ISSUES PAPER ONE

EXPLORATION, EXTRACTION AND MILLING

NUCLEAR FUEL CYCLE ROYAL COMMISSION

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EXPLORATION, EXTRACTION AND MILLING

THE NUCLEAR FUEL CYCLE ROYAL COMMISSION IS TASKED BY ITS TERMS OF REFERENCE WITH CONSIDERING THE FEASIBILITY OF EXPANDING THE CURRENT LEVEL OF EXPLORATION, EXTRACTION AND MILLING OF MINERALS CONTAINING RADIOACTIVE MATERIALS IN SOUTH AUSTRALIA, THE CIRCUMSTANCES NECESSARY FOR SUCH AN INCREASE TO OCCUR AND TO BE VIABLE, THE RISKS AND OPPORTUNITIES CREATED BY EXPANDING THE LEVEL OF EXPLORATION, EXTRACTION AND MILLING, AND THE MEASURES THAT MIGHT BE REQUIRED TO FACILITATE AND REGULATE THAT INCREASE IN ACTIVITY.

YOUR SUBMISSION

The Royal Commission is seeking submissions from interested members of the community, both within Australia and overseas, who have evidence, information or views which are relevant to its inquiry.

The purpose of this Issues Paper is to assist those proposing to make a submission to the Royal Commission.

It provides a factual background relevant to understanding the questions on which the Commission seeks submissions. A submission should be in response to the questions posed in this Issues Paper. Your submission may address all, some or only one of the questions. Your submission is not limited by the factual background set out in this Issues Paper.

If you wish to make a submission on a topic that is not in response to a question in this Issues Paper you may do so, but it must be contained as an Appendix to your main submission which addresses the questions posed.

Before writing your submission you should read the Submissions Guideline (www.nuclearrc.sa.gov.au) issued by the Royal Commission. It may answer questions you have as to the form and content of your submission and how your submission will best assist the Commission.

BACKGROUND

The geology underlying South Australia is some of the oldest on Earth, being the product of the amalgamation of several ancient continents. Two-thirds of the State is underlain by the solid nucleus of basement rock known as the Gawler Craton (Figure 1). Parts of that geology have been dated to be between 1.4 and 3.3 billion years old. Other geology in the State is substantially younger, but is still relatively old compared to many other places in the world.

Figure 1: Geology of South Australia (1.4 to 3.3 Billion Years Old)
(Source: DSD SARIG 2015)

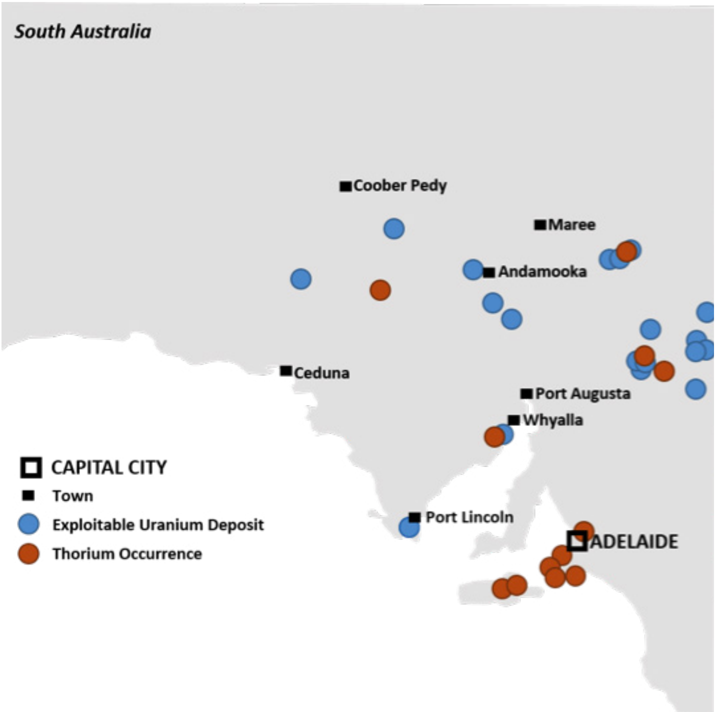

Figure 2: Exploitable Uranium Deposits and Thorium occurrence in South Australia
(Source: DSD SARIG 2015)

The areas of South Australia containing economic quantities of radioactive minerals are those located in the north of the State (see Figure 2).

Both uranium and thorium are common, naturally occurring radioactive metallic elements in the Earth's crust. They are found in varying concentrations in rock, sand and in even in seawater. Uranium is the more economically significant mineral, although there is also some interest in thorium. Despite their general prevalence, only a few concentrated and commercially exploitable deposits of uranium and thorium are currently known.

One of the most significant geological features for commercial mining activities is a granite formation with an age of about 1.5 billion years. That granite formation hosts the Olympic Dam deposit, which was formed through the fracturing of the granite and the subsequent emplacement of minerals derived from hot upward moving fluids within both the fracture zones and overlying sediment. This system contains economic quantities of iron, gold, silver, uranium, copper and rare earth elements

This deposit highlights a significant feature of mineral geology relevant to commercial exploitation of uranium - often commercial mineral commodities, particularly copper, gold and iron, are found in association with minerals containing radioactive materials.

In addition to the granite which hosts Olympic Dam, other geological features are of interest. There are also mineral deposits which were formed when older igneous (volcanic) and metamorphic (original rock transformed by a heat and/or stress) rocks were exposed to water and heat, causing the transportation of minerals through stream sediments and channels. These secondary deposits may also contain commercially exploitable quantities of minerals including uranium. This is the type of deposit at the existing uranium operations at Honeymoon, Beverley, Beverley North, and Four Mile.

A. EXPLORATION

Despite minerals containing radioactive substances being detected in a number of locations in South Australia, the greatest exploration effort has been directed to those areas which contain commercial quantities of uranium. The main radioactive minerals in South Australia that are targeted in commercial exploration for uranium are the minerals uraninite (pitchblende), autunite, torbernite, uranophane, and carnotite. There has also been exploration activity to identify minerals containing concentrations of thorium. For thorium, the main minerals are thorite and monazite.

At the present time, mineral exploration is conducted principally by exploration companies with a focus on targeted commodities. Previously, exploration had been carried out by government, individual prospectors, land-owners and also by specialised exploration companies. Currently, 249 exploration licences are issued in South Australia which relate to uranium either exclusively, or in addition to, other commodities (about 30% of the total number of licences issued in the State). Forty-seven companies – some Australian and others international - participate in the exploration for uranium. Being commercially driven, those activities are not co-ordinated and are directed by the independent interests of the entities concerned. Only three companies are involved in exploration for thorium in South Australia.

A variety of techniques are employed in contemporary exploration. These processes include ground and air geophysical surveys (magnetics, gravity, and radiometric) and geological investigation by historical activities reviews, collecting surface mineral samples and drilling programs. Exploration is conducted in regions where there is basic geological knowledge (green fields), where there has been historical activity (brown fields) and to extend existing known resources.

Those activities have demonstrated that there are locations in South Australia that possess economic uranium and thorium deposits. These are summarised generally in Figure 2.

The current estimate of uranium mineral resources in South Australia is 1,371 kilotonnes uranium (kt U).[1] This represents 80% of those in Australia and, on a global scale, 29% of identified conventional resources (with production costs between USD $130/kg U and USD $260/kg U) and 24% of high cost resources (with production costs of more than USD $260/kg U).[2] The total of those resources of uranium which are currently of economic grade are estimated to be 1,174 kt U.[3] In contrast, South Australia with 11 kt Th has only a small fraction of Australia's total identified thorium resources of 595kt Th[4]. Australia has approximately 9% of global thorium resources.

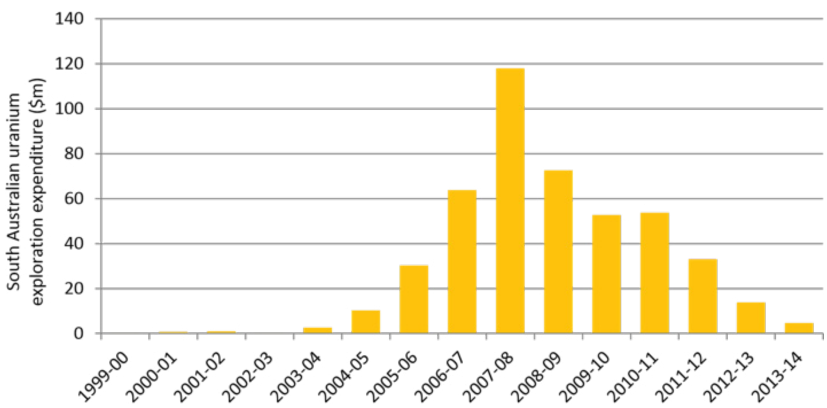

Figure 3: South Australian uranium exploration expenditure
(Source: South Australian Government (DSD))

EXPLORATION CONTINUED

Against that background,

1.1. Are there opportunities for new or further exploration activities directed at locating new mineral deposits, or to better understand existing deposits containing economic concentrations of uranium or thorium in South Australia? What specifically are those opportunities? What might understanding those opportunities be reasonably expected to reveal? What needs to be done to understand their potential more clearly?

The extent of exploration activity carried out is substantially affected by the prices prevailing in commodity markets and general economic conditions. This applies to exploration for uranium. Expenditure on exploration peaked in 2007 at a time when uranium spot prices peaked and immediately prior to the Global Financial Crisis (see Figure 3 and contrast Figure 5).

The total expenditure associated with exploration for uranium in South Australia was $4.8 million in 2013-14.[5] This was 4% of total mineral exploration expenditure ($117 million). Additionally, the South Australian Government, through a program called the Plan for Accelerating Exploration (PACE), seeks to encourage further exploration and development in the resources sector by directing funding towards those activities.

1.2. What are the economic conditions including those in resource markets that would be necessary for the financial viability of new exploration activities directed at locating uranium or thorium? Aside from economic conditions, how do factors such as access to investment, skills training, taxation, research and development, innovation and regulation, bear on decisions to invest in new activities? What is most important?

1.3. What might be necessary to encourage further exploration for uranium and thorium? What might be done to promote viability? Are existing government plans sufficient? Could support be provided in other ways and, if so, how could that be done most effectively? Is there a sufficient availability of information from exploration activities previously undertaken?

[1] Geoscience Australia, Australia's Identified Mineral Resources 2013 (Commonwealth of Australia, 2014).
[2] Uranium 2014: Resources, Production and Demand, OECD Nuclear Energy Agency and International Atomic Energy Agency. Paris. NEA No. 7209, OECD 2014.
[3] Geoscience Australia, Australia's Identified Mineral Resources 2013 (Commonwealth of Australia, 2014).
[4] Geoscience Australia, Australia's Identified Mineral Resources 2013 (Commonwealth of Australia, 2014).
[5] Department for State Development, Minerals Score Card, 2013-14 (South Australian Government, 2015).

B. EXTRACTION AND MILLING

South Australia's first mine from which radioactive substances were extracted was at Radium Hill which first commenced operation in 1909. More sustained mining activities occurred at Radium Hill between 1954 and 1961 when extraction activities finally ceased. The Radium Hill mine was an underground mining operation which employed the use of central vertical shafts and horizontal tunnels. Ore was manually loaded and dug by workers, then transported through the mine using a combination of rail and shaft hoisting mechanisms. The ores were then milled on-site. Partially and non-mineralised rock wastes from the mining process were stockpiled above ground on site during operations.

The modern phase of the commercial extraction of uranium in South Australia commenced in 1988 with the exploitation of the resource at Olympic Dam by the Western Mining Corporation (subsequently acquired by BHP Billiton).

Uranium is extracted from that deposit in conjunction with other commodities: copper, silver and gold. The proposal to expand extraction at the Olympic Dam by converting the existing underground mine to an open cut mine was put on hold by its operator in 2012. However, expansion of the operation remains under consideration.

The number of mines in South Australia has subsequently expanded following changes to the Commonwealth policy which to that time had limited the number of mines which could operate in Australia. Four mines are now approved to operate in South Australia. Olympic Dam and Four Mile (operated by Quasar Resources and Alliance Craton Explorer) are currently in production. Honeymoon was operated by JSC Atomredmetzoloto until 2013 and Beverley was operated by Heathgate Resources until 2014. Both are currently in care and maintenance mode. Beverley North is currently processing uranium ore from Four Mile.

Globally, there are presently three techniques employed for extracting uranium: open-cut excavation (used for mineralised dune sand and fractured granite), underground explosive (where the minerals are in granite), and in-situ leaching. In addition, there are other techniques not used commercially in Australia for extracting uranium, such as acid heap leaching.

In the case of the first and second techniques, both used at Olympic Dam, once the uranium ore is physically extracted it undergoes further processing by crushing and grinding (milling), and is then further chemically processed. From the final solution, uranium oxide is precipitated, dried and roasted before being packaged for transport.

In-situ leaching is utilised where the uranium-containing minerals are within less consolidated aquifer geology. This involves the injection under pressure through an in-ground bore of an acid solution, which is then recovered through an extraction bore. Once extracted, the mineral is dried and prepared for export on-site. This is the technique used at the mines at Beverley, Beverley North, Honeymoon and Four Mile.

Water and electrical infrastructure are required to support extraction and milling activities. Uranium oxide is transported utilising road, rail and port infrastructure, under regulated transport plans, and is stored prior to transport within purpose built secure buildings.

In contrast with uranium, there is presently no current or targeted mining production for thorium in South Australia, although mines have historically operated. Presently, thorium-containing minerals are recovered as a by-product of mineral sands mining operations but are not sold. Processing of thorium involves the mineral monazite being separated from other minerals by gravity and electrostatic methods, then dissolved in acid to produce a rare earth element, uranium, and thorium-rich fluid, which is further processed with solvent extraction, and reduced by heat and gases to separate thorium oxide.

The workforce involved directly in mining activities as a whole in South Australia was estimated in 2012 as 13,800. [6] There is also substantial employment in mining services and other related activities. It is difficult to estimate the employment figure attributable to uranium extraction and milling alone as multiple commodities are extracted at Olympic Dam and figures are not separated in reported information. Training for the resources sector is offered by tertiary and trade education providers. The activities require a wide range of skills and technical competencies ranging from geology, radiation protection, environmental science, metallurgy, engineering, survey and trade skills such as electrical, plumbing and fabrication.

EXTRACTION & MILLING CONTINUED

In addressing the feasibility and viability of expanding the current level of mining and milling activity, the Commission asks:

1.4. Are there either existing proven uranium or thorium resources which might feasibly be developed? Where are they? What specifically needs to be done to develop these? How long would the development process take?

1.5. What would be necessary to develop new mine sites or expand existing sites? To what extent are those factors affected by the ability to extract commercial resources other than uranium? What are the necessary factors that might stimulate an expansion in activity? What is the evidence that those factors have been relevant to an expansion in activities elsewhere?

1.6. Does more need to be done now and in the future with factor inputs (including skills and training, research, education and infrastructure) which are relevant to decisions made to invest in new projects or to expand those that already exist? What capabilities and capacities would be required for the development of new projects? What is the evidence that any specific deficiency influences new investment? What needs to be done to address any deficiency and how would it be done?

International demand for uranium is primarily driven by its use in electricity generation. The major demand is from the United States of America, the European Union, Japan, China, Russia, South Korea, Canada, Ukraine, India and Taiwan.[7] There are currently 395 nuclear power stations operating worldwide, with a total generating capacity of 339 gigawatts (GW). In addition there are 43 reactors (with a generating capacity of 40 GW) currently shut down in Japan, awaiting possible restart. According to the World Nuclear Association, a further 66 reactors (generating capacity of 65 GW) are under construction.[8] Some 165 reactors, totalling 185 GW of generating capacity, are planned.[9] The International Energy Agency (IEA) estimates that almost 200 of the currently operating reactors are due to be decommissioned in the next 25 years. For that reason the scale of future nuclear power generation will be significantly affected by government policy about replacement of that generating capacity. A significant proportion (about three quarters) of the expected expansion in generating capacity will be concentrated in China, Russia, India and Korea. Demand will therefore be significantly influenced by the approach taken in those countries.

The IEA canvasses in its *World Energy Outlook 2014* a range of future scenarios ranging from global nuclear capacity being significantly lower than that today to a future in which it nuclear energy generates about 50% more electricity than present levels. The IEA states that nuclear power is one of the few options available at scale to reduce carbon dioxide emissions, but its potential expansion depends on listening to, and addressing, public concerns about the technology.

In addition to the total capacity of operating reactors, uranium demand is affected by the fuel cycle strategy used, either a "once-through" cycle or a cycle involving reprocessing and recycling of recovered uranium. Further, the efficiency of reactors has improved over recent decades reducing the amount of uranium needed to generate a fixed amount of electricity. Though that does not affect existing reactors, this will have an effect in the long term. Demand could be affected in the longer term should there be any significant development of new reactor technologies.

Demand for uranium is met by supply both from mines and from previously mined resources, including stockpiled uranium and recycled uranium which is processed for use in reactors. While Australia, and specifically South Australia, are significant suppliers, there are also substantial mines extracting uranium from deposits in Kazakhstan, Canada and Africa. The global pattern of uranium production and demand is shown in Figure 4.

EXTRACTION & MILLING CONTINUED

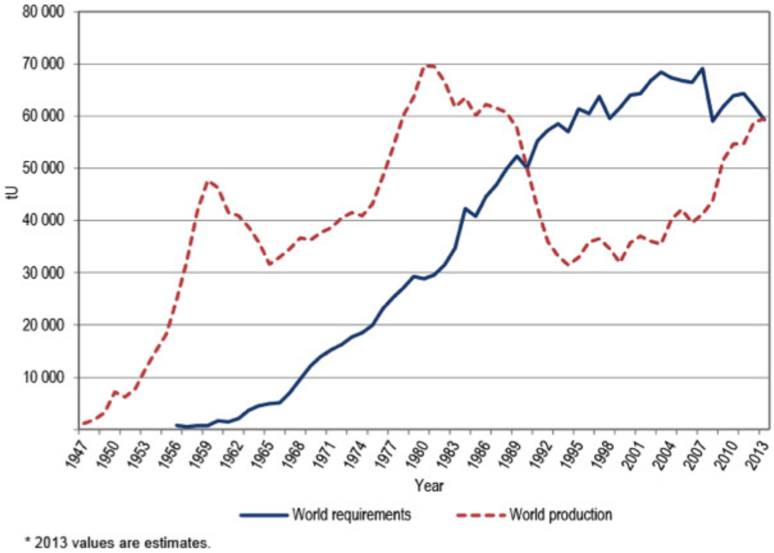

Figure 4: World Uranium Production and Demand [10]

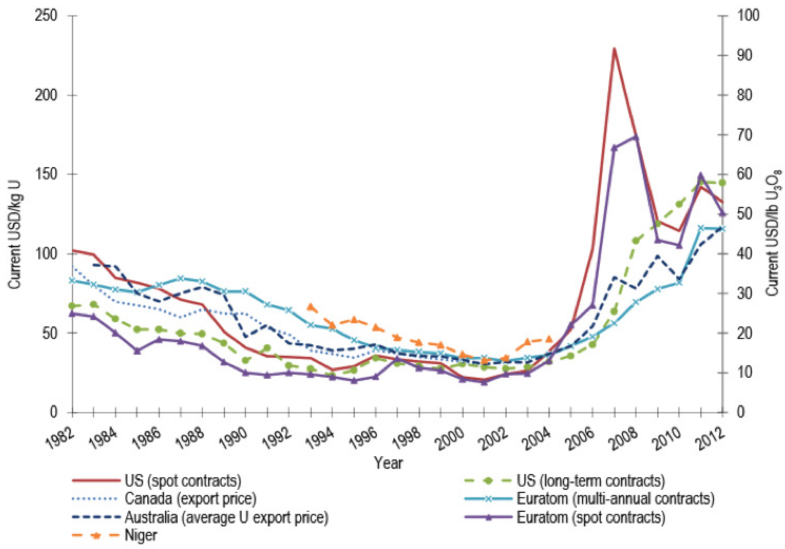

Figure 5: Traded price for uranium [11]

The interaction of these factors has been reflected in the traded price of uranium oxide (Figure 5).

The price of uranium oxide depends on the arrangements by which it is traded. While spot prices peaked in 2007 and 2011, the Australian export price and the price on US long term contracts have not been subject to similar fluctuations and have increased in the last decade. Separately, some major users of uranium oxide have vertically integrated their operations and secured supply by acquiring mines.

Against that background of dynamic global energy demand,

1.7. Is there a sound basis for concluding that there will be increased demand for uranium in the medium and long term? Would that increased demand translate to investment in expanded uranium production capacity in South Australia (bearing in mind other sources of supply and the nature of South Australia's resources?).

[6] Australian Bureau of Statistics, Labour Force Survey cat. No. 6291.0.55.003, DEEWR trend.

[7] Australian Mines Atlas, 1 April 2015.

[8] IAEA, 13 April 2015.

[9] World Nuclear Association, 1 April 2015.

[10] Uranium 2014: Resources, Production and Demand, OECD Nuclear Energy Agency and International Atomic Energy Agency. Paris. NEA No. 7209, OECD 2014.

[11] Uranium 2014: Resources, Production and Demand, OECD Nuclear Energy Agency and International Atomic Energy Agency. Paris. NEA No. 7209, OECD 2014.

C. RISKS AND OPPORTUNITIES

Regulators asked to approve new exploration, mining or milling activities must consider possible impacts on the community.

Consideration is given to impacts of new extraction or milling activities on the community primarily at the point of regulatory approval. Prior to mining leases being granted under the *Mining Act 1971* (SA) the impact on the community must be considered. Written submissions are sought from members of the public in relation to any application. Submissions may address any potential impact on the community, health and safety, on the proposed location and on factors which might alter the habitability and enjoyment of the immediate and surrounding areas. Those submissions must be considered in the decision to grant the lease and any conditions which might be imposed at the time of approval.

New activities involving mining or mineral processing of uranium or other radioactive substances are required to be licenced under the *Radiation Protection and Control Act 1982* (SA). Any licence granted must ensure that the exposure of persons to radiation is kept below maximum limits and "as low as reasonably achievable". What is "reasonably achievable" depends on an analysis of the activity, risk, duration and the precautions that can be taken. Employers and contractors also owe a general statutory duty to ensure the health and safety of their workers and the community under the *Work Health and Safety Act 2012* (SA). The combined effect of those regulatory arrangements is that workers who deal with these substances must be provided with information about any potential hazards prior to commencing work and be provided with personal protective equipment which is specifically designed to protect against radiation exposure. In addition to limits being placed on the amount of radiation to which a worker may be exposed, other techniques such as monitoring and radiation tagging are required to be employed in specific circumstances. Limits and requirements for radiation protection of the community are developed in accordance with Australian and international standards.

The interests of land holders and traditional rights holders need to be considered both prior to approval and during operations. In the case of exploration activities, land holder consent must be obtained. Further, agreement must be reached with the native title holder or claimants, in respect of land in which native title rights subsist or over which a claim is pending. Relevant agreements are regulated under the *Mining Act 1971* (SA) and the *Native Title Act 1993* (Cth).

Heritage issues must also be considered in planning and conducting exploration and extraction activities. Sites of aboriginal significance are protected by the *Aboriginal Heritage Act 1988* (SA). A specific application must be made for authorisation to take any action in relation to such culturally significant locations. In determining whether to authorise an action under that legislation, the relevant authority must consult with traditional land owners and other interested aboriginal organisations and individuals.

Bearing in mind existing arrangements,

1.8. Would an expansion in extraction activities give rise to new or different risks for the health and safety of workers and the community? If so, what are those risks and what needs to be done to ensure they do not exceed safe levels?

1.9. Are the existing arrangements for addressing the interaction between the interests of exploration and extraction activities and other groups with interests such as landowners and native title holders suitable to manage an expansion in exploration or extraction activities? Why? If they are not suitable, what needs to be done?

Mining operations conducted using the surface excavation or underground methods produce waste, the most significant being rock wastes produced during extraction, and tailings produced during the milling and processing phases. Those tailings contain low levels of radioactive substances. These are stored in tailings dams during operations. Those wastes need to be managed to protect both human health and the environment. With respect to the environment, a particular issue of concern is the protection of groundwater resources. Potential impacts for in-situ leaching include increasing acidity and release of other elements within groundwater systems.

Where they have a relevant bearing on understanding the impacts of a potential future expansion, the Commission will consider whether there are lessons to be learned from past uranium extraction and milling practices.

Environmental impacts associated with the exploration for uranium are mainly related to the clearance of native vegetation to allow for the access of vehicles and operation of drill rigs and associated machinery. Restoration of exploration sites is a requirement of State licencing.

RISKS & OPPORTUNITIES CONTINUED

Given these issues, exploration and extraction activities are subject to regulation by both the Commonwealth and State governments. In South Australia, no exploration or mining activities may be carried out unless a program approved under the *Mining Act 1971* (SA) is in place which details the management of environmental impact from those activities and also specifies the required site rehabilitation. Commercial exploration activities can only be carried out pursuant to a licence issued under the *Mining Act 1971* (SA). Before a potential mining site can be developed, an assessment must be carried out under both Commonwealth and State legislation which must examine, among other issues, the likely effects of the proposed activity on the environment and strategies for managing those issues. This is usually in the form of an Environmental Impact Statement.

Possession, security and transport of uranium oxide are also regulated. Permits to possess and transport uranium oxide must also be obtained under the *Nuclear Non-Proliferation (Safeguards) Act 1987* (Cth), reflecting international safeguards and security requirements. Production and export of uranium must be reported to the International Atomic Energy Agency. Separate authorisation is required under the *Customs (Prohibited Exports) Regulations 1958* (Cth) in order to export substances containing uranium or thorium.

Bearing that in mind:

1.10. Would a future expansion of exploration, extraction and milling activities create new environmental risks or increase existing risks? If so, are current strategies for managing those new risks sufficient? If not, in what specific respects? How would any current approach need to changed or adapted?

1.11. Given current techniques of extraction and milling and their regulation, what are the relevant lessons for the contemporary management of environmental impacts that should be learned from past extraction and milling practices?

In 2013-14, uranium mining production in South Australia produced 4.5 kt of uranium oxide (U308) for export. The greater part of that production was from the Olympic Dam mine. Total production had a value of $350 million.

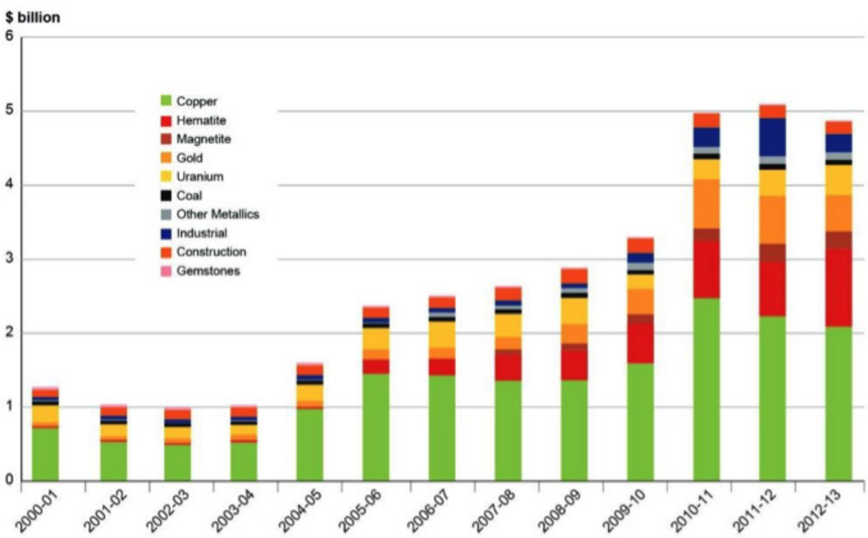

Figure 6: South Australian Mineral Production 2000-1 to 2012-13[12]

RISKS & OPPORTUNITIES CONTINUED

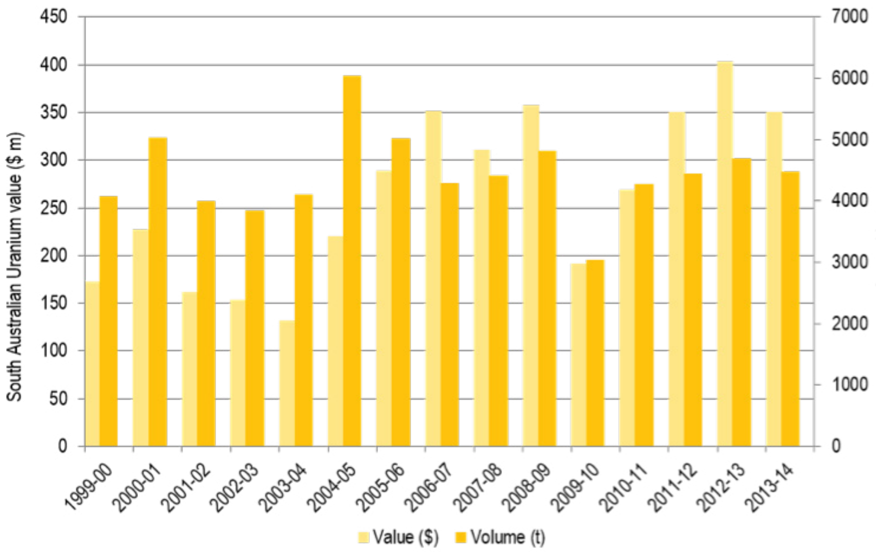

Figure 7: South Australian uranium production volume and value (Source: South Australian Government (DSD))

That production represented 8% (by value) of the State's mineral commodities for export in 2013-14. On the basis of that production, royalties of $16.5 million were paid to the South Australian government. As indicated in Figure 7, uranium production by volume has in most years over the last decade generally ranged between 4,000 and 5,000 tonnes annually.

It has been suggested that an expansion in exploration or extraction activities could have a negative impact on other sectors of the economy including tourism and agriculture. It has also been suggested it may encourage the development of related sectors with specialities relevant to those activities.

Considering those matters,

1.12. If an expansion of exploration or extraction activities were viable, what would the estimated benefit be expected to be directly in those sectors, in terms of economic activity? Can growth in employment relating to the extraction or milling of uranium (alone or in conjunction with other commodities being extracted) be estimated? Is there evidence increased extraction and milling would create additional capabilities and capacities in related sectors? What are those sectors? What would their value be?

1.13. Would an increase in extraction activities give rise to negative impacts on other sectors of the economy? Have such impacts been demonstrated elsewhere in Australia or in other economies similar to Australia?

[12] World Nuclear Association, 1 April 2015.

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