Submission No. 42

Australian Government

Geoscience Australia

Submission by Geoscience Australia to the House of Representatives Standing Committee Inquiry into the Development of Australia's Non Fossil Fuel Energy Industry:

The Strategic Importance of Australia's Uranium Resources

May 2005

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1. INTRODUCTION

Geoscience Australia is a prescribed agency within the Commonwealth Industry, Tourism and Resources portfolio. It serves governments and the broader community by providing technical information and advice to assist in making appropriate and informed decisions about mineral and petroleum resources, the management of the environment and the safety and wellbeing of citizens. Its qualifications to provide authoritative input to this inquiry stem from its roles in:

- Producing annually a national inventory of Australia's mineral resources, including uranium and fossil fuels;
- Providing advice into government on a range of issues in relation to resources, exploration, mining infrastructure and regional development. General access to such information is provided through a national on-line information system at http://www.australianminesatlas.gov.au/; and
- Representing Australia at meetings of the Uranium Group – a joint initiative between the United Nations' International Atomic Energy Agency (IAEA) and the OECD's Nuclear Energy Agency (NEA) – which collects and reports on data relating to uranium resources, production and demand.

This submission provides background information on Australia's considerable uranium endowment and focuses on the first two terms of reference (ToR) for this inquiry:

1. Global demand for Australia's uranium resources and associated supply issues; and
2. Strategic importance of Australia's uranium resources and any relevant industry developments;

It also provides summary material related to the third ToR:

3. Potential implications for global greenhouse emission reductions from further development and export of Australia's uranium resources.

This submission has benefited from valuable comments and information provided by the Uranium Section, Resources Division, Department of Industry, Tourism and Resources.

2. SUBMISSION IN RELATION TO SPECIFIC TERMS OF REFERENCE

2.1. ToR 1. Global demand for Australia's uranium resources and associated supply issues

2.1.1. Global Demand for Australia's uranium resources

Mine production

From the start of production at Mary Kathleen mine in 1976, Australia's uranium mining industry has grown progressively to become the world's second largest producer (in terms of annual mine production) with approximately 22% of world production in 2004, when Ranger mine produced 5138 t U_3O_8 (11% of world production), Olympic Dam 4370 t U_3O_8 (9%) and Beverley 1084 t U_3O_8 (2%).

Export markets

All of Australia's mine production of uranium is exported. Tonnages of Australian exports have increased steadily from less than 500 t U_3O_8 in 1976 to a record level of 9648 t U_3O_8 in 2004. Exports for 2004 were valued at A$411 million. In thermal quantities, uranium accounts for approximately 40% of Australia's energy exports (4083 PJ in 2003-04).

Australian mining companies supply uranium under long-term contract to electricity utilities in the following countries: United States, Japan, European Union (United Kingdom, France, Germany, Spain, Sweden, Belgium, Finland), South Korea, Canada, and to Taiwan under United States safeguards agreements

Australia has a strong reputation as a reliable and responsible supplier of uranium to world markets for peaceful purposes. It is well positioned to be able to sustain this role because of its very large identified and potential uranium resources, provided the development of these is permitted by future government policies. These resources are amenable to low cost production with minimal long term environmental and social impacts.

Potential major new market

China is a potential major new market for Australian uranium as it pursues an ambitious nuclear power program, with assistance from Canadian, French and US companies in the designing and construction of nuclear plants. However, a bilateral safeguards agreement between Australia and China must be signed before any exports can occur. China has nine nuclear power reactors in operation which currently provide about 2-3% of the country's total electricity generation. A further two power reactors are under construction. Total installed nuclear capacity is approximately 10 Gigawatts. Additional reactors are planned to give a four-fold increase in nuclear capacity to 40 Gigawatts by 2020. China's known uranium resources and mine production are insufficient for future domestic requirements for electricity generation.

2.1.2. Supply Issues

Transport of uranium concentrates

During the last few years there has been increasing reluctance by some shipping companies to transport uranium concentrates. The main reasons for 'denial of shipping services' include:

- Security and liability issues have become of increasing concern to shipping companies, operators of chartered container ships, port authorities and governments; and

- Many intermediate ports will not permit the transit of radioactive (IAEA Class 7) cargoes. Ships operating between Australian and European destinations, in particular, are unable to enter some ports of call en route; for example, all Italian ports are nuclear-free.

In 2004, charter shipping companies operating through Port Adelaide announced that they would no longer handle cargoes of uranium concentrates. They negotiated with WMC Resources and Heathgate Resources, as an interim measure, monthly service with limited capacity. The companies have conducted a successful three month trial whereby the uranium concentrates were railed from Adelaide to Darwin to access the shipping lines from Port Darwin.

2.2. ToR 2. Strategic importance of Australia's uranium resources and any relevant industry developments

2.2.1. Strategic Importance of Australia's Uranium Resources

Geoscience Australia estimates that as at December 2004, Australia has 701 000 t U in the category of Reasonably Assured Resources (RAR: Uranium Group terminology) of uranium recoverable at costs of less than US$40/kg U. Australia has the world's largest resources, with 40% of world resources in this category. Other countries with significant low cost uranium resources include Canada (17%), Kazakhstan (16%), South Africa (7%), Niger (5%), Uzbekistan (4%), Namibia (3%) and Russian Federation (3%).

Approximately 90% of Australia's total resources in RAR recoverable at ≤US$40/kg U are within six deposits: Olympic Dam (SA; ~70% of total), Ranger, Jabiluka, Koongarra in the Alligator Rivers region (NT), Kintyre and Yeelirrie (WA).

Olympic Dam is the world's largest deposit of low cost uranium. Based on ore reserves and mineral resources reported by WMC Resources as at December 2004, Geoscience Australia estimated that the deposit contains 499 400 t U in RAR recoverable at <US$40/kg U. This represents 30% of the world's total resources in this category.

As at December 2004, Australia has 343 000 t U in Estimated Additional Resources - Category 1 (EAR–1) recoverable at costs of <US$40/kg U – by far the world's largest resources in this category. These inferred resources are mainly in the south-eastern part of the Olympic Dam deposit, where current drilling is discovering large tonnages of additional resources.

Australia's total Identified Resources (RAR + EAR–1) recoverable at <US$40/kg U amount to 1 044 000 t U, as at December 2004.

2.2.2. Industry Developments - Australia

Olympic Dam expansion

WMC Resources is investigating the feasibility of a major expansion of the operations that would increase annual production to 500 000 t copper 15 000 t U_3O_8 and 500 000 ounces gold. This would require mining 40 Mt of ore per year. The study includes:

- A major drilling program (90 drill holes) to better define the resources in the southern part of the deposit;
- Assessing the alternative mining, treatment and recovery methods for the southern part of the deposit;
- Identifying and evaluating water and energy supply options; and
- Logistics planning that may include linking Olympic Dam to the national rail network.

On-going drilling continues to identify large tonnages of additional resources in the south-eastern portion of the deposit. The total resources as at December 2004 are almost 30% higher than in December 2003.

Beverley

Commonwealth and South Australian Government agencies have recently considered a proposal from Heathgate Resources to optimise the Beverley operations to produce up to 1500 t U_3O_8 per year. Geoscience Australia and the Bureau of Rural Sciences provided technical advice on this proposal to Department of Industry, Tourism and Resources, and the Department of the Environment and Heritage.

In 2004, after considering this technical advice together with further reports from the company, the Minister for Industry, Tourism and Resources approved the extension and granted Heathgate Resources a new uranium export permit.

Heathgate announced the discovery of a new zone of uranium mineralisation approximately 3 km south of the Beverley deposit. This ore zone, referred to as the Deep South zone, was discovered using a range of geophysical surveys followed up by an extensive drilling program comprising more than 120 holes.

Jabiluka

Jabiluka is a world class uranium deposit. Mining was approved in 1999 subject to over 90 environmental conditions, but did not have the consent of the Aboriginal traditional owners at that time. ERA Ltd has announced that there would be no further development at Jabiluka without the formal support of the Aboriginal people, and subject to feasibility studies and market conditions. The project site remains on long-term environmental care.

Honeymoon

Following a lengthy environmental impact assessment process which lasted almost two years, Southern Cross Resources received environmental clearances from government to develop the Honeymoon in situ leach project. The company has also been granted a uranium export permit. Following a review of development options for the Honeymoon project, a decision was made to focus on a 400 t U_3O_8/year capacity plant with a mine life of 6-8 years. Development of the project is currently on hold pending an investment decision.

Metallurgical recovery of uranium from brannerite ores

Most uranium is recovered from the common mineral uraninite, but there are significant amounts of uranium in the mineral brannerite [$(U,Ca,Ce)(Ti,Fe)_2O_6$] in some deposits. Metallurgical tests and other studies in recent years have achieved considerable improvements in the recoveries of uranium from brannerite mineralisation, which have the potential to significantly increase Australia's recoverable resources mainly at Olympic Dam and would, in turn, have important ramifications for Australia's uranium mining industry.

Exploration and uranium prices

Expenditures on uranium exploration in Australia have fallen almost continuously over the last 20 years. Annual expenditures on uranium exploration reached a peak in 1980 of $35.0 million (A$105 million in constant 2003A$) and declined to $6.4 million in 2003.

During the late 1970s and early 1980s, up to 60 companies were exploring for uranium in Australia. As market prices fell from 1980 onwards, most of these companies ceased uranium exploration. By 2003 only 5 companies were actively exploring for uranium and this work was confined to areas adjacent to known deposits, mainly western Arnhem Land (NT), Frome

Embayment and Gawler Craton-Stuart Shelf (SA). Despite the lack of discoveries since 1985, Australia's low-cost resources have continued to increase due to the delineation of additional resources at the known deposits, particularly Olympic Dam.

Over the last two years, spot market uranium prices have more than doubled from around US$10/lb U_3O_8 in early 2003 to US$26.25/lb U_3O_8 in May 2005 (Ux Consulting Company, LLC). This increase was due to a number of factors including: a decrease in the availability of secondary supplies (mainly highly enriched uranium) from the Russian Federation, very high world oil prices, temporary reductions in supply due to flooding of the McArthur River mine (Canada) and damage to the metallurgical plant at Olympic Dam caused by fires in 2003.

These recent price rises have resulted in increases in exploration activity and the number of small (speculative) exploration companies listed on the Australian Stock Exchange. Currently there are more than 20 companies exploring in Australia.

2.2.3 Industry developments – International

Secondary sources of supply

Uranium is unique among energy fuel resources in that demand is being met by a combination of mine production and secondary sources, including:

- Stockpiles of natural and low-enriched uranium, held by electricity utilities and conversion utilities (up to 30% of current world demand);
- Down blending of highly enriched uranium (HEU) from Russian and US government ex-military stockpiles (10% of world demand);
- Re-enrichment of depleted uranium 'tails' – residual fissile material is recovered from depleted uranium tails at enrichment plants (3-4% of world demand); and
- Uranium from reprocessing of spent reactor fuels (very small proportion of world demand).

Since 1990, mine production has accounted for less than 60% of world requirements, with the balance being met from secondary sources.

Over the last few years, mine production in the Russian Federation has been insufficient to meet the country's growing demand for electricity generation. As a consequence, supplies of HEU (down blended) are currently being retained by the Russian Federation for domestic electricity generation rather than being sold on world markets.

2.3. ToR 3. Potential implications for global greenhouse emissions reductions from further development and export of Australia's uranium resources

Since the Kyoto Protocol came into effect, nuclear power has become an important consideration for many countries as they develop strategies to reduce greenhouse gas emissions. Given that it has a high proportion of the world's known uranium resources, Australia's uranium production will be needed to fuel nuclear power generation around the world in the foreseeable future.

For nuclear electricity there are no emissions of greenhouse gases during electricity generating operations, and emissions for the whole life cycle for nuclear power are low (5 – 20g CO_2 equiv. per kW hour), several orders of magnitude less than for fossil fuel power generation.

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The Strategic Importance of Australia's Uranium Resources

1. INTRODUCTION

Geoscience Australia[1] is a prescribed agency within the Commonwealth Industry, Tourism and Resources portfolio. As Australia's national geoscience and spatial information agency, Geoscience Australia undertakes a wide range of activities onshore and in the marine zone. It serves the government and helps the community make appropriate and informed decisions about mineral and petroleum resources, the management of the environment and the safety and wellbeing of its citizens. To this end, it maintains a range of regional to national scale fundamental geoscience datasets, which are available free online or at the marginal cost of transfer.

Geoscience Australia produces annually a national inventory of Australia's mineral resources, including uranium and fossil fuels and provides advice into government on a range of issues in relation to resources, exploration, mining infrastructure and regional development. It has facilitated general access to such information through development, with support from the Regional Minerals Program and the Minerals Council of Australia, of a national on-line information system, at http://www.australianminesatlas.gov.au/

Dr Ian Lambert, a Group Leader within Geoscience Australia, represents Australia as Vice Chair of Uranium Group – a joint initiative between the UN's International Atomic Energy Agency and the OECD's Nuclear Energy Agency which collects and reports on data relating to uranium resources, production and demand from some 44 countries.

This submission provides background information on Australia's considerable uranium endowment and addresses three of the terms of reference (ToR) for this inquiry. It does so with most authority in relation to the first two, drawing on our resources and advice role in the Australian Government, which is facilitated by our involvement in the Uranium Group:

1. Global demand for Australia's uranium resources and associated supply issues; and
2. Strategic importance of Australia's uranium resources and any relevant industry developments;

We also provide some information on the third ToR:

3. Potential implications for global greenhouse emission reductions from further development and export of Australia's uranium resources.

In this case we make general comments based on information we have distilled from other sources, accessed through the Uranium Group.

The fourth ToR, dealing with regulation, is not addressed here. This issue has been covered exhaustively in a range of earlier inquiries, and Geoscience Australia has nothing to add.

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[1] Geoscience Australia grew out of the Bureau of Mineral Resources (BMR) and the Division of National Mapping, both of which were founded soon after World War 2. BMR became the Australian Geological Survey Organisation in 1992, several years after Division of National Mapping had become the Australian Surveying and Land Information Group (AUSLIG). AGSO and AUSLIG merged to become Geoscience Australia in 2001. Further information is available at www.ga.gov.au.

2. SUBMISSION IN RELATION TO SPECIFIC TERMS OF REFERENCE

2.1. ToR 1. Global demand for Australia's uranium resources and associated supply issues

2.1.1. Global Demand for Australia's uranium resources

Australia has three operating uranium mines: Ranger (NT), Olympic Dam and Beverley (SA) (Fig. 1). Recent production from these mines is shown in Table 1.

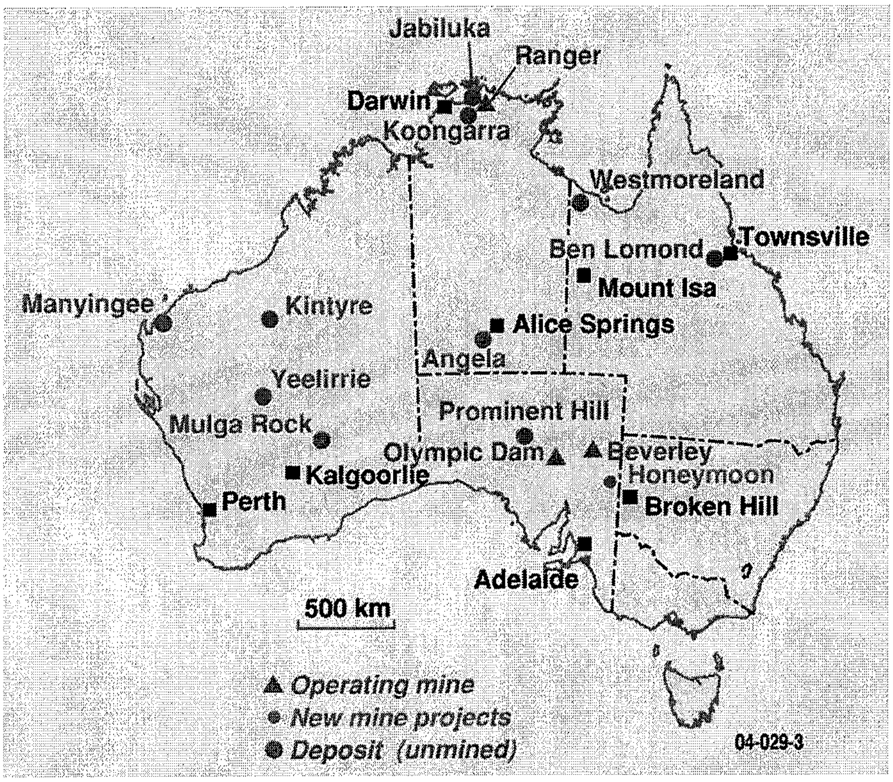

Figure 1: Australian uranium mines and deposits.

Table1: Recent production (tonnes U_3O_8) from Australian uranium mines. Percentage of world production in parentheses. [(a)] estimate (WMC, 2005).

	1998 t U_3O_8	1999 t U_3O_8	2000 t U_3O_8	2001 t U_3O_8	2002 t U_3O_8	2003 t U_3O_8	2004 t U_3O_8
Ranger	4 050 (10%)	3 857 (10%)	4 437 (10%)	4 203 (10%)	4 470 (11%)	5 065 (12%)	5 138 (11%)
Olympic Dam	1 722 (4%)	3 199 (8%)	4 500 (11%)	4 355 (10%)	2 867 (7%)	3 176 (7%)	4 370 (9%)
Beverley				546 (1%)	746 (2%)	689 (2%)	1 084 (2%)
Australia total	5 722 (14%)	7 056 (18%)	8 937 (21%)	9 104 (21%)	8 083 (20%)	8 931 (21%)	10 592 (22%)
World mine production	41 139	37 947	42 466	43 656	42 502	42 184	46 700[a]

From the start of production at Mary Kathleen mine in 1976, followed by Nabarlek 1980, Ranger 1981, Olympic Dam 1988 and Beverley mine 2001, Australia's uranium mining industry has grown progressively to become the world's second largest producer (in terms of annual production). In 2004, Australia produced approximately 22% of world uranium production and exported 9 648 t U_3O_8. Canada remains the world's largest producer with 13 676 t U_3O_8 in 2004.

Ranger

The Ranger mine is located 230 km east of Darwin in the Alligator Rivers region (Fig. 2). The Ranger Project Area and the Jabiluka Mineral Lease are surrounded by, but not part of, the Kakadu National Park. Both areas are part of a land title granted to the traditional Aboriginal owners. The mine operator, Energy Resources of Australia Ltd (ERA) pays 4.25% of net sales via the Commonwealth to the Aboriginal Benefits Trust Account for distribution to the Aboriginal owners. In addition, ERA pays 1.25% of net sales via the Commonwealth to the NT to cover the costs of administration.

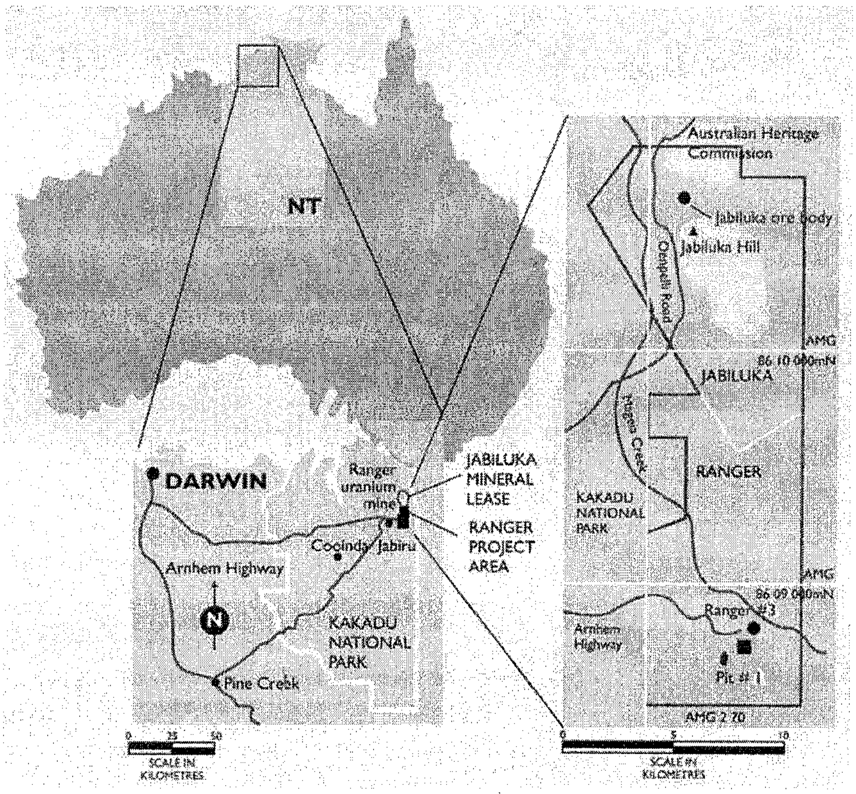

***Figure 2**: Ranger Project Area and Jabiluka Mineral Lease (Source: ERA Ltd Annual report 2000).*

Within the Ranger Project Area there are two orebodies – Ranger No. 1 (mined out) and Ranger No. 3 which is currently being mined. Open cut mining at the Ranger No. 1 orebody began in August 1981 and was completed by December 1994. Production from the processing plant continued from stockpiled ore until open cut mining commenced at Ranger No. 3 orebody in October 1996.

The Ranger mill has a nominal production capacity of 5 000 t U_3O_8 per year (4 240 t U), however production has exceeded this in recent years. Approximately 2.1 Mt of ore are milled annually. The mill uses a sulphuric acid leach process to dissolve uranium from the ore. Uranium is recovered from the leachate by solvent extraction and is precipitated as ammonium diuranate (yellowcake). This is then calcined (heated to more than 200°C to remove volatile components) to produce concentrates of uranium oxide (grey–green coloured powder) assaying 99.2% U_3O_8.

Since August 1997, the No. 1 orebody open cut has been used as a repository for mill tailings. The company proposes to finally dispose of all mill tailings into the No. 1 and No. 3 orebody open cuts, on completion of mining.

In 2004, Ranger mine employed 379 people and produced 11% of total world production. It was the world's second largest uranium mine (in terms of annual production), behind the very high grade McArthur River mine in Saskatchewan (Canada) with production of 8 490 t U_3O_8 in 2004.

Olympic Dam

Olympic Dam is a large-scale underground mining operation using sub-level open stoping methods. The mine, which is owned 100% by WMC Resources Ltd, produces copper, uranium, gold and silver.

Production commenced in August 1988. Between 1989 and 1995, the annual capacity of the processing plant was increased in two stages to 85 000 t copper and 1 700 t U_3O_8 (1 440 t U) plus associated gold and silver from the processing of 3.0 Mt ore/year. A major expansion of the project was completed in March 1999 at a cost of A$1.94 billion. Annual production capacity was increased to 200 000 t copper, 4 600 t U_3O_8 (3900 t U), 2 050 kg gold and 23 000 kg silver. To sustain this rate of production, approximately 8.7–9.2 Mt ore are mined and processed annually (WMC, 1997). Water required for mining and processing operations and for the township of Roxby Downs is pumped from borefields within the Great Artesian Basin. The main borefield is located more than 175 km north-east of the mine.

Government approval for the major expansion was granted after a comprehensive Environmental Impact Statement was assessed jointly by the Commonwealth and South Australian Governments. In addition to the existing environmental regulations and controls on the project, new requirements were imposed relating to the management of the Great Artesian Basin water resources, future assessments of the tailings management systems, and impacts of future changes to technology and mining practices (refer 'Olympic Dam expansion study').

The metallurgical processes to recover copper, uranium, gold and silver are complex, however the processes relating to uranium recovery can be summarised as follows. After crushing and grinding, the ore is mixed with water and the slurry is pumped to the flotation plant. Copper concentrates are produced using standard flotation processes. The non-sulphide particles, which do not float (referred to as flotation tailings), contain most of the uranium minerals. Acid mixed with an oxidant is then added to leach uranium from the flotation tailings, and the slurry is heated to 60°C to improve the leach process. Uranium is recovered from the leach liquor by solvent extraction. Pulsed column technology is used to improve the recovery rate and to reduce the consumption of organic reagents. As at Ranger, the solutions containing dissolved uranium are treated with ammonia and calcined to produce uranium oxide powder.

In 2004, Olympic Dam was the third largest uranium producer, with 9% of world's total mine production. The operation employs 1 670 people (including contractors) of which 283 people worked in the uranium production sector.

Beverley
The Beverley project, which is Australia's first commercial in situ leach uranium mining operation, is owned and operated by Heathgate Resources Pty Ltd, a wholly-owned subsidiary of General Atomics of the US. Production commenced in 2001. Uranium occurs in porous sandstones saturated with groundwater. Uranium is leached in situ using sulphuric acid and an oxidant (hydrogen peroxide) which is introduced into the sandstones via injection wells. The leach solutions containing dissolved uranium are then pumped to the surface via production wells and into the processing plant. Uranium is recovered in the processing plant using ion-exchange technology. The final product is hydrated uranium oxide $UO_4.2H_2O$ which is a yellow powder also referred to as 'yellow cake'. This is heated in a low temperature zero-emissions dryer to remove moisture and residual chemical reagents.

In 2004, the operation produced 1 084 t U_3O_8 which makes it the world's largest single in situ leach uranium mine (D. Brunt, Vice President, Heathgate Resources, pers. comm.). Beverley production was greater than total United States production for 2004 which was from a number of ISL operations in Wyoming, Nebraska and Texas. Beverley mine employs 85 people.

Main export markets for Australian uranium
All Australia's mine production of uranium is exported. Australia has no nuclear power plants and consequently no demand for uranium for domestic electricity generation. Australian export tonnages have increased steadily from less than 500 t U_3O_8 in 1976 to reach a record level of 9 648 t U_3O_8 in 2004. Exports for 2004 were valued at A$411 million (Table 2; Fig. 3). In thermal quantities, uranium accounts for approximately 40% of Australia's energy exports (4083 PJ in 2003-04).

Exports were shipped to uranium conversion plants in France, USA, Canada and UK. These plants process the concentrates to produce uranium hexafluoride (UF_6) which is then further processed (usually by enrichment) to make uranium fuel for use in nuclear power stations.

Table 2: Exports of Australian uranium and average export values. Note: Export values are free-on-board (fob). (Note: Annual average US$/A$ exchange rate calculated from RBA daily rates). Source: Department of Industry, Tourism and Resources.

Exports	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
tonnes U_3O_8	5424	6916	5553	7578	8766	9239	7637	9612	9648
Value A$ million	248	287	270	349	426	463	363	398	411
Average export values									
$A/lb U_3O_8	20.75	18.82	22.03	20.89	22.07	22.72	21.58	18.78	19.32
US$/lb U_3O_8	16.18	13.96	13.83	13.47	12.85	11.77	11.73	12.24	14.22

Australian mining companies supply uranium under long-term contract to electricity utilities in the following countries: United States, Japan, European Union (United Kingdom, France, Germany, Spain, Sweden, Belgium, Finland), South Korea, Canada, and to Taiwan under United States safeguards agreements. Australian uranium mining companies have gained a reputation as reliable suppliers to customer countries and utilities.

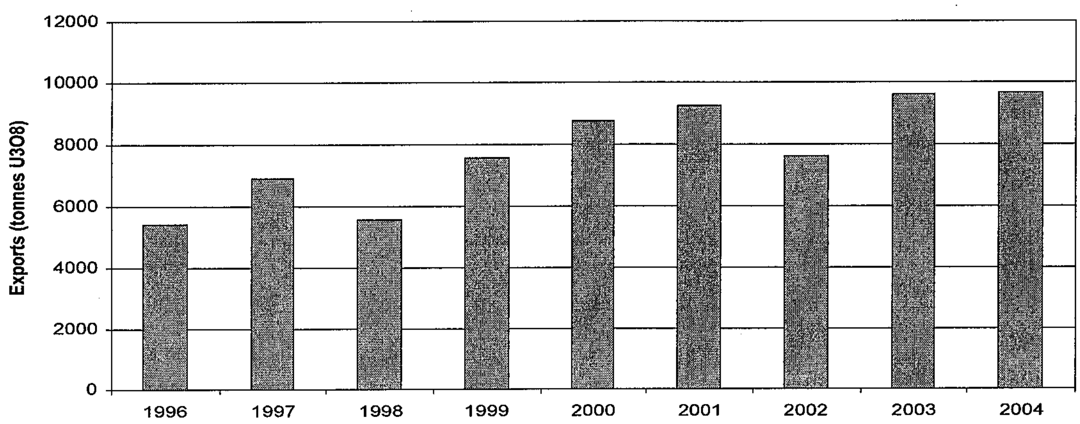

Figure 3: Australian uranium exports (tonnes U_3O_8).

Table 3 shows sales (deliveries) of Australian uranium in 2004 to meet long-term contracts.

Table 3: Australian uranium sales (deliveries) by region for 2004.

	Tonnes U_3O_8	% of total (rounded)
USA	3513.89	38.4%
Japan	2292.49	25.0%
European Union [a]	2284.36	24.9%
Republic of Korea	930.00	10.2%
Canada	136.08	1.5%
Total	9156.82 [b]	100%

(a) European Union sales to France, Germany, Sweden, Finland, UK and Spain.
(b) Total sales differ from total export tonnages for 2004 because of time required for shipping.
Source: Department of Industry, Tourism and Resources.

Potential major new market

China is pursuing an ambitious nuclear power program with assistance from Canadian, French and US companies with design and construction of nuclear power plants. However, a bilateral safeguards agreement between Australia and China must be signed before any exports can occur. China has nine nuclear power reactors in operation which currently provide about 2-3% of the country's total electricity generation. A further two power reactors are under construction. Total installed nuclear capacity is approximately 10 Gigawatts.

Additional reactors are planned to give a four-fold increase in nuclear capacity to 40 Gigawatts by 2020.

China's known uranium resources and mine production are insufficient for future domestic nuclear electricity generation. As an outcome of our participation in the NEA-IAEA Uranium Group, China's National Nuclear Corporation (CNNC) requested that Geoscience Australia facilitate a visit by a CNNC delegation in February 2004, to discuss potential future uranium supplies from Australia to fuel China's burgeoning nuclear power sector. In organising this meeting, Geoscience Australia invited the Uranium Industry Section of the Department of Industry Tourism and Resources (DITR), Invest Australia and the Australian Safeguards and Non-Proliferation Office of the Department of Foreign Affairs and Trade (DFAT) to make presentations to clarify the Government policies and safeguards issues that would have to be considered in relation to China's access to Australian uranium.

DFAT has subsequently had discussions with Chinese officials regarding the possibility of a bilateral safeguards agreement with China in relation to exports of Australian uranium.

2.1.2. Supply issues

In recent years, mine production of uranium occurred in seven main countries (in descending order of production) – Canada, Australia, Niger, Russian Federation, Kazakhstan, Namibia and Uzbekistan. In 2003, these countries provided 88% of the world's uranium mine production. The two largest producers, Canada and Australia accounted for more than 50% of world production in 2003. So Australia is a crucial supplier of uranium to global markets.

World mine production (referred to as primary source of supply) is insufficient to meet total world uranium requirements (demand) for electricity generation. Figure 4 shows the relationship between world mine production and uranium requirements for electricity generation (including the former Soviet Union and the Eastern bloc countries). Since 1990, uranium requirements have exceeded mine production and in recent years, mine production accounted for less than 60% of world requirements. In 2003, world mine production (35 772 t U) provided only about 52% of world requirements for nuclear electricity generation (68 435 t U), the remainder coming from secondary sources (see section 2.2.3.).

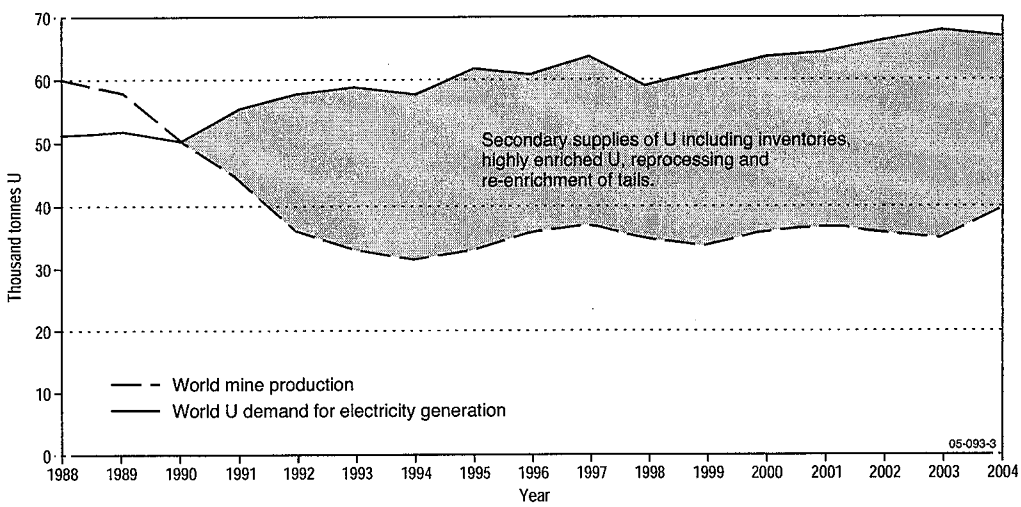

Figure 4: *Comparisons of world mine production and world uranium demand for electricity generation (Sources: OECD/NEA & IAEA, 2004; WMC, 2005). The deficit between mine production and demand has been filled by uranium from secondary sources.*

Denial of shipping services for Australian uranium exports

During the last few years there has been increasing reluctance to ship uranium concentrates (and other Class 7 cargoes). There are various reasons for such 'denial of shipping services', including (IAEA, 2004; Colgan, 2005):

- Since September 11 2001, there has been increasing reluctance by many vessel owners and shipping companies to be involved with the transport of Class 7 cargoes. Security and liability issues have become of increasing concern to shipping companies, port authorities and governments;
- A large proportion of container ships are chartered rather than owned, and in recent years these charter operators have refused to carry nuclear materials. Charter shipping companies have been citing high insurance costs and onerous requirements as reasons for refusing to handle radioactive ores;
- Container shipping companies are usually members of a consortium in which several companies contribute vessels and are entitled to container capacity on each vessel. Uranium concentrates are generally excluded from such capacity swapping arrangements and require acceptance by each ship operator;
- Many intermediate ports will not permit the transit of radioactive cargoes. Ships operating between Australian and European or North American destinations are unable to enter some ports of call on route because these refuse to allow entry of Class 7 cargoes, for example, Italian ports are nuclear-free.

Concentrates from Olympic Dam and Beverley have been exported through Port Adelaide for many years. In 2004, charter shipping companies operating through Port Adelaide announced that they would no longer handle cargoes of uranium concentrates. A monthly service with limited capacity (17 containers) was negotiated with WMC Resources and Heathgate Resources. The companies have also completed a three month rail trial whereby the uranium concentrates were transported from Adelaide to Darwin to access the shipping lines from Port Darwin. This trial was successful with no incidents and the companies are exploring this as an on-going option (Fig. 5).

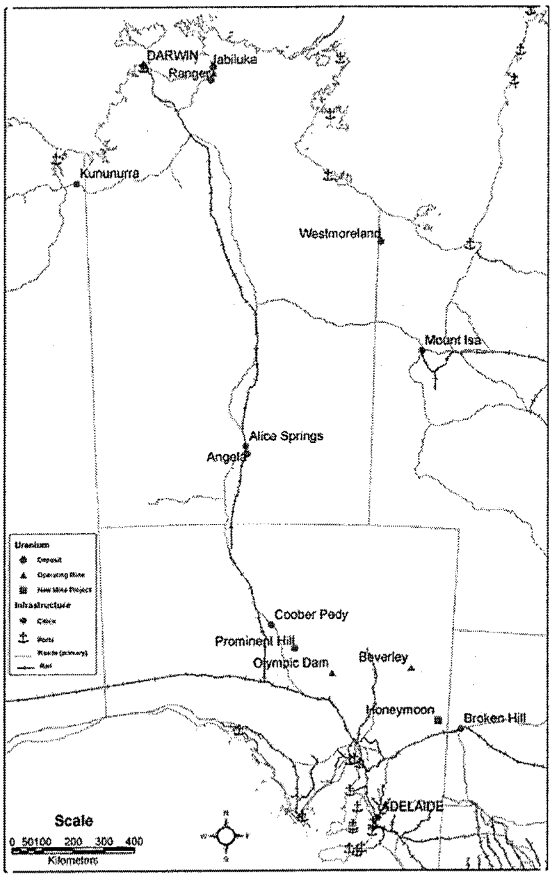

***Figure 5**: Location of uranium mines and main road, rail and port infrastructure.*

Nuclear Safeguards for Australian uranium exports

A comprehensive description of Australian nuclear safeguards and the roles of the Australian Safeguards and Non-Proliferation Office will be provided in the submission to the inquiry from the Department of Foreign Affairs and Trade. Consequently only a brief description of nuclear safeguards for exports of Australian uranium is presented here.

Exports of Australian uranium are controlled by stringent safeguards agreements. These exports are approved under bilateral safeguards agreements. This means that the importing country must be a signatory to International Atomic Energy Agency safeguards arrangements and must also have signed an agreement with the Australian government to adhere to Australian safeguards obligations for exporting uranium. These safeguards agreements ensure that Australia's uranium is used only for electricity generation and that it is not diverted to any military purposes. This compliance is monitored by the Australian Safeguards and Non-Proliferation Office, Department of Foreign Affairs and Trade. Australian uranium is appropriately accounted for as it moves through the nuclear fuel cycle.

Australia has 19 bilateral safeguards agreements with: Argentina, Canada, Czech Republic, Euratom (European Union Supply Agency), Finland, France, Hungary, Japan, Mexico, Republic of Korea, Russian Federation[2] (limited), Sweden, Switzerland, UK, USA (also covering supplies to Taiwan), New Zealand and Egypt. These bilateral agreements cover 27 countries in total (including Taiwan).

[2] The Australia/Russia Agreement covers the processing (conversion, enrichment or fuel fabrication) of Australian uranium in Russia on behalf of other countries, but does not permit the use of Australian uranium by Russia.

2.2. ToR 2. Strategic importance of Australia's uranium resources and any relevant industry developments

2.2.1 Strategic Importance of Australia's Uranium Resources

Geoscience Australia prepares annual estimates of Australia's uranium resources within categories defined by the Uranium Group. These estimates are published biennially in the OECD/NEA and IAEA publication *Uranium Resources, Production and Demand*, commonly known as the 'Red Book' (because of the colour of its cover).

Under the NEA/IAEA resource classification scheme, Identified Resource estimates are divided into two categories that reflect the level of confidence in the quantities reported:

- Reasonable Assured Resources (RAR; comprising the categories Proved and Probable Reserves plus Measured and Indicated Resources of the Joint Ore Reserves Code [JORC] used for commercial reporting in Australia),
- Estimated Additional Resources – Category I (EAR–1; comprising Inferred Resources of JORC).

These resources are further separated into categories based on the cost of production: ≤US$40/kg U; US$40-80/kg U; and US$80-130/kg U.

National agencies from each country provide estimates of resources in response to questionnaires distributed by the NEA/IAEA Uranium Group. All the resource estimates are expressed in terms of tonnes of uranium (t U) recoverable from minable ore; i.e. the estimates include allowances for ore dilution, mining and milling losses.

Table 4 shows estimates for Australia's RAR of uranium as at December 2004. Australia has the world's largest resources in RAR recoverable at ≤US$40/kg U, with 40% of world resources in this category (Fig. 6). Approximately 90% of Australia's total resources in RAR recoverable at ≤US$40/kg U are within six deposits: Olympic Dam (SA), Ranger, Jabiluka, Koongarra in the Alligator Rivers region (NT), Kintyre and Yeelirrie (WA). Other countries that have large resources in this category include Canada (17%), Kazakhstan (16%), South Africa (7%), Niger (5%), Uzbekistan (4%), Namibia (3%) and Russian Federation (3%).

Olympic Dam is the world's largest deposit of low cost uranium. Based on ore reserves and mineral resources reported by WMC Resources as at December 2004, Geoscience Australia estimated that the deposit contains 499 400 t U in RAR recoverable at <US$40/kg U. This represents 30% of the world's total resources in this category.

As at December 2004, Australia has 343 000 t U in EAR–1 recoverable at <US$40/kg U which is by far the world's largest resources in this category. The majority of Australia's resources in this category are in the Olympic Dam deposit, particularly the south-eastern part which is currently being drilled.

Australia's total Identified Resources (RAR + EAR–1) recoverable at <US$40/kg U amount to 1 044 000 t U as at December 2004.

Table 4: Reasonably Assured Resources (t U) as at December 2004

	Cost Ranges (a)	
	≤US$40/kg U (≤US$15/lb U_3O_8)	**US$40-80/kg U (US$15-30/lb U_3O_8)**
Australia	701 000	13 000
Brazil (b)	26 235	59 955
Canada	297 264	36 570
China (b)	26 235	8 825
Kazakhstan (b)	280 620	104 005
Mongolia (b)	7 950	38 250
Namibia	57 262	82 035
Niger	89 800	12 427
Russian Fed.(b)	52 610	71 440
South Africa	119 184	112 480
Ukraine (b)	15 380	19 250
USA (c)	NR	102 000
Uzbekistan (b)	61 510	0
Others (d)	7 445	67 420
Total adjusted for losses (e)	1 742 495	727 657

Sources: Data for Australia compiled by Geoscience Australia as at December 2004. Estimates for all other countries are from OECD/NEA & IAEA (2004).

(a) Resources in US$40-80 category are additional to those resources in ≤US$40 category.
(b) In situ resources were adjusted by NEA/IAEA Secretariat to estimate recoverable resources.
(c) USA only reports total RAR recoverable at ≤US$80. The proportion of this total that is in ≤US$40 category is not reported.
(d) Algeria, Argentina, Bulgaria, Central African Republic, Congo, Czech Republic, Gabon, Greece, Indonesia, Islamic Republic of Iran, Italy, Malawi, Mexico, Peru, Portugal, Slovenia, Spain, Zimbabwe.
(e) Totals are higher than sum of all figures in the table because certain countries do not report resource estimates for reasons of confidentiality.
NR: not reported

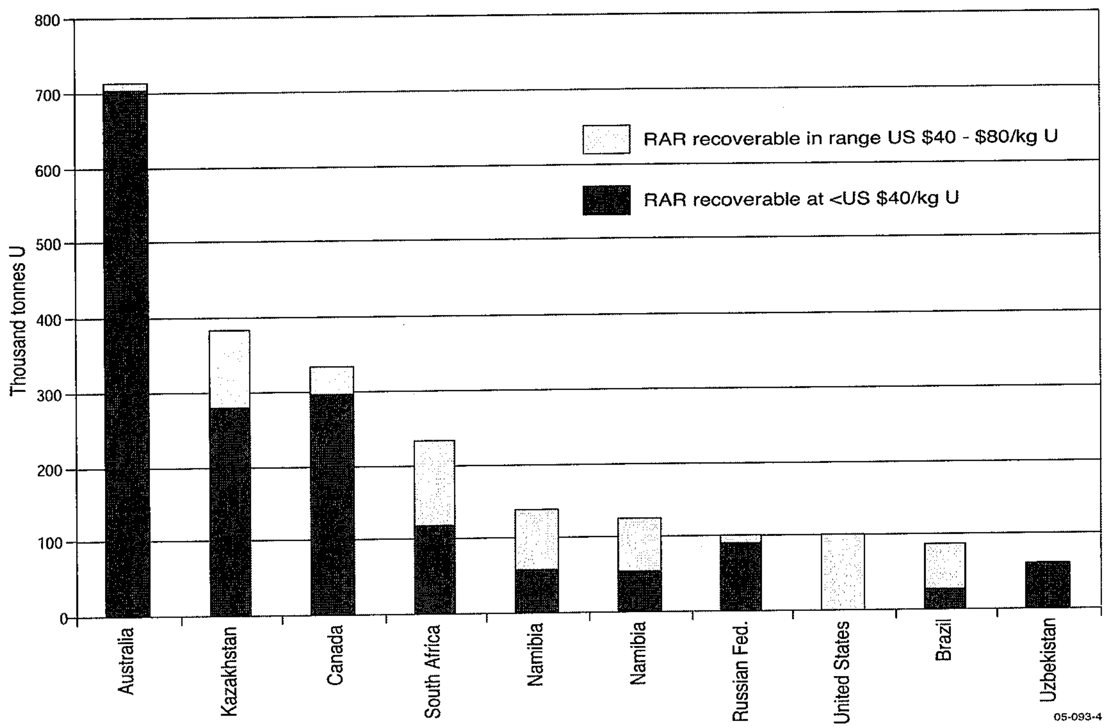

***Figure 6**: Distribution of Reasonably Assured Resources among countries with major resources.*

Types of uranium deposits and their economic significance in Australia and worldwide

The OECD/NEA & IAEA (2004) have classified uranium deposits worldwide into fifteen deposit types on the basis of their geological setting. Most of Australia's uranium resources occur within four such deposit types:

- *Hematite breccia complex deposits:* some 70% of Australia's total uranium resources occur in Proterozoic hematite-rich granitic breccias at Olympic Dam. Broadly similar, but apparently smaller, hematite-rich breccia mineralisation is being evaluated elsewhere in the same geological province, at Prominent Hill. These are examples of 'iron oxide copper gold deposits' with higher uranium contents than most deposits of this type.
- *Unconformity-related deposits:* about 18% of resources are associated with Proterozoic unconformities, mainly in the Alligator Rivers field, NT (Ranger, Jabiluka, Koongarra).
- *Sandstone uranium deposits:* constitute about 6% of resources, mainly in the Frome Embayment field, SA (Beverley, Honeymoon) and the Westmoreland area, Queensland.
- *Surficial (Calcrete) deposits*: constitute about 4% of Australia's uranium resources, mostly in the Yeelirrie deposit (WA).

Government policies influencing uranium mining and exploration

Commonwealth and State Government policies on uranium exploration and mining have influenced exploration expenditures in Australia. The following is a brief summary of some relevant policies and legislation.

During the early 1980s, the Victorian and New South Wales State Governments introduced legislation to prohibit exploration and mining of uranium, consequently there has been no uranium exploration in these States since then. The Western Australian State Government has prohibited the mining of uranium for nuclear purposes from any mining lease granted after June 2002. The Queensland State Government has also actively discouraged potential new mine developments despite the absence of any legislation that specifically prohibits uranium mining.

In 1983 the Commonwealth Labor Government introduced the 'Three mines' policy. Under this policy, exports of uranium were permitted only from the Nabarlek, Ranger and Olympic Dam mines. The 'Three mines' policy was abolished by the Liberal–National Party Coalition upon election to Government in 1996. This cleared the way for the development of new uranium mines, provided they comply with strict environmental, heritage and nuclear safeguards requirements.

In general, foreign companies and organisations consider that uranium mining in Australia remains a politically sensitive issue and that government policies could change with changes in political parties elected to government.

Some general unease has been expressed internationally, including within the Uranium Group, about policies and philosophical concerns that could limit medium to long term uranium supplies from Australia (and some other countries including Canada). In Australia's case, concerns centre on the "No new mines policy" of the Australian Labor party.

2.2.2. Industry developments - Australia

Olympic Dam expansion

Ore reserves and mineral resources for Olympic Dam as reported by WMC Resources are shown in Table 5. These estimates were made using the following assumptions for long-term metal price: A$1.42/lb for copper, A$30/lb for U_3O_8 and A$500/oz for gold. Long-term metal prices are the basis for estimating the reserves and resources because copper, uranium, gold and silver, all contribute to the economic parameters for these estimates.

Table 5: Olympic Dam ore reserves and mineral resources at December 2004 (Note: The Measured and Indicated Mineral Resources are **inclusive** of those Mineral Resources modified to produce the Ore Reserves) (WMC Resources, 2005).

Reserves/Resources Classification		Million tonnes	Cu (%)	U_3O_8 (kg/t)	Contained U_3O_8 (tonnes)	Au (g/t)
Reserves	Proved	119	2.1	0.6	71 400	0.5
	Probable	642	1.4	0.5	321 000	0.5
Resources	Measured	650	1.5	0.5	325 000	0.5
	Indicated	1420	1.1	0.4	568 000	0.5
	Inferred	1740	1.0	0.3	522 000	0.5
Total Resources		3810	1.1	0.4	1 415 000	0.5

The huge Olympic Dam deposit is the world's largest resource of low cost uranium with 30% of world's RAR recoverable at less than US$40/ kg U, the world's fourth largest copper resource and fourth largest gold resource (WMC Resource, 2005).

In 2004, the company commenced a study to investigate the feasibility of a major expansion of the operations that would increase annual production to 500 000 t copper 15 000 t U_3O_8 and 500 000 ounces gold. This would require mining 40 Mt of ore per year. The study includes:

- a major drilling program (90 drill holes) to better define the resources in the southern part of the deposit,
- assessing the alternative mining, treatment and recovery methods for the southern part of the deposit,
- identifying and evaluating water and energy supply options,
- logistics planning that may include linking Olympic Dam to the national rail network.

Recent drilling has identified significant additional resources in the south-eastern portion of the deposit. The resources as at December 2004 are almost a 30% increase over the resources to December 2003. The company considers that these resources are '....of sufficient size to support an expanded world-class operation for many decades' (WMC, 2005).

Evaluation of the various mining methods and the scale of operations was completed in March 2005. Two mining options were evaluated: underground (sub-level caving or block caving) and open pit (Fig. 7). From the results of the study, the company selected open pit as the preferred method because it provides 'clear economic benefits over the alternatives based upon commercially proven technology' (WMC, March 2005).

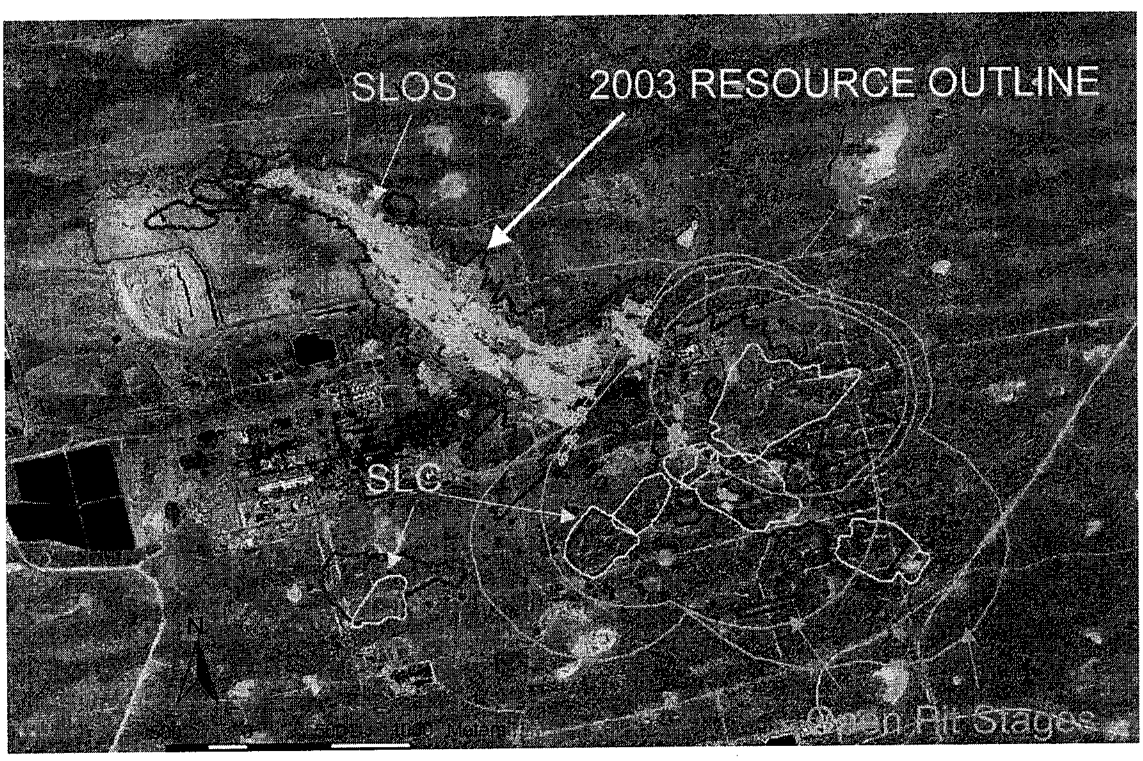

Figure 7: *Mining methods studied for the proposed expansion at Olympic Dam mine. The current and proposed areas to be mined by sub-level open stoping (SLOS) methods are shown in the northern portion of the orebody. Sub-level caving (SLC) and open pit mining methods were considered for the southern portion of the orebody (Courtesy WMC Resources Ltd).*

Beverley

The total in place resources minable by in situ leach is currently estimated to be approximately 16 300 t U_3O_8. Heathgate Resources (1998) estimated that total recoverable resources for Beverley deposit prior to commencement of mining was 10 600 t U_3O_8. This estimate assumed that in situ leach mining would recover a minimum of 65% of the total in place resources. From the commencement of production in late 2001, a total of 3 065 t U_3O_8 was produced up to end of December 2004.

During 2003, in situ leach mining at Beverley progressed from the North orebody into the much larger Central orebody. Installation of the main pipelines (trunklines) connecting the plant to the Central orebody was completed and by early 2004, production reached an annualised rate of 1000 t U_3O_8, the licensed capacity of the plant at that time (Fig. 8).

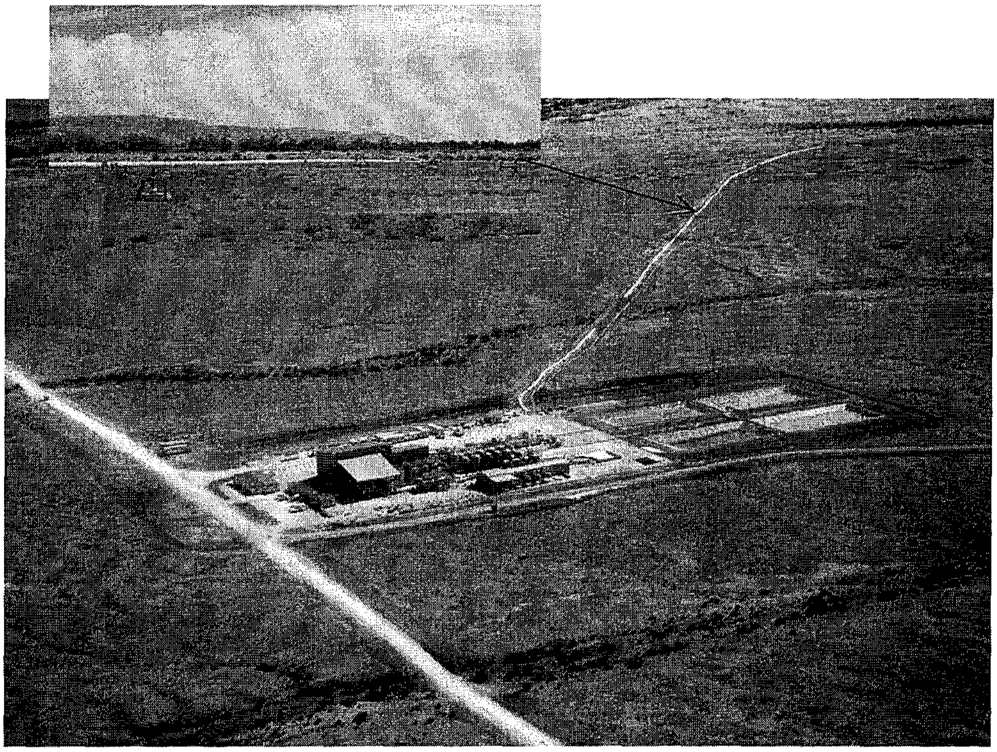

***Figure 8**: Beverley in situ leach operations.*

Commonwealth and South Australian Government agencies have recently considered a proposal from Heathgate Resources to optimise the Beverley operations to produce up to 1500 t U_3O_8 per year. Geoscience Australia (GA) and the Bureau of Rural Sciences (BRS) provided technical advice on this proposal to DITR and Department of the Environment and Heritage. GA and BRS advised that the company should be required to undertake groundwater studies to determine the hydrological impacts on the Beverley aquifer which could result from increased rates of disposal of liquid wastes from the in situ leach operations.

In 2004, after considering this technical advice together with further reports from the company, the Minister for Industry, Tourism and Resources approved the extension and granted Heathgate Resources a new uranium export permit. As part of the export permit, the Minister imposed a number of conditions including (inter alia) that the Beverley operations are to be carried out on the basis of a **neutral water balance**, ie. total volume of fluid injected into the aquifer from all sources must equal the total volume pumped out.

Heathgate announced the discovery of a new zone of uranium mineralisation approximately 3 km south of the Beverley deposit (Brunt, 2004). This ore zone, referred to as the Deep South zone, was discovered using a range of geophysical surveys followed up by an extensive drilling program comprising more than 120 holes totalling 23 745 m. The Deep South ore zone is within sands similar to the main Beverley deposit. Resource estimates for this zone have not been reported to date.

The company has also recently reported other discoveries in and around the Beverley Mine area in addition to the Deep South zone. These more recent discoveries are new and require additional follow-up, however, the success of on-going exploration is expected to increase the life of the project.

Ranger

This mine is owned by Energy Resources of Australia Ltd (ERA) a subsidiary of Rio Tinto. Mining of No. 3 orebody is expected to continue until at least 2008, with milling operations continuing until at least 2011. From 2008 onwards, the No. 3 orebody open cut will be used as a tailings repository. ERA is currently exploring for extensions of the No. 3 orebody. The latest company estimates of ore reserves and mineral resources for Ranger No. 3 orebody are shown in Table 6.

Table 6: Ore Reserves and Mineral Resources for Ranger No. 3 orebody at December 2004 (ERA, 2005).

	Million tonnes	**Grade (% U_3O_8)**	**Contained U_3O_8 (tonnes)**
Stockpile	6.34	0.20	12 878
Proved and Probable Ore Reserves	11.65	0.27	31 017
Total Reserves + Stockpile	17.99	0.24	43 895
Measured and Indicated Resources	7.06	0.19	13 549
Inferred Resources	7.86	0.18	14 520
Total Resources (**exclusive** of Reserves)	14.92	0.19	28 069
Total Reserves + Stockpile + Resources	32.91	0.22	71 964

Jabiluka

Jabiluka is a world class uranium deposit with total Proved and Probable Reserves of 71 000 t U_3O_8 and an additional 92 000 t U_3O_8 in mineral resources (total Measured + Indicated + Inferred Resources). Mining was approved in 1999 subject to over 90 environmental conditions. As with Ranger, Jabiluka is surrounded by, but is not part of, Kakadu National Park. In consideration of World Heritage concerns about the impact of Jabiluka's development on the park, ERA has previously agreed that Jabiluka and the nearby Ranger operation would not be in full operation simultaneously.

The traditional Aboriginal land-owners have refused to grant their approval for development of the mine. ERA Ltd has announced that there would be no further development at Jabiluka without the formal support of Aboriginal people, and subject to feasibility studies and market conditions. The project site remains on long-term environmental care.

In February 2005, the Mirarr Gundjeihmi Aboriginal people, ERA Ltd and the Northern Lands Council signed an agreement on the long-term management of the Jabiluka lease. This agreement obliges ERA Ltd (and its successors) to secure Mirrar consent prior to any future mining development of uranium deposits at Jabiluka.

Honeymoon
Following a lengthy environmental impact assessment process which lasted almost two years, Southern Cross Resources received Commonwealth and South Australian Government environmental clearances to develop the Honeymoon in situ leach project. The company has also been granted a uranium export permit.

Exploration has continued in recent years at both the Honeymoon and Goulds Dam deposits. Table 7 shows the latest resource estimates.

Table 7: Mineral resources for Honeymoon, East Kalkaroo, Goulds Dam and Billeroo deposits (Southern Cross, 2004).

	Resource category	Million tonnes	Grade % U_3O_8	Contained U_3O_8 tonnes
Honeymoon	Indicated	2.8	0.12	3 300
East Kalkaroo	Indicated	1.2	0.074	910
Goulds Dam	Indicated	5.6	0.045	2 500
Billeroo	Inferred	12.0	0.03	3 600
Total Resources				10 310

Following a review of development options for the Honeymoon project, a decision was made to focus on a 400 t U_3O_8/year capacity plant with a mine life of 6-8 years (PIRSA, 2005). Development of the project is currently on hold pending an investment decision. However, '.....assuming a positive outcome on feasibility study work, production is possible in late 2005 or early 2006' (Southern Cross, 2004).

Metallurgical recovery of uranium from brannerite ores
Conventional acid leach plants are used widely (Ranger, Olympic Dam and many others around the world) for recovering uranium from uraninite (UO_2) ores. Brannerite [(U,Ca,Ce)$(Ti,Fe)_2O_6$], another important uranium mineral, is not dissolved in these sulphuric acid plants. This was confirmed by the Australian Atomic Energy Commission during the 1960s, after research on bulk metallurgical samples from brannerite-rich mineralisation (Valhalla deposit, Qld).

Metallurgical tests and other studies in recent years have achieved considerable improvements in the recoveries of uranium from brannerite mineralisation. For example, Summit Resources recently engaged a research metallurgical company to investigate possible technologies for recovering uranium from brannerite ores in the Valhalla deposit. Investigations using increased temperatures and pressures for the acid leach process have yielded improved recoveries.

A cost effective process(es) to recover uranium from brannerite would result in a significant increase in Australia's low cost resources (recoverable) of uranium.

Uranium recoveries from the processing of Olympic Dam ores have always been comparatively low. Currently only about 70% of the uranium is recovered and it has been lower than this in past years. Olympic Dam uranium ores have a mixture of uraninite and brannerite (about 30%). The brannerite remains in the heavy fraction which is sent to the tailings dam for disposal. WMC Resources is engaged in a major research program to investigate uranium recoveries, and is testing hot leaching in conjunction with other techniques. During 2004, the company implemented the first phase of these metallurgical improvements (so-called tailings leach program) and reported recoveries as high as 77% in the fourth quarter (WMC, 2005). The implications of these results are far reaching because, if they can improve recoveries up to 85% (as proposed), this will have a marked improvement in production and revenues. In the lower grade ores at Olympic Dam, the ratio of brannerite:uraninite increases with decreasing ore grade. It is very important for future expansions of the operations into the southern section of the orebody (lower grade) that this brannerite problem be solved.

Exploration and uranium prices

Geoscience Australia (and predecessor organisations) undertakes an annual survey of uranium exploration in Australia as part of its work in providing technical advice to Government. The following analysis of these results shows the impacts of market prices on exploration expenditures.

Historically, uranium exploration in Australia has been highly successful - during the period from 1969 to 1980 many deposits were discovered including a number of world-class deposits such as Ranger, Jabiluka, Nabarlek and Koongarra in the Alligator Rivers region (NT); Olympic Dam and Beverley (SA); and Yeelirrie in Western Australia (WA). Exploration leading to the discovery in 2001of the Prominent Hill deposit (SA), was focussed on copper and gold. This deposit, like Olympic Dam, comprises low-grade uranium mineralisation associated with copper and gold and is within hematite-rich breccias. On present knowledge, it is much smaller and has lower uranium grades than Olympic Dam.

Despite the steady growth in mining and exports, expenditures on uranium exploration in Australia have fallen over the last 20 years (Fig. 9). Annual expenditures on uranium exploration reached a peak in 1980 of $35.0 million (A$105 million in constant 2003A$). During the late 1970s and early 1980s, up to 60 companies were actively exploring for uranium in Australia. Exploration was carried out in 'greenfields' areas as well as the known uranium provinces. Subsequently, expenditures declined, bottoming at $6.4 million in 2003, when only 5 companies were actively exploring for uranium in areas adjacent to known deposits, mainly in western Arnhem Land (NT), the Frome Embayment and the Gawler Craton-Stuart Shelf (SA). This long decline was interrupted by two brief periods of increasing expenditures following the discovery of the Kintyre deposit (Paterson Province, WA) in 1985, and the abolition of the 'Three mines' policy by the Commonwealth Government in 1996.

The decline in exploration expenditure resulted from several factors:

- Falling uranium prices over two decades;
- Restrictions in some jurisdictions on uranium exploration and production;
- Increasing availability of supplies from secondary sources (mainly highly enriched uranium stocks);
- Decreasing costs of production resulting from large-scale, low-cost mining in Canada and Australia.

Despite the paucity of discoveries since 1985, Australia's low-cost resources have continued to increase as a result of the delineation of resources at known deposits, mostly at Olympic Dam (Fig. 9).

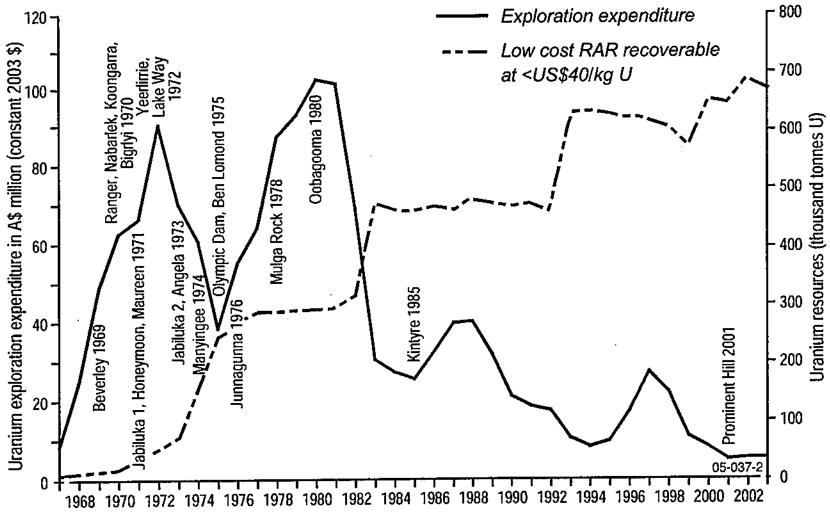

__Figure 9:__ Trends in uranium exploration expenditures, discovery of deposits and the increase in Australia's low cost RAR.

Uranium prices decreased progressively over more than two decades from 1979 up to 2003. Spot market prices fell from an average of US$42.57/lb U_3O_8 (US$110.67/kg U) in 1979 to an average of US$8.30/lb U_3O_8 (US$21.60/kg U) for 2002. Although the spot market represents only a relatively small portion of total annual uranium transactions worldwide (sales were approximately 10% of demand in recent years), it remains an important indicator of the uranium market as long-term contracts have become increasingly linked to spot prices. The majority of Australian exports are sold under long-term contracts that are now priced well below the current spot price. As contracts expire over the next few years, Australian exporters will be able to take advantage of much higher long term prices during the negotiation process.

Over the last few years spot market prices have more than doubled from around US$10/lb U_3O_8 (US$26/kg U) in early 2003 to US$26.25/lb U_3O_8 (US$68/kg U) in May 2005 (Ux Consulting Company, LLC). This increase was due to a number of factors including: decreases in secondary supplies (HEU) from the Russian Federation for sale on world markets, very high world oil prices, and temporary reductions in supply due to flooding of the McArthur River mine (Canada) and damage to the Olympic Dam metallurgical plant by fires in 2003.

These marked price rises in 2003 and 2004 have resulted in considerable increases in exploration activity and the number of small (speculative) exploration companies listing on the Australian Stock Exchange. Currently there are more than 20 companies exploring for uranium in Australia. Exploration expenditure increased modestly in 2004, and there are indications of larger increases for 2005.

2.2.3. Secondary sources of supply and impacts on uranium prices

Uranium is unique among energy fuel resources in that a significant portion of demand is supplied from secondary sources rather than mine production. Secondary sources include:

- Stockpiles of natural and low-enriched uranium, held by electricity utilities and conversion plants (up to 30% of current world demand). These were the legacy of over-production during the 1970s and 1980s (particularly in the former Soviet Union and USA). Early forecasts (during 1970s) of growth in nuclear electricity capacity were over-optimistic, and mine production increased in response to these forecasts. However, expansion of nuclear capacity worldwide was less than anticipated, resulting in a build up of stockpiles;
- Down blending of highly enriched uranium (HEU) from ex-military stockpiles in both the Russian Federation and the USA that have become available to commercial markets (10% of world demand);
- Re-enrichment of depleted uranium 'tails' – residual fissile material is recovered from depleted uranium tails at enrichment plants (3-4% of world demand);
- Uranium from reprocessing of spent reactor fuels (very small proportion of world demand).

Since 1990, mine production has accounted for less than 60% of annual world uranium requirements, with the balance of requirements (up to 40%) being met from secondary sources.

Uranium from secondary sources has had a significant impact on the market and it is anticipated that secondary sources will continue to play a major role in supplying commercial markets in the near future. The IAEA suggest that supplies of HEU will be exhausted by the year 2023 (IAEA, 2001).

Secondary supplies are sold at current market prices, rather than the original costs of production. Despite the importance of these secondary sources of uranium, there is uncertainty about the size of available stocks because many countries are unable (due to confidentiality requirements) to provide detailed information on stockpiles held by governments (ex-military stockpiles) and consumers.

In a significant development over the last few years, mine production in the Russian Federation has been insufficient to meet the country's growing demand for electricity generation. As a consequence, supplies of HEU (down blended) are currently being retained by the Russian Federation for domestic electricity generation rather than being sold on world markets.

2.3. ToR 3 Potential implications for global greenhouse emissions reductions from further development and export of Australia's uranium resources

The Kyoto protocol has led many countries, in considering possible means of reducing greenhouse gas emissions, to look towards nuclear power in their options for generating large amounts of electricity required to meet 'base load' demands. Given that it has some 40% of the world's known low cost uranium resources, it is very clear that Australia's uranium production will be needed to fuel nuclear power generation around the world in the foreseeable future.

The following is a summary of information which discusses the relative contributions of different sources of electrical power to greenhouse gas emissions. This is drawn from information gathered by a major electricity utility company, Electricite de France, which is involved in electricity generation using various fuel types and operates a large number of nuclear power stations in France, and from the Uranium Information Centre (http://www.uic.com.au).

Areva (2004) reports on Life Cycle Analysis studies that were undertaken by Electricite de France (using ISO 14040) to determine the amount of greenhouse gasses emitted by various types of electricity generation and various types of fuel. The company is one of the world's largest generators of nuclear electricity with leading expertise in this area. The results are set out in Table 8, where they are reported in grams of CO_2 equivalent per kilowatt hour of electricity, from 'cradle' (production of fuel) to 'grave' (waste disposal and decommissioning). These figures typify the situation in France and some other European countries. The results show that for nuclear electricity there are no emissions of greenhouse gasses during the operation of electricity generation and that emissions for the whole life cycle for nuclear power are low (5g CO_2 equiv. per kW hour). In contrast, emissions from coal, fuel oil, gas turbine and diesel power generation are much higher for the operation of electricity generation and for the whole of life cycle

The Uranium Information Centre supports the very low whole of life emissions of greenhouse gases from nuclear plants, putting this at about 20 g CO_2/kWh on average. The whole of life emission rate for nuclear power plants in France (5g CO_2 equiv. per kW hour) is lower than the average for other countries (20g CO_2 equiv. per kW hour) because nuclear electricity is used in the enrichment plants which fabricate uranium fuel, whereas in other countries these fuel fabrication plants use electricity from coal-fired power stations.

Table 8: Greenhouse gas emissions for different sources of electricity generation and various fuel types. Data are typical for France and other European countries (Source: Electricite de France, reported in Areva, 2004).

Energy source	**Operation** grams CO_2 equiv. per kW hour	**Remainder of Cycle** grams CO_2 equiv. per kW hour	**Total** grams CO_2 equiv. per kW hour
Coal 600 MWe	892	111	1 003
Fuel oil	839	149	988
Gas turbine	844	68	912
Diesel	726	159	895
Hydro-pumped storage	127	5	132
Photovoltaic	0	97	97
Hydroelectric	0	5	5
Nuclear Energy	0	5	5
Wind generation	0	3	3

Geoscience Australia notes that whole of life emissions will vary somewhat depending on circumstances. For fossil fuel power plants these include transport distances and gases emitted during production. For nuclear, the kind of enrichment process used is a variable. Overall we consider that the assessments above provide a reasonable indication of greenhouse gas emissions from 'cradle to grave'.

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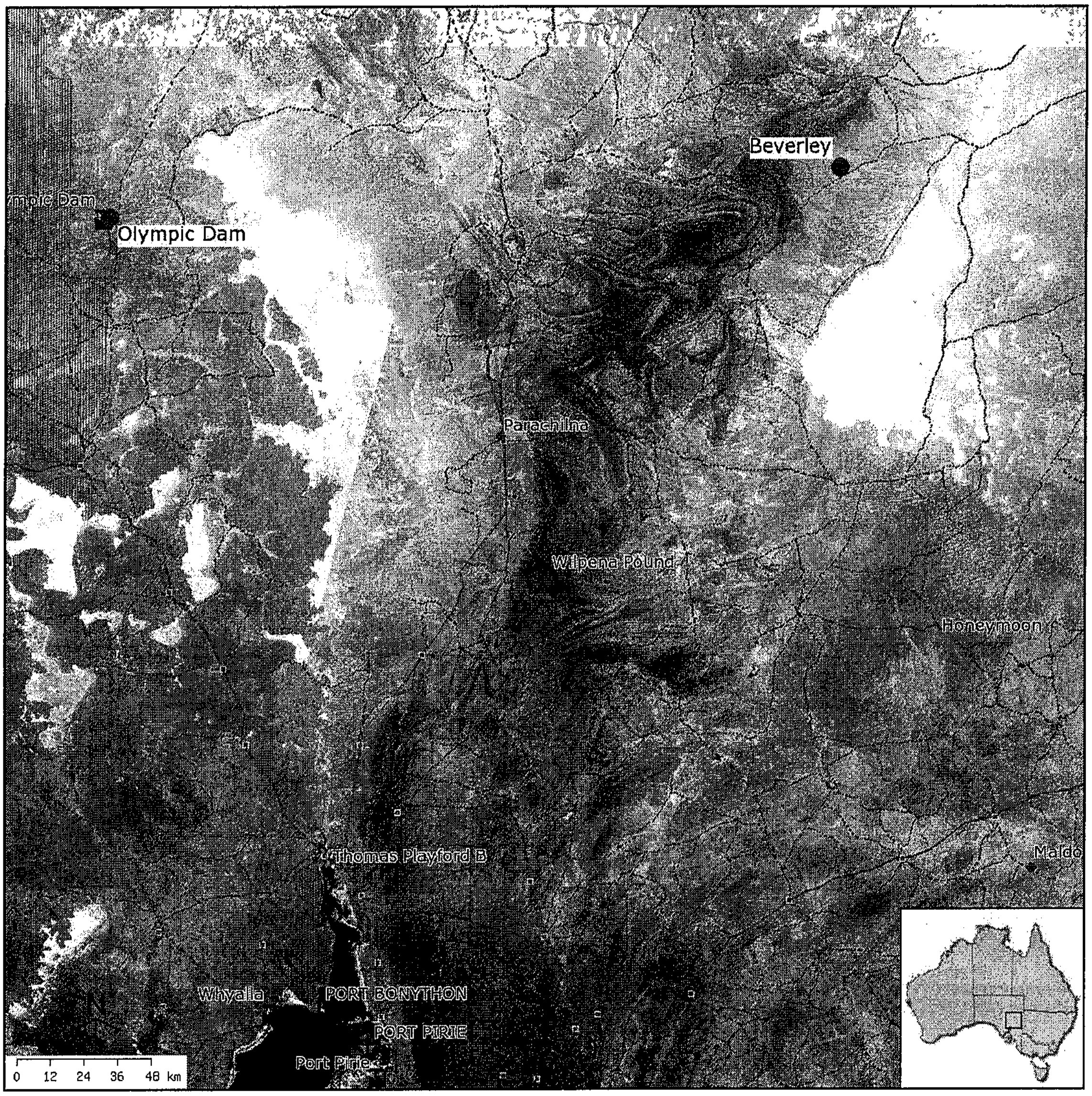
APPENDIX: Images of Australian uranium mines created from the Australian Atlas of Mineral Resources, Mines & Processing Centres.

The Australian Atlas was developed by Geoscience Australia with support from the Commonwealth Department of Industry, Tourism and Resources (Regional Minerals Program) and the Minerals Council of Australia. http://www.australianminesatlas.gov.au/

www.**australianminesatlas**.gov.au

Olympic Dam and Beverley uranium mines



Projection: Lambert Conformal Conic (Central meridian:134; Standard parallels:-18,-36; Datum:WGS84) Map centre: 138.6°E, 31.461°S

- Operating mine
- Processing centre
- Port

Power station - Fossil fuel
- Operating
- Proposed/Under construction
- Closed/Not operating

Power station - Renewable energy
- Operating
- Proposed/Under construction
- Closed/Not operating

- Major projects
- Railroad line
- Railroad yard
- Primary road
- Secondary road
- Minor road
- Prohibited Areas

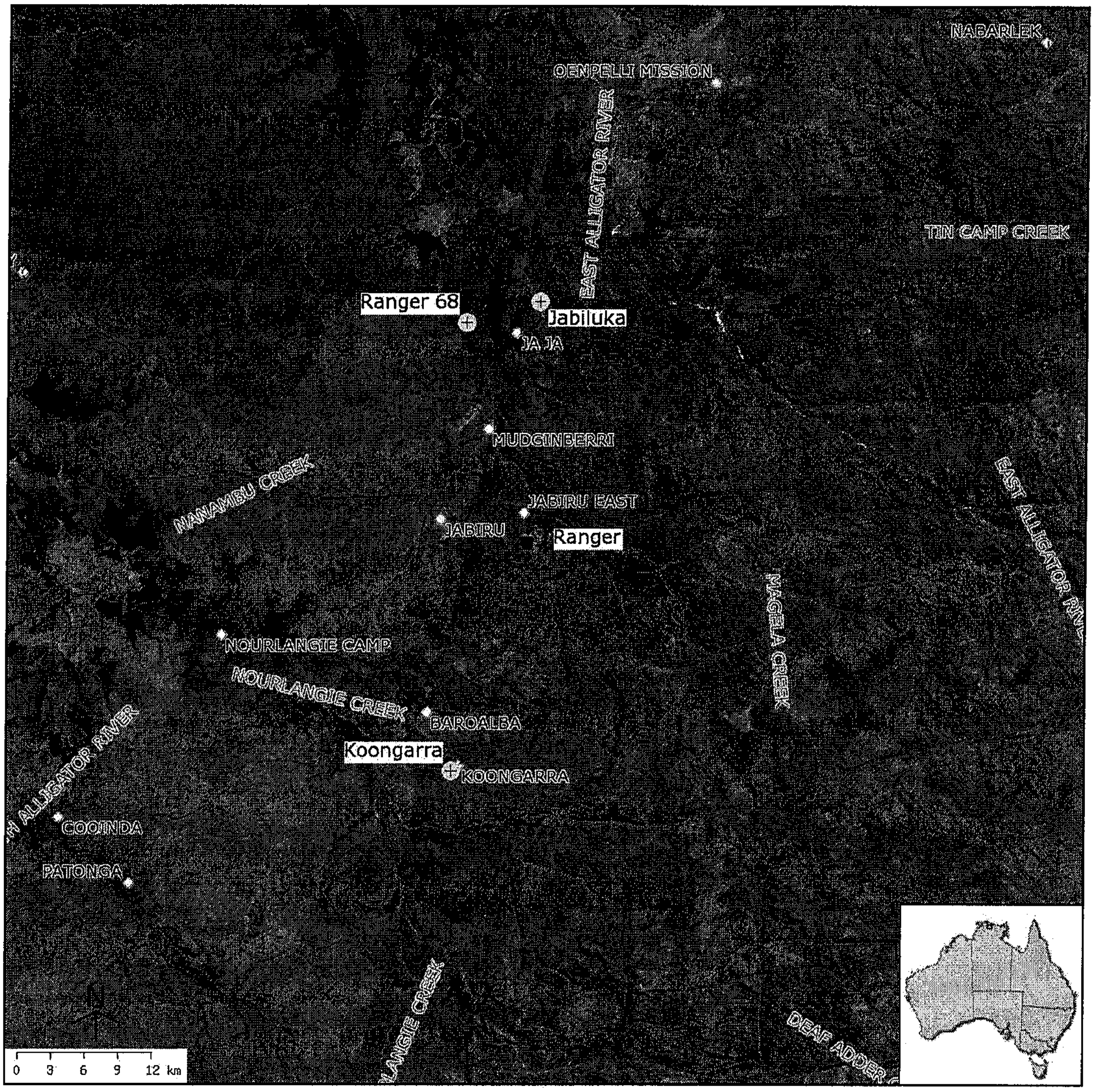
Landsat 7 (2000)

Australian Government
Department of Industry Tourism and Resources
Geoscience Australia

Minerals Council of Australia

www.**australianminesatlas**.gov.au

Ranger, Jabiluka & Koongarra U deposits



Projection: Lambert Conformal Conic (Central meridian:134; Standard parallels:-18,-36; Datum:WGS84) Map centre: 132.918°E, 12.692°S

- Operating mine
- Mineral deposit
- Coastline
- Canal
- Built up areas

Watercourse

- Perennial
- Non-Perennial, Fluctuating

- Railroad line
- Railroad yard
- Primary road
- Secondary road
- Minor road
- Population centre

Landsat 7 False Colour

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