 237,000 people. It is safe to assume that the total Chernobyl death toll for the period from 1987 to 2004 has reached nearly 417,000 in other parts of Europe and Asia and Africa and nearly 170,000 in North America, accounting for nearly 824,000 deaths worldwide." [1.]

The study by Alexi Yablokov, Vassily Nesterenko, and Alexey Nesterenko "Chernobyl Consequences of the Catastrophe for People and the Environment" is a comprehensive scientific study which incorporates literature from more than 5,000 publications, much of which is in Slavic languages. There are more than 30,000 publications on the consequences of the Chernobyl catastrophe and millions of documents and materials available in Internet information systems.

Yablokov is critical of the IAEA/WHO "Chernobyl Forum" Report (2005), advertised by WHO and IAEA as the "fullest and objective review" of the consequences of the Chernobyl accident, but which mentions only 350 mainly English publications.

Dr. rer. nat. Sebastian Pflugbeil et al[2.] Have concluded that "According to figures given by the Russian authorities, more than 90% of the liquidators have become invalids; i.e. at least 740,000 severely ill liquidators. They are aging prematurely, and a higher than average number have developed various forms of cancer, leukemia, somatic and neurological psychiatric illnesses. A very large number have cataracts. Due to long latency periods, a significant increase in cancers is to be expected in the coming years." and " Independent studies estimated that 112,000 to 125,000 liquidators will have died by 2005" .

In the aftermath of Chernobyl not only was there an increase in the incidence of stillbirths and malformations in Europe, but there was also a shift in the ratio of male and female embryos. Significantly fewer girls were born after 1986. A paper by Kristina Voigt, Hagen Scherb also showed that after 1986, in the aftermath of Chernobyl, around 800,000 fewer children were born in Europe than one might have expected. Scherb estimated that, as the paper did not cover all countries, the overall number of "missing" children after Chernobyl could be about one million. Similar effects were also observed following above-ground nuclear weapons tests[3.]

This one nuclear accident polluted half the globe. Chernobyl fallout covered the entire Northern

Hemisphere. We were very fortunate in Australia to avoid the worst of it.

- The Royal Commission is urged to acknowledge the epidemiological data and conclusions of Professor Alexey V. Yablokov[1.] on the health effects of the Chernobyl meltdown and the difficulties this scientist has experienced presenting his findings to the Western World.

- The Royal Commission is urged to acknowledge that in the contaminated territories of Belarus, Ukraine, and European Russia, the additional Chernobyl death toll for the first 15 years after the catastrophe amounted to nearly 237,000 people. And that the total Chernobyl death toll for the period from 1987 to 2004 has reached nearly 417,000 in other parts of Europe and Asia and Africa and nearly 170,000 in North America, accounting for nearly 824,000 deaths worldwide.

- The Royal Commission is urged to recognise that Alexi Yablokov's work “Chernobyl Consequences of the Catastrophe for People and the Environment”[1,] it's extensive in detail and inclusion of literature from more than 5,000 publications, much in Slavic languages.

- The Royal Commission is urged to recognise that the 2003 ECRR radiation risk model covering ingested radionuclides accurately models Yablokovs findings and is directly applicable to Chernobyl and nuclear operations in South Australia.

- The Royal Commission is urged to find that the human health consequences of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia would be significant and unacceptable.

- The Royal Commission is urged to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

Nuclear Fuel Cycle Royal Commission Tentative Findings
RISKS AND CHALLENGES RADIATION RISKS
124.
In relation to the Fukushima Daiichi accident in 2011,
UNSCEAR concludes:
a. No plant staff, emergency worker or member of the public died or developed ARS as a result of radiation exposure. A small proportion of workers received higher doses during the accident and in the immediate clean-up period.

b. There may be an increased risk of thyroid cancer in more vulnerable groups in Fukushima (the most exposed workers, and infants and children in the evacuation zone). An increase in other types of cancer is not expected. Any such increase would be difficult to attribute to the accident, given the understood levels of exposure. To date, the most important health impact has been on psychological wellbeing.

The data presented in finding 124 is substantially incomplete. Complete analysis of the data available from Japan should cause the Royal Commission to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

"Two reports recently released from Japan, one by Japanese medical professionals and the second from Tokyo Electric Power Corporation TEPCO, acknowledge that there will be numerous cancers in Japan, much greater than normal due to the radioactive discharges from the triple meltdown at Fukushima Daichi. First, a long term Tokyo Electric employee at Fukushima Daichi has be diagnosed with leukaemia and TEPCO has announced that his leukemia is due to his exposure to ongoing radiation following the meltdowns.....I believe as do many of my colleagues that there will be at least a hundred thousand and as many as one million more cancers in Japans future as a result of this meltdown." (Gundersen A.)[13.]

"The total gaseous releases and liquid releases from Fukushima Daichi meltdown exceeded the radiation released during and after the Chernobyl meltdown while Fukushima Daichi's radiation continues to bleed into the Pacific Ocean."[11] Radiation penetrated all six barriers engineers designed for Fukushima Daichis safe operation. The ceramic fuel pellet, the zircalloy fuel cladding, the 6-8 inch thick steel reactor barrier, the emergency cooling system and the thick steel and concrete containment vessel all failed one after the other. Thousands of people were injured by exposure to significant amounts of radiation after the detonation shockwave caused containment failure. Burning fuel from the fuel pool and containment vessel released enormous amounts of radiation as radioactive gas.

"The stark revelations of illness following exposure to the fission products and uranium released by the Chernobyl accident are absolutely applicable to the illness which will develop inevitably in northern Japan following the Fukushima catastrophe. "[5] (C. Busby et al 2011).

Claims that the most important public health impact from the Fukushima Daichi meltdown are psychological are incorrect. "Psychological factors ("radiation phobia") simply cannot be the defining reason because morbidity continued to increase for some years after the catastrophe, whereas radiation concerns have decreased. And what is the level of radiation phobia among wolves, swallows, frogs, and pine trees, which demonstrate similar health disorders, including increased mutation rates? " "There is no question but that social and economic factors are dire for those sick from radiation. Sickness, deformed and impaired children, death of family and friends, loss of home and treasured possessions, loss of work, and dislocation are serious financial and mental stresses." [1.] (Yablokov et al. 2009)

- The Royal Commission is urged to acknowledge the total gaseous releases and liquid releases from Fukushima Daichi meltdown exceeded the radiation released during and after the Chernobyl meltdown and that Fukushima Daichi's radiation continues to bleed into the Pacific Ocean.

- The Royal Commission is urged to acknowledge that there will be numerous cancers in Japan, much greater than normal due to the radioactive discharges from the triple meltdown et Fukushima Daichi.

- The Royal Commission is also urged to find that the consequences of the Chernobyl radiation release to health are equally applicable to the Fukushima Daichi accident and to nuclear operations in South Australia.

- The Royal Commission is urged to find that the most important public health impact from the Fukushima Daichi meltdown are not psychological.

- The Royal Commission is urged to find that the consequence of accidental radiation release from nuclear fire, explosion or natural disaster in South Australia is significant and unacceptable.

- The Royal Commission is urged to reverse its key finding that storage and disposal of used nuclear fuel in South Australia would meet a global need and be likely to deliver substantial economic benefits to the community.

REFERENCES

1. ALEXEY V. YABLOKOV , VASSILY B.NESTERENKO, ALEXEY V.NESTERENKO
"Chernobyl Consequences of the Catastrophe for People and the Environment" Volume published by the New York Academy of Sciences (NYAS) in 2009.

2. Dr. Sebastian Pflugbeil, Henrik Paulitz, Dr. Angelika Claussen, Prof. Dr. Schmitz-Feuerhake "Health Effects of Chernobyl 25 years after the reactor catastrophe."

3. "Increased Reproductive Health Risks After Chernobyl Across Europe," Waclawek M., Proceedings of ECOpole 2009, Opole Poland, 2010, Vol. 4., No. 1, pp. 9-14;

4. "Radiation-induced genetic effects in Europe and the Chernobyl Nuclear Power Plant catastrophe", Conference "Criticisms and Developments in the Assessment of Radiation Risk" ECRR and University of the Aegean, Molyvos Island of Lesvos, Greece, 5th and 6th May 2009;

5. "Detrimental Genetic Effects of Ionizing Radiation across Europe after the Chernobyl Accident", All-Russian scientific-practical conference with foreign participation: "Roentgen-radiological technologies and radiation medicine in treatment – solving liquidation problems of man-made disasters" – on account of the 25th anniversary of the Chernobyl accident, Moscow, February 15th-16th, 2011.

6. (C. Busby et AL 2011). "Fukushima and Health: What to Expect". Proceedings of the 3rd International Conference of the European Committee on Radiation Risk, Lesvos, Greece 2009."

7. New Scientist. 6 February 2016 pp 10& 11. "Forever Haunted by it's Nuclear Past".

8. KBS-3 Wikipedia Article Viewed at https://en.wikipedia.org/wiki/KBS-3, Feb 2016.

9. "What's Leaking from the Nuclear Waste Isolation Pilot Program" Arnie Gundersen, Fairewinds Energy Education, www.fairewinds.org March 2014}

10. "Waste isolation pilot Plant" Wikipedia, March 2015.

11. “Nuclear Containment Risk” Fairewinds Energy Education www.fairewinds.org January 29 2015. https://www.youtube.com/watch?v=FgG4JK_ot6E

12. “Cancers on the rise in Post Fukushima Japan” Fairewinds Energy Education www.fairewinds.org January 29 2015.} https://www.youtube.com/watch?v=FgG4JK_ot6E

13. “Nuclear Containment Risk” Fairewinds Energy Education www.fairewinds.org November 4 2015, http://www.fairewinds.org/nuclear-energy-education/cancer-on-the-rise-in-post-fukushima-japan

14. “Kyshtym Disaster” Wikipedia, March 2015 https://en.wikipedia.org/wiki/Kyshtym_disaster

15. Peter Szakálos and Seshadri Seetharaman (2012). "Technical Note 2012:17: Corrosion of copper

16. “ Surface and Corrosion Chemistry *of* **PLUTONIUM”** *John M. Haschke, Thomas H. Allen, and Luis A. Morales 1991*

17. The Lesvos Declaration (European Committee on Radiation Risk). “Fukushima and Health: What to Expect, (C. Busby)”. Proceedings of the 3rd International Conference of the European Committee on Radiation Risk, Lesvos, Greece 2009.” pp 318, 319 & 320

18. (C. Busby et al 2011). “Fukushima and Health: What to Expect”. Proceedings of the 3rd International Conference of the European Committee on Radiation Risk, Lesvos, Greece 2009.” pp213-232

[19] {“What’s Leaking from the Nuclear Waste Isolation Pilot Program” Arnie Gundersen, Fairewinds Energy Education, www.fairewinds.org March 2014}

[20]. {“Waste isolation pilot Plant” Wikipedia, March 2015.}