ANNUAL REPORT E24451

NGALIA REGIONAL PROJECT

PERIOD ENDING 6 FEBRUARY, 2006

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SUMMARY

Exploration License E24451 is part of the Ngalia Regional Project and is located 200 kilometres (by road) northwest of Alice Springs. The Ngalia Regional Project is 100% owned and operated by Energy Metals Limited. The Bigrlyi Project located ~ 150kms along strike to the west northwest, is a Joint Venture between Energy Metals Limited with 53.3% (operator), Valhalla Uranium (a subsidiary of Paladin Resources Ltd) with 41.7% and Southern Cross Exploration NL with 5%. The Bigrlyi camp and core yard faculty is used to support the entire Ngalia Regional Project.

The Malawiri Prospect is located in the southeast of the Ngalia Basin, on E24451 approximately 200 kilometres northwest of Alice Springs. Exploration was carried out on the Malawiri Prospect between 1978 and 1982 in a Joint Venture between Central Pacific Minerals, Urangesellschaft GmbH and AGIP, following discovery of the Minerva uranium deposit by AGIP along strike.

Uranium mineralisation was discovered at Bigrlyi by a joint venture managed by Central Pacific Minerals (CPM) in 1973 which occurs to the west northwest of E24451. In the period 1974 to 1982 the project was subject to several major drilling campaigns, with some 413 holes (total 37,500m) completed. Subsequent to 1982 CPM completed metallurgical testing and resource calculations, with a global resource of 809,000 tonnes at 3.43 kg/t U₃O₈ for 2,770 tonnes of contained U₃O₈ delineated at Bigrlyi (note that these resources are not JORC 2004 compliant). Field activities conducted in the period 1983 to 2004 were limited to maintenance of the core shed.

In May 2005 Energy Metals acquired a 53.3% interest in, and assumed management of, the Bigrlyi project through the purchase of the interests of CPM and Yuendumu Mining Company NL. In September 2005 Energy Metals listed on ASX after raising $3m, primarily to fund exploration at the Bigrlyi and Ngalia Regional Projects.

Exploration undertaken in the period 06 February 2006 to 06 February 2007 included:

- Re-establishment of the exploration camp
- Review/compilation of historical data
- Converting historic data to digital format
- Surface prospecting and mapping
- Exploration planning/logistics
- CLC exploration notifications/negotiations

Expenditure for the period was approximately $63,524.
INTRODUCTION

The Ngalia Regional project comprises ten 100% owned exploration licences (total area 2,840 km²) located in the Ngalia Basin, between 180 and 350 km northwest of Alice Springs in the Northern Territory (Figure 1 & 2). Seven of these tenements are contiguous and enclose the Bigrlyi project as well as containing a number of uranium occurrences including the Malawiri prospect (EME 52%) and the Walbiri prospect (EME 42%). The remaining 3 applications cover discrete uranium anomalies located southwest of the Bigrlyi deposits.

Figure 1: Location of the Bigrlyi/Ngalia Regional Projects (NT).
Figure 2: Granted Tenements of the Bigrlyi/Ngalia Regional Projects (NT).

Four exploration licences, including E24451 enclosing the Bigrlyi project, were granted in the March 2006 quarter, with E24807 granted in August 2006.
PREVIOUS WORK

Bigryli and Ngalia Regional Projects

Exploration on the Ngalia Regional and Bigryli Projects commenced in August 1971 with the granting of Authority to Prospect (A to P) 2677 valid for one year. This A to P was converted to Exploration Licence 605, and renewed annually to October 1977. Exploration on this property was managed by Central Pacific Minerals NL on behalf of various joint venture partners including Magellan Petroleum Australia Ltd, Agip Nucleare Pty Ltd, Uranegesellschaft mbH & Co. and the Atomic Energy Commission.

The Malawiri Prospect was identified in 1978 and is located in the southeast of the Ngalia Basin, on E24451 approximately 200 kilometres northwest of Alice Springs. Exploration was carried out on the Malawiri Prospect between 1978 and 1982 in a Joint Venture between Central Pacific Minerals, Urangesellschaft GmbH and AGIP, following discovery of the Minerva uranium deposit by AGIP along strike.

The Joint Venture drilled a total of 20 pre-collared diamond core holes testing a concealed portion of the Mount Eclipse Sandstone, south of the Yuendumu to Alice Spring Road, close to the southern boundary of the Ngalia Basin.

Drilling between 1979 and 1982 was carried out on seven sections and uranium mineralisation was intersected on 3 of the sections, in 8 separate holes. The mineralisation is usually present in multiple narrow intervals with the uranium present as uraninite. The depth to the bedrock Mount Eclipse Sandstone below Cainozoic cover rocks is typically between 104 and 122 metres in depth and future exploration will be of necessity drill intensive.

In 1977 the Minerva Deposit was discovered by AGIP, which is excised from E24451. The area was mapped at 1:250,000 scale by the BMR during 1968-69. Reconnaissance gravity and seismic surveys were carried out by the BMR during 1965, 1969 and 1970. Magellan Petroleum carried out gravity surveys over parts of the Ngalia Basin during 1971-72. Agip’s exploration activities commenced in 1977 with a program of geological mapping, ground radiometric surveying, resistivity surveying, groundwater analysis and stratigraphic rotary drilling (35 holes for 3,468.95m) and percussion drilling (13 holes for 1,372m), with ancillary downhole geophysical logging (over a total depth of 4,589m).

During 1978, stratigraphic and follow-up drilling programs were undertaken, with 8,751.89m of rotary drilling completed in 74 holes and 1,148.9m of diamond drilling completed in 15 holes. Ancillary activities included downhole geophysical logging, carried out over a total depth of 10,452.7m.

Elsewhere in the Ngalia Basin exploration on the project area involved airborne radiometric surveys in 1972 and 1974, radiometric ground traversing and geological mapping. The Bigryli Prospect was found in 1973 and in 1974 mapping and trenching located uranium mineralisation at a number of the 16 anomalies now comprising the Bigryli Project. These anomalies occur intermittently over a 11.5 km strike length within the Treuer Range and south of prominent strike ridge formed by the Vaughan Spring Quartzite.

The northern margin of the Ngalia Basin and the Arunta Inlier basement to the north have been the focus of substantial regional exploration since the discovery of uranium mineralisation in the region.
in the early 1970’s. Exploration has been for a wide variety of mineralisation, particularly uranium, in both the Ngaila Basin sediments and the Arunta Inlier granites and metasediments and for diamonds, gold and base metals in the Arunta Inlier.

The following summaries the more significant programmes of exploration for uranium near to or along the northern margin of the Ngaila Basin covered by Energy Metals exploration licence E24533.

In 1976 a mapping and radiometric survey was undertaken by CPM which covered ~ 6km of strike length of the Lower Mt Eclipse Sandstone over the eastern part of E24533. Shallow percussion drilling ~ 20m depth was undertaken to test previously identified Track Etch anomalies (AUPH1-9) No anomalous radioactivity was identified from this program.

In 1979 Afmeco Pty. Ltd. carried out a programme to test the extent of uranium mineralisation in the basal unit of the Mount Eclipse Sandstone at the Dingo’s Rest North and Dingo’s Rest South uranium prospect. Dingo’s Rest is located approximately 20 kilometres southeast of the Bigrlyi uranium deposit and extends over a 3 kilometre north-south striking basal section of the Mount Eclipse Sandstone. Afmeco drilled, 8 percussion (2,504.1m) and 9 diamond core holes (4,153.1m) within an area 3 kilometres by 6 kilometres, westerly and down-dip from Dingo’s Rest. The best result recorded by Afmeco was recorded in hole DIN12 where from 312.8m to 313.4m a mineralised sediment assayed 1,760ppm uranium and 1,130 ppm vanadium. Three holes were also drilled on E24533 to explore for uranium mineralisation in the basal sandstone with a best result of 100cps over an ~ 2.5m interval from 51.0m.(Hole number 01/01/1328)

In 1990 Lachlan Resources Limited carried out a drainage geochemical survey of 313 samples over the basal sector of the Ngaila Basin and immediately underlying Arunta Inlier rocks from the Dingo’s Rest location north and westerly to Waite Creek, a distance of approximately 100 kilometres. Samples were analysed for copper, lead, zinc, arsenic, silver and gold. Four weakly anomalous areas were located.

In 1999 Rio Tinto Exploration reported on the results of a 3 year programme undertaken on a 1,497 square kilometre exploration licence that covered the northern flank of the Ngaila Basin and extended over the Arunta Inlier to the north. The tenement covered the Bigrlyi Project and the Dingo’s Rest Prospect.

Rio Tinto concluded that their Anomaly 44 was the only anomaly containing visible secondary uranium mineralisation, as torbernite, which was concentrated along the contact between granite and a quartz vein, with a semi-continuous anomalous zone over 1 kilometre. Sampling of the sporadic high grade zones returned a maximum of 3.95 kg/tonne uranium. Rio Tinto concluded that the potential for a large, high-grade, continuous zone of mineralisation was very low.

**WORK COMPLETED FROM 6^TH FEBRUARY 2006 TO 6^TH FEBRUARY 2007**

**Site Works**

Reference is made to the Bigrlyi Project due to its location (west northwest along strike of E24451 and the fact that the Bigrlyi Project is the location of the field base, coreyard/sampling facility and camp used to service E24451. All available core and remaining drilling samples that was possessed by CPM are contained within the Bigrlyi core yard or has been removed.

Rehabilitation of the core shed area continued during the period. A security fence was erected around the area and safety placards posted in prominent positions. A 25 person exploration camp
comprising caravans and transportable units was established adjacent to the core shed, with both the core shed and camp plumbed to septic tanks. Ducted electrical wiring was also installed during the period. Scoping, budgeting, planning and sourcing equipment for intended work was undertaken during the period.

**Validation & Digitisation of Historic Data**

Energy Metals received the first tranche of exploration data from previous managers CPM (mainly comprising geological plans and the drillhole database referred to above) in May 2005. These data were reviewed, 1:2,000 scale geological plans were scanned and digitised and GDA coordinates for a number of holes were located in the field using a conventional GPS (accuracy 5-10 metres), enabling historical data (local grid base) to be merged with previously acquired regional datasets.

Most data captured was related to the Bigrlyi prospect with the regional geophysical datasets compiled for E24451. The remainder of the data compilation has been sorting through numerous reports and identifying key data sets for digitising. Over 300 hardcopy reports, drawings and plans including geophysical logs have been sorted and catalogued for future digitisation. Compilation of a drillhole and assay dataset for the previous exploration work is partially completed. Sorting of all available maps and reports have been completed in a comprehensive library of material that includes most work done on the tenement E24451.

Compilation and planning/budgeting of the geological datasets occurred during the period. Formulation of local geological models based on data from the neighboring Minerva/Malawiri prospects and the CPM hardcopy geological database was also undertaken. Digitising of all field data is incomplete and the work will be continued in 2007.

**Mapping and Surveying**

Limited prospecting was undertaken to confirm previous mapping results and to gain a better understanding of the local prospect geology/terrain with a view to logistics and work planning for exploration programs scheduled for 2007. Field logistics of operating on the tenement was examined including, condition and location of major access routes for heavy vehicles, logistics in operating in locations close to population areas, logistics in relation to potable, drilling and ground water use/contamination. Scoping, budgeting, planning and sourcing equipment for intended work was undertaken during the period. Significant access clearance will be required for future work and this will be done via a staged program of grading and road building in conjunction with other areas of the Ngalia Project Area.

Detailed ground clearance reports have been submitted to the CLC for Aboriginal Heritage clearance to particular areas for drilling. It is expected that further ground clearances will be completed by the traditional owners in conjunction with the CLC to approve drilling programs on E24451.

The first sediments deposited in the basin were those of the Late Proterozoic Vaughn Springs Quartzite. Marine and continental sedimentation continued until the Late Devonian – Early Carboniferous deposition of the uranium prospective Mt Eclipse Sandstone. The Mt Eclipse Sandstone comprises a thick sequence of non-marine, synorogenic sandstone and shale, deposited in piedmont and sub-aerial deltaic environments. On E24451 the Mt Eclipse Sandstone is widely covered by thick Tertiary and Quarternary deposits.
The prospective Mt Eclipse Sandstone has been divided into geochemical facies on the basis of post depositional alteration characteristics as follows:

- Silcrete and minor ferricrete
- Pallid zone, strongly kaolinised with rare limonite
- White (reduzate) facies – fresh. Rocks contain pyrite, carbon, fresh feldspar and minor chlorite
- White (reduzate) facies – weathered. Rocks contain kaolinite nad limonite
- Mottled red facies – fresh. Red facies, with reduzate mottles, containing haematite, chlorite and feldspar
- Mottled red facies – weathered. Red facies, with reduzate mottles, containing limonite, haematite, chlorite and kaolinite
- Transitional facies – fresh. Rock contain chlorite, haematite, pyrite, carbonaceous matter and feldspar
- Transitional facies – weathered. Rocks are comprised of interbands of weathered red and reduzate facies, and contain haematite, limonite, chlorite and kaolinite
- Red facies – fresh. Rocks contain haematite and feldspar
- Red facies – weathered. Rocks contain limonite, haematite and kaolinite.

Interpretations of the results of past gravity and aeromagnetic surveys over the Ngalia Basin, and of the results of Agip’s stratigraphic drilling programs, indicates that the Basin is composed of a number of en echelon horst and graben structures.

Regional Geophysics Datasets

Early exploration on the property involved airborne radiometric surveys in 1972 and 1974, radiometric ground traversing and geological mapping. This work resulted in the discovery of The Bigrlyi Prospect in 1973, and in 1974 mapping and trenching located uranium mineralisation at 16 anomalies now comprising the Bigrlyi Project. Existing geophysical mapping has been acquired and re-imaged and plans for Hoist-EM trials are well advanced. Refer Figure 3 and 4. During the period a major geophysical interpretation study incorporating E24451. This survey is designed to assist with targeting areas for drilling follow up in the 2007 season. The geophysical interp will incorporates 1:100,000 regional interpretations and local areas of 1:50,000 and 1:25,000. The estimated cost of the geophysical work is greater then $70,000 and a pre-payment was made of $31,360 was made to ensure the work would get completed. Unfortunately due to late scheduling the results of the exercise are outstanding and is now scheduled for completion in the march quarter with follow-up drilling in the June quarter.
Figure 3: E24451 and Re-imaged Total Count Regional Radiometrics
Radiation Monitoring and Audit

Radiation expert Mark Sonter was engaged to undertake an audit of the Bigrlyi project (in particular the core shed and surrounding area, and to provide specialist advice on radiation management. Early November 2005 Mr Sonter conducted a site visit and installed monitoring equipment and inducted field personnel as well as preparing a Radiation Management Plan (RMP) outlining procedures to minimise radiation risk at Bigrlyi. Work done on E24451 is conducted under guidelines set out in the Radiation Management Plan. (See Appendix 1)
Commodity Prices

The spot market price for uranium continued to rise during the year. The Restricted U$_3$O$_8$ spot price was US$63.00/lb at the end of November 2006, rising from US$34.50/lb in late November 2005 (Figure 2). Despite the value of the Australian dollar increasing from US$0.74 to US$0.78 over the same period, the A$ price of uranium increased from A$46.60/lb to A$80.87/lb.

On the other hand vanadium pentoxide prices fell significantly during the period, from an average price of US$20.60/lb in the 6 months to 30 June 2005 to US$6.40/lb late November 2006. Market observers note that the fall in price was in line with demand from the steel industry where some producers switched to cheaper substitute material such as ferro-niobium.

Figure 5: Restricted U$_3$O$_8$ prices from January 2004 to November 2006.

Figure 6: V$_2$O$_5$ prices from December 2005 to November 2006
WORK PROPOSED FOR 2007

Work to be commenced in the first quarter of 2007 will comprise the following:

(i) Analysis of exploration results from the period to 6th February 2007/development of local geological/geophysical models for E24451 and surrounding tenements in the Ngalia Regional Project;
(ii) Review of outstanding geophysical interpretations at various scales and conduct target generation work prior to drill program budgeting;
(iii) Scoping, budgeting, planning and sourcing equipment for prospecting, geophysical surveys, drilling and sampling;
(iv) Continued digital data capture of historic exploration mapping and drilling;
(v) Geochemical Aircore and/or RC drilling and sampling for uranium, vanadium and other elements;
(vi) Analysis of geological and ground water models to assess exploration strategy and implications;
(vii) Liaison with local Aboriginal groups to implement community work programs for Energy Metals Limited;

It is anticipated that exploration expenditure on E24451 for the year ending 06 February 2008 will exceed $65,000.
REFERENCES


Freeman, M.J., Shergold, J.JH., Morris, D.G. and Walter, M.R., 1990. Late Proterozoic and Palaeozoic basins of Central and Northern Australia – Regional geology and


Appendices

Apendix 1

Radiation Management Plan
RADIATION MANAGEMENT PLAN

Bigryli Uranium Project

Energy Metals Ltd

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Version1, 3-10-05
INTRODUCTION -- DESCRIPTION OF PROJECT AND REASON FOR RMP

Energy Metals Ltd is investigating the Bigryli uranium prospects on leases west of Alice Springs, first investigated in the early 1980s. The uranium grade of core samples from these prospects averages 0.35% U$_3$O$_8$ with some samples going over 1%. For comparison, uranium in ordinary soil averages about 3 parts per million (ppm), and U is up to about 30 ppm in some granites. Uranium ores range from 0.03% (300 ppm) up to a few percent.

Energy Metals is intending to carry out an ongoing drilling program, using both RC percussion and diamond core drilling, to prepare JORC-compliant resource data. Old core will be split at a refurbished on site core store for pulverizing and assay at an offsite facility.

When drilling and handling samples of mineralization containing uranium, workers are potentially exposed to radiation. Corporate ‘duty of care’ and risk management therefore indicate the need to monitor radiation levels, and manage radiation using proper control measures so as to minimize workers’ doses. It is also important to control and contain spills and releases, which could cause contamination of the environment, and to avoid release of radioactively contaminated items and equipment from worksites before they have been cleaned.

This document describes the proposed Radiation Management Plan (RMP) for control of radiation at Bigryli. This RMP has been prepared to fulfil NT DBIRD requirements that radiation be addressed in the formal Exploration Operations Management Plan, and bearing in mind the more general requirements of the Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing recently released by ARPANSA, the Australian Radiation Protection and Nuclear Safety Agency. The Regulations and Code apply to exploratory excavations, including drilling activities. In addition, the Code of Practice for Safe Transport of Radioactive Materials 2001 is relevant for regulating the transport of samples to prep and analytical laboratories.

Compliance with the RMP will ensure that good practice is established, and give assurance to Energy Metals, to its contractors and workers, and to the regulators, that appropriate controls are in place.

During drilling activities and sample prep, radiation monitoring will be carried out so as to provide data for radiation dose calculation and control, and to provide feedback to workers, management, and the regulatory agency. This data will also give input to future feasibility and E.I.S. studies.

Radiation monitoring needs to collect data relevant to several pathways for delivery of dose to the human body, namely, (i) direct gamma irradiation from radiation-emitting materials (in this case, core samples and drill cuttings); (ii) inhalation of airborne radionuclides (in this case, airborne dust containing uranium and its radioactive daughter atoms, and - less importantly - radon daughter atoms in the air); and (iii) dose from
ingestion of radionuclides in any dust which has been collected on hands and transferred to mouth when eating or smoking.

**WORKFORCE**

The work force for the near term exploration and resource estimation activities program will be variable, but probably average out at no more than 10 personnel on a fulltime basis. Site supervision for compliance with this Plan will be provided by the Project Site Geologist, following training by the Radiation Consultant (Mark Sonter).

**Radiation Dose Delivery Pathways**

Uranium is the ‘parent’ of a series of radioactive elements which emit alpha, beta, and gamma radiation. The Uranium Decay Chain is shown in the Radiation Safety Manual (see attached). There are four possible pathways for delivery of radiation doses to the human body that should be considered in mining industry situations, and that may require active control, depending on the circumstances. They are:

- Direct irradiation by gamma radiation from mineralised cuttings, core or sludges. (This is only significant if long periods are spent close to large masses of relatively high grade ore.)
- Inhalation of radon progeny (radon daughters).
- Inhalation (of airborne ore dust or tailings dust containing long-lived alpha-emitting uranium, thorium, and radium).
- Ingestion (of radioactive contamination such as ore dust transferred from hands to mouth when eating or smoking).

Radiation dose control therefore requires (a) dust minimization and if necessary, use of respiratory protection; (b) good housekeeping and personal hygiene; and (c) planning to ensure that there are no major quantities of gamma-emitting materials which arise on the surface.

**Radiation Dose Control methods – equipment, facilities, procedures**

Gamma radiation does not generally require any active control measures, but it will be monitored by survey meter, and personal doses will be measured using radiation (TLD) badges, as described below and the results reported as described below. With intermediate to high grades that can be occasionally encountered at Bigryli, we expect badge results will show doses in the order of 300 microsieverts or so per 3 month wearing period.

Radon progeny (radon daughters) in air do not require active control other than in underground mines and exploration shafts and adits, and other enclosed spaces requiring active ventilation. There will be no specific control requirements for radon progeny on these prospects.
Airborne long lived alpha emitters in dust (airborne dust dose) will be controlled by dust minimization equipment (e.g. dust extraction systems where appropriate) and work practices (e.g. use of wet rather than dry methods for cleaning of work areas), and by use of respiratory protection (dust masks) as necessary, this being determined by monitoring results. As in all uranium mining and exploration activities, control of airborne ore dust is important. Any RC drilling in ore intersections above the water table will probably require use of respiratory protection, such as disposable P1 or P2 type dust masks. RC sample riffling will definitely require dust respiratory protection. Core cutting and sample handling will also need consideration of dust control measures. Monitoring results will give the information necessary to decide control measures.

Ingestion of radioactive material will be prevented by maintaining proper levels of workplace and personal cleanliness, and by requiring washing of hands before mealbreaks. Monitoring will be carried out to check on worksurfaces, desks, tables, and skin contamination levels.

**Radiation Monitoring Program**

Radiation monitoring will be carried out so as to provide data for radiation control and for personal dose estimation, and to give feedback to workers, management, and the regulatory agencies. This data will also be relevant to any future Feasibility Study and Environmental Impact Statement.

The radiation monitoring program will address gamma radiation, long-lived alpha emitting radionuclides in airborne dust, radon daughter exposure, and surface contamination. All results will be made available to the workforce as they become available, and will be collated into a formal report for the management and the regulatory agencies.

Gamma radiation monitoring results will only be enhanced above local background where core is present, or where bulk quantities of material originating from the ore zone(s) are collected and stored. In these areas, gamma surveys will be performed. Doserrates will generally be very low, because of the small quantities exposed. However, workers handling sample bags and core trays will receive measurable doses (probably in the range 200 to 400 microsieverts per quarter, for Bigryli ore). Personal dosimeters (TLD badges) will be sourced from ARPANSA as a commercial service and will be issued to drillers and their offsiders, and others handling ore (geologists sample prep workers, etc). Results from gamma surveys will be communicated to the workers, at the time, and will be recorded in the Radiation Logbook, and subsequently reported by a formal report to management and the regulatory agency. TLD badge results will be reported to workers.

Radionuclides in airborne dust will be monitored in short campaigns using a personal air sampler for shift-average assessments. The intent is to take an adequate number of shift samples so as to obtain a statistically sound average, and to repeat this campaign at six monthly or yearly intervals. The filters from the personal air sampler will be counted in an alpha drawer assembly to determine the shift-average concentration of airborne alpha-emitters. This data will help decide the need (or otherwise) for respiratory protection. Results will be recorded in the Site Radiation Logbook.
Limited radon daughter (radon progeny) monitoring will be carried out in a single short campaign so as to obtain indicative figures for local background and its variability. Enhanced natural background levels occur in still-air, atmospheric inversion layer conditions, which may be apparent in some early morning readings. These sample results will really only be giving environmental baseline data and are to be interpreted as such. Results will be recorded in the Site Radiation Logbook.

Surface contamination monitoring will be performed using a large area alpha contamination probe. This will be used to check work surfaces, tables and desks, ablutions area, and opportunistically, workers’ hands, clothes, etc. Results will be recorded in the Site Radiation Logbook (see below).

**Dose Assessment**

At completion of the program, or on a yearly basis if the program continues, an assessment of workers’ doses will be carried out by the Radiation Consultant. This will add TLD badge results from ARPANSA, and airborne dust sampling results, averaged by work category and adjusted for the individual worker’s total number of shifts on site, according to the formula:

\[
\text{Dose} = \text{‘dust dose’} + \text{gamma dose}, \text{or:}
\]

\[
\text{Dose} = (\text{average } \alpha\text{dps/m}^3 \text{ for job} \times \text{DCF for U ore (}\mu\text{Sv/}\alpha\text{dps) } \times \text{hrs on job} \times 1.2 \text{ m}^3/\text{hr}) + \text{TLD (}\mu\text{Sv)}
\]

Where DCF = Dose Conversion Factor, given in the Code as 3.5 \(\mu\text{Sv/}\alpha\text{dps} \) for \(5 \mu\text{m AMAD dust particle size} \), and 1.2 \(\text{m}^3/\text{hr} \) is assumed breathing rate.

It is expected that doses will be small, and well below annual limit for workers (20,000 microsieverts), based on the Radiation Consultant’s past experience in similar circumstances.

**WASTE MANAGEMENT AND CONTROLS**

The main requirement to minimize impact on the environment is to limit dispersion of radioactive materials. Thus we will seek to contain mineralized drill cuttings to the extent reasonably practical. In diamond core drilling, the cuttings will be trapped in the drill site sump, and buried to a depth of 20 cm to minimize dispersion, after drying out. In RC drilling, essentially all cuttings are captured via cyclone and bagged.

Core cutting will generate sludges which must be captured and disposed of in a controlled way.

Mineralization excess to sampling needs, spillage, sludge from core cutting, and wastes from sample prep activities, will be disposed of by burial in one or more specially designated costeans or pits within the mineralized areas. These costeans will be located by GPS and recorded.

"Gatehouse control" – equipment contamination clearance
Any equipment, large or small, leaving site must be washed and checked and only released after it is certified clean and uncontaminated. Certificates will be issued for items which are permanently leaving site, such as hire equipment items being returned to owners, and departing drill rigs. These clearances are essential both for minimization of spread of contamination and to provide defensive evidence in case of assertions of release of contaminated equipment by antinuclear critics. All clearances must be recorded in the Site Radiation Logbook.

NOTHING WHICH HAS BEEN IN THE GROUND OR ON DRILL RIG OR IN CONTACT WITH CORE OR CUTTINGS MAY LEAVE THE SITE WITHOUT A CONTAMINATION CHECK AND SIGNED CLEARANCE CERTIFICATE.

PERSONAL HYGIENE CONTROL

Workers will be instructed to wash hands and face before meal breaks and before smoking. Workers should also shower and change at the end of shift.

If a worker’s skin shows contamination, DO NOT DAMAGE THE SKIN BY EXCESSIVE SCRUBBING. If the contamination will not come off easily with soap and water and a soft cloth, then the correct thing to do is to cover with a band-aid, and rewash and recheck daily. Gradually the contamination will sweat out, or slough off with dead skin cells.

Worker Inductions and training

All workers will be given a Radiation Safety Induction briefing shortly after arrival on site and will be issued with a Radiation Safety Manual. Records of Inductions will be kept, along with a signed receipt for the Manual. A copy of the Radiation Safety Manual is given as an Appendix to this Plan.

Periodical further radiation safety briefings will be given as the occasion arises, e.g., as Toolbox Meeting topics, e.g., to reinforce personal monitoring, dust control, spillage control, or site clearance control measures. These Periodical Briefings will be recorded in the Radiation Logbook.

Transport requirements

Sample material is transported to laboratory and to permanent storage via road. In this, the Project will comply with the Code of Practice for Safe Transport of Radioactive Materials 2001, which is referenced in the Australian Dangerous Goods Transport Code and the WA radiation control legislation. The Code sets out rules for (i) labelling of packages containing radioactive materials; (ii) placarding of vehicles which transport them, and (iii) issue to driver of Consignor’s Certificate describing the material being transported. Packages giving less than 5 $\mu$Sv/hr on the external surface may be transported as an ‘Excepted Package, UN2910’; this allows them to be sent without package labelling or vehicle placarding as “Radioactive”. Checking of these readings will be by the Site Geologist and recording will be in the Site Radiation Logbook.

STORAGE AND SIGNAGE
Designated holding areas and permanent storage areas for chip or core or bulk samples and sample residues will be fenced locked and signposted.

**Recordkeeping and Reporting**

All radiation monitoring results will be recorded and reported, both to workers and management, and to the regulatory agency, viz., NT DBIRD. All radiation records will be kept in a bound hardcopy Site Radiation Logbook, maintained by the Site Geologist.

The report will be made via a formal review document at the end of the drilling program, and within 3 months of program completion. The report will give workers’ dose estimates and will review the overall radiation management plan, the doses received, and the adequacy of the control procedures which were implemented.

**RADIATION PROTECTION RESOURCES**

The necessary monitoring equipment will either be purchased directly, or may initially be hired from Radiation Advice & Solutions P/L. (Principal, Mark Sonter). The monitoring program will be set up and the initial measurements will be performed by M. Sonter, the consultant Radiation Safety Advisor, with subsequent measurements performed by the Site Geologist following training.
Appendix: Monitoring and Instruments

Gamma Surveys:

When using gamma survey meter, always check battery first. Then check natural background, away from known sources. For natural background you should get a reading (anywhere in Australia) in the range from less than 0.1 to more than 0.2 microsieverts per hour ($\mu$Sv/hr). Scintillometer readings in counts per second depend on the instrument sensitivity and settings.

Always keep the beta window closed or beta attenuation cap on. Use S (slow) setting for best readings. Allow enough time to estimate the average rate from the meter fluctuations. General work area and environmental readings are to be taken at waist height. Record readings in the Site Radiation Logbook.

Surface (Alpha) Contamination:

The alpha probe will only give accurate reading when within one cm of the surface being checked. (Remember alpha particles have a maximum range in air of only 2.5 cm, or so.)

Before using surface contamination probe, check that it reads zero when ‘looking at air’, indoors (see comments below). Do ‘operability check’ using a gas lamp mantle. Record both results.

Surface contamination readings should be taken weekly at: work areas (e.g., on workbenches); office (e.g., on floor at door, under desks, on desks, etc); cribroom (e.g., tables, floor, sink); ablutions block (sink, floor). Check workers’ hands as opportunity arises! Record readings in the Site Radiation Logbook.

Surface contamination clearance checks:

When doing surface contamination checks, check the operation of the alpha probe by withdrawing the probe from the contaminated surface by 5 or so cm, to note that the countrate drops to zero. This is because alphas have a range in air of about 2.5 cm. If the countrate does NOT drop to zero, you know that you have spurious counts, possibly due to either (a) contamination, or (b) poor cable connection, or (c) a pinhole puncture in the probe window. Check for visible dirt. Check whether spurious counts are being caused by loose / dodgy cable (shake it!).

If you do get counts when probe is more than 5 cm distant from any surface, and the cable is good, and there is no obvious dirt / mud on the window that could carry contamination, then check mylar window for light leaks. Hold the probe to the sun, in direct sunlight. If the mylar is punctured, the meter will ‘scream’. You can find where the hole is by using a cardboard sheet to block off light from different parts of the probe surface. Small holes can be patched with a small dab of ‘White-Out’ correction fluid. Regularly check the probe is measuring as expected by using a gas lamp mantle as an “operability” check source.
Surface contamination release criterion is 0.4 Bq/cm$^2$. Contaminated equipment exceeding this level is NOT to leave site.

The clearance procedure will involve (i) visual inspection for dust and mud, (ii) washing of all external surfaces and flushing of all internals, (iii) alpha monitoring of accessible surfaces. Any perceptible alpha counts should be regarded as evidence of contamination. If alpha monitoring is not possible, gamma monitoring can be used to give a qualitative indication. If the reading with the gamma meter held against the object goes to double background, you should consider the item contaminated.

Decontamination should in the first instance be removed by degreaser or detergent and water; if this doesn’t shift the contamination, then you may need to attack it with a wire brush. You may get a slow improvement in cleanliness (reduction of surface count) over several cleaning attempts.
RADIATION SAFETY MANUAL

Introduction:

Energy Metals Ltd is investigating the Bigryli uranium ore body west of Alice Springs. Uranium is widely present in the Earth’s crust, averaging about 3 parts per million (ppm) in ordinary soil, and up to about 30 ppm in some granites. Uranium ores range from 0.03% (300 ppm) up to a few percent in the richest Canadian deposits. The mineralization at Bigryli averages about 0.35% $\text{U}_3\text{O}_8$.

In discussing radiation control in uranium mining (or mineral sand mining), we need to recognize that radiation is part of our natural environment. We all receive radiation doses, all the time, from gamma rays from uranium, thorium, and potassium in the ground, from breathing in radon gas in the air, from cosmic rays from outer space, and even from radioactive elements in the food we eat. The world-wide population average annual dose from all these sources, collectively called natural background, is about 2 or 3 millisieverts per year. In high radiation areas, (granite country, mineral sand coastlines) this can be over 10 mSv per year.

When working on sites exploring for, mining, or processing uranium, you can receive a radiation dose which is higher than the normal background level. Therefore it is important to monitor radiation levels, and (if necessary) put in place control measures to minimize the doses received from your work. It is also important to avoid spread of contamination in the local area, and to avoid accidental transport of radioactive contamination off site as dirt on vehicles and equipment.

This Manual gives an introduction to radiation and sets out the simple rules you need to follow to minimize your radiation dose and to prevent radiation contamination both on and off site.

Provided you follow these rules, you can be sure that the radiation dose you receive during your work at Bigryli will remain well below the annual limit for members of the public, and that environmental contamination will also remain small and well-controlled.
Radiation Dose Delivery Pathways

Radiation doses can be received by the human body by four ‘dose delivery pathways’. These are:

(i) direct shine by gamma rays emitted by radioactive materials;
(ii) inhalation of radon gas progeny (or ‘radon daughters’) in the air;
(iii) inhalation of airborne dust containing radioactive materials;
(iv) ingestion of radioactive materials.

All these pathways contribute differently depending on the work circumstances and the controls in place. For instance, in an underground uranium mine, inhalation of radon progeny is most important, requiring a high standard of ventilation, whereas in all above ground situations (like Summit) it is trivial. For a pipeline weld testing industrial radiographer using a sealed high intensity gamma ray source, item (i), direct gamma irradiation, is very important, and requires careful control, but all other pathways for dose delivery are non-existent.

For work with Energy Metals on the Bigryli Project, inhalation and ingestion of dust containing radioactive atoms, are the main pathways that need to be assessed and could potentially require control. Pathway (i), gamma radiation, will also be monitored, as the ore is of medium grade, and very close contact with it can give measurable doses. In addition, gamma monitoring gives ‘early warning’ of the presence of radioactive materials. Pathway (ii) radon daughters in the air, will be addressed by a short campaign of measurements to provide background data.

Uranium is a radioactive metal and is the ‘parent’ of a series of other radioactive elements:

**U-238 Decay Chain**

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Radiation</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium 238</td>
<td>α</td>
<td>4.5 billion yrs</td>
</tr>
<tr>
<td>Thorium 234</td>
<td>β, γ</td>
<td>24 days</td>
</tr>
<tr>
<td>Protactinium 234</td>
<td>β</td>
<td>1.2 minutes</td>
</tr>
<tr>
<td>Uranium 234</td>
<td>α</td>
<td>250 000 yrs</td>
</tr>
</tbody>
</table>
Thorium 230  $\alpha$  80 000 yrs
Radium 226  $\alpha, \gamma$  1600 yrs

**Radon 222 (gas)**

Polonium 218  $\alpha$  3 minutes
Lead 214  $\beta, \gamma$  27 minutes
Bismuth 214  $\beta, \gamma$  20 minutes
Polonium 214  $\alpha$  160 microsecs
Lead 210  $\beta, \gamma$  22 yrs
Bismuth 210  $\beta$  5 days
Polonium 210  $\alpha$  140 days
Lead 206  ---  stable

$\alpha$ = alpha particle, doubly charged helium nucleus, 2 protons + 2 neutrons.
$\beta$ = beta particle, high speed electron emitted from nucleus.
$\gamma$ = gamma ray, electromagnetic radiation, similar to x-ray.
Radiation: what is it?

Radioactive atoms, including atoms of uranium, radium, and thorium, carry excess energy, and are unstable (like a wound-up spring, or a ball balanced on a fencepost). They break down, or decay, to make new ‘daughter’ atoms and eject some of their excess energy in tiny ‘packets’ of energy called alpha, beta, and gamma radiation. Alpha, beta and gamma radiations have different ranges in solid matter:

- Alpha particles are electrically charged helium atoms, ejected at very high speed from the atom at the instant of breakdown. They are slowed down and stopped by about the thickness of a sheet of paper (say 50 microns, 0.05 mm), and by about 3 cm of air. But they make a dense ionization damage trail along the stopping track.
- Beta particles are electrons formed by the transformation of a neutron to a proton, emitted by the atom at a very high speed. They can travel a centimeter or so in solids and many centimetres or metres in air before stopping, but carry less energy, and give it up in a much more spread out and less dense track (so the damage is very much less).
- Gamma rays are electromagnetic energy, like x-rays, and are very penetrating, and can pass through several centimetres of solids (e.g., 1 cm of lead, or 2 cm of steel, or 10 cm of sand).
When radiation is absorbed by matter it causes damage to the chemical molecules making up the material, and the amount of damage is proportional to the energy delivered per unit mass. Because radiation can ionize atoms, it can damage chemical structures in living cells, such as DNA, the information-carrying molecules that control what the cell does. The *biological damage to living tissue by radiation energy* is described as the “dose”.

Radiation dose to humans is measured in unit called Sieverts (Sv). A Sievert is a very large dose, and therefore in normal situations, doses are discussed in units of millisieverts (mSv), equal to one-thousandth of a Sievert, and microsieverts (μSv), equal to one-millionth of a Sievert.

On the basis of the observed health effects (namely, excess cancers and leukaemias) in people exposed to radiation in high-dose situations in the past (the Japanese atom bomb survivors, overexposed medical patients, radiologists, etc) and taking the cautious approach of *assuming* there is no dose level below which there is zero risk, a dose of 1 Sievert is assumed to deliver a risk (of radiation-caused cancer) of 4% in the exposed person’s lifetime.

Working from this basis, the **International Commission on Radiological Protection** (ICRP) has recommended 1 Sievert of dose as the *lifetime* limit, for radiation workers, and, *assuming fulltime work for 50 years in a “radiation job”*, has therefore set one-fiftieth of a Sievert as the yearly dose limit, equal to 20 millisieverts per year. This limit is written into the National Standard for Occupational Exposure to Ionizing Radiation, and the Radiation Control legislation of all the states, and the Code of Practice on Radiation Protection in Mining and Mineral Processing.

Most full-time radiation workers (e.g., uranium miners, mineral sand mine separation plant operators, industrial radiographers, medical radiologists and radiographers, nurses, and radiotherapy technicians in hospitals) receive an annual dose much lower than the 20 mSv limit, generally 2 or 3 mSv, up to a maximum of about 5 or 6 mSv.
The Annual Limit for Members of the Public from human practices such as mining research or industry, is set at 1 mSv per year, on top of Natural Background. (This lower figure takes into account the need for lower dose limits for children and pregnant women, and the fact that non-workers may have ongoing health problems.)

The average dose from natural background radiation (from soil, cosmic rays, etc) received by everyone in the world is, depending on where you live, about 2 or 3 mSv per year.

For comparison, medical radiation procedures generally give the patient somewhat more radiation: a ‘CAT’ scan covering the chest and abdomen gives about 10 to 20 mSv; a heart stress test using radiopharmaceuticals gives about 12 mSv; other nuclear medicine scans generally give 5 or 6 mSv.

Fulltime work on a drillrig on a uranium prospect might give something between 0.5 mSv and 2 mSv in a year, depending mainly on dust control and ore grade. However, full time work on RC rig drilling in ore, without dust protection, could give significantly higher doses.

General Principles of Radiation Control

For protection against “beamed” energy, i.e., against direct exposure to x-rays or gamma rays, TIME, DISTANCE, and SHIELDING are used to minimize dose. You either minimise your time exposed, or keep your distance (the inverse square law says that double the distance will give a quarter of the dose rate), or use some absorbing shielding (like sand, lead, or steel). HOWEVER, there are no gamma ray sources at Bigryli so strong that they will need active control like this.

For protection against airborne contamination, e.g., airborne dust which may contain uranium, thorium and radium: GOOD DUST CONTROL AND VENTILATION ARE IMPORTANT. Stay out of any plume of dust, mist or spray. If you cannot avoid airborne radioactive dust, then DUST MASKS or RESPIRATORS should be used. (simple P1 or P2 type half face disposables are fine)
For protection against dose from ingestion of surface contamination (e.g., on hands or on tables), SIMPLE WASHING IS EFFECTIVE. Washing your hands and meal tables adequately removes all dirt and mud, whether it is carrying radioactive substances or not.

The general guiding principle in all radiation protection is to try to keep doses “As Low As Reasonably Achievable” in the circumstances. (This is called the “ALARA” principle) This does not mean that we must prevent every particle of thorium from escaping (which is impossible and unnecessary), or that we must shield against even the lowest intensity of gamma rays, but it does mean that sensible good practices (reasonable measures) are obligatory to minimize doses.

**Work Procedures**

1. **Occupational hygiene and dose control:**

   During drilling and other work at Energy Metals sites, the main requirement as regards radiation dose will be CONTROL OF RADIOACTIVE DUST.

   The radioactive dust can be (i) breathed in; and (ii) ingested (eaten or swallowed).

   When you are handling core or cuttings etc, you should be aware that these contain radioactive material and it is important to minimise the amount of dust stirred up into the air, and to minimize your inhalation of that dust. If the work activities are unavoidably dusty, then you **must** wear a respirator or dust mask.

   **Before crib and smoko, it is important to wash your hands and face,** to remove dust. This is to prevent the transfer of dust onto food or onto cigarettes and then to your mouth. **Smoking is not allowed in the work areas,** and you should only light up away from work areas and only **after washing** your hands and face.

   You should **shower and change clothes at the end of shift.**
PROVIDED THESE RULES ARE FOLLOWED, THE RADIATION DOSE THAT YOU WILL RECEIVE AT WORK WILL BE WELL BELOW THE REGULATORY LIMIT.

2. **Environmental Contamination Control:**

Cuttings should not be left spread around after drilling of a hole is completed. All excess loose mineralized material (i.e., material which gives surface countrate in excess of 2 times background) should be buried, either by being pushed back into the drill hole (after all clear by site geologist) or pushed into drill sumps and buried with surface soil to a depth of at least 20 cm, so as to avoid leaving loose mineralized contamination on the surface which could then be dispersed.

3. **Site Departure Clearance Checks:**

Nothing should go off site if it is contaminated with radioactive dust or mud!! This includes personal tools, heavy equipment, vehicles, drill rigs, or yourself!! Radioactive contamination is not magic, it can be removed like any other dirt, namely by washing. Anything leaving site should be washed first, then checked and only after passing the contamination clearance, and formally recorded as clean and cleared, may it leave site. Heavily contaminated equipment may need to be cleaned with a Gerni gun, and may even need repeat cleaning.

*This is very important and must not be treated lightly.*

**RADIATION MONITORING ON THE BIGRYLI URANIUM PROJECT**

**Gamma irradiation:**

Personal radiation dose badges (“TLD badges”) will be issued. These are obtained as a commercial service from the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Laboratory, in Melbourne, a section of the Commonwealth Department of Health. Your TLD badge must be worn at work; after work it is to be kept on a badge board after you change out of your work clothes. Don’t lose your badge - **ARPANSA**
charges $20 for each lost badge, and this cost will be passed on to you if you lose your badge.)

A gamma survey monitor (Geiger counter) will be used to check core and cuttings for the presence of radioactive elements.

Radiation dose by Inhalation:
Workers will be occasionally required to wear a personal air sampling pump, to provide information on airborne dust contamination levels. This pump sucks air from your ‘breathing zone’ through a filter on which airborne dust is trapped. The filter is afterwards counted by an alpha radiation counter to assess the level of contamination in the air. Please assist us by cooperating in this monitoring, it is intended to provide for your well-being, to enable dose calculations, and to assess the need (or otherwise) for use of respirators.

![Personal Air Sampler and Filter Holder](image1.png)

**Personal Air Sampler and Filter Holder**

![Alpha Drawer Assembly and Counter](image2.png)

**Alpha Drawer Assembly and Counter**

**Radiation dose by Ingestion:**
There will be a surface contamination monitor available with the Site Geologist so that you can check your hands for contamination before smoko and lunch. You need to wash your hands before checking to minimize the risk of contaminating the instrument!! Tables and desks will be scanned for surface contamination as part of the monitoring program.

Large Area Surface Alpha Contamination Probe

**Personal Dose Calculations**

On a yearly basis, dose calculations will be done for all workers involved, based on dust sampling results, time on job, and radiation badge readings, and the results will be reported to the individuals concerned, as well as to the regulator (NT DBIRD) and the company (Energy Metals Ltd).
Energy Metals, Bigryli Uranium Project

Acknowledgment of Radiation Safety Instructions and Briefing

I certify that I have received a verbal briefing on radiation safety as it applies to the Bigryli Uranium Project activities, and have been given a copy of the Project Radiation Safety Manual.

NAME OF WORKER: ............................................................................................................

Date of Birth: ..................................................................................................................

Home Address (for return of Radiation Badge readout):
.............................................................................................................................
.............................................................................................................................
.............................................................................................................................

Any previous Uranium or Mineral Sands Project work?...........................................

-- If so, where and when? ..........................................................................................

(This is for linking with previous dose reports, if any)

SIGNATURE OF WORKER: .......................................................................................

NAME OF INSTRUCTOR: ..........................................................................................

Signature of Instructor: ..........................................................................................

Date of Briefing: .................................................................................................
(This receipt must be torn out and retained by Instructor after filling out.)