



Chapter 4 Alternatives

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4 ALTERNATIVES

4.1 INTRODUCTION

This chapter describes feasible alternatives considered for the Ranger 3 Deeps underground mine (the Project), discusses the advantages and disadvantages of the alternatives and explains why the selected alternatives were chosen. The chapter is divided into two major sub-sections:

Section 4.2, Best Practicable Technology (BPT), describes the detailed options analysis process followed by Energy Resources of Australia Ltd (ERA) including how each option complies with the principles and objectives of ecologically sustainable development and how the options compare from various cultural, social, environmental, technical, operational and financial criteria.

Section 4.3, Project Alternatives, examines the feasible alternatives identified in the BPT assessment in greater detail, considers any additional information available since the BPT assessment was completed and explains why the selected alternatives were chosen.

4.2 BEST PRACTICABLE TECHNOLOGY

Section 4.1 of the EIS guidelines, Risk Assessment Approach, requires ERA to demonstrate that the Project represents BPT. While the assessment of BPT is a form of risk assessment, it is fundamentally an options analysis technique and would be difficult to merge into ERA's current risk assessment method. Instead, a BPT assessment was completed on the range of available Project options, with those found to represent BPT taken forward into the risk assessment.

The options identified as BPT are described in detail in the Project Description, refer **Chapter 3**, with the remaining options representing the Project alternatives being discussed further in **Section 4.3**.

4.2.1 BPT Assessment Method

A BPT assessment allows selection of an option that reasonably achieves the maximum environmental benefit with the most efficient allocation of resources. The concept of BPT in uranium mining in Australia was first developed in the second report of the Ranger Uranium Environmental Inquiry in 1977 (Fox et al., 1977) and was included as a requirement in the initial approvals process for the Ranger mine. The concept was further refined in the late 1990s with an updated definition included in section 12.4 of the Ranger Environmental Requirements (Commonwealth of Australia, 2000). The assessment of BPT for the Project has been carried out using this most recent definition:

"BPT is defined as:

That technology from time to time relevant to the Ranger Project which produces the maximum environmental benefit that can be reasonably achieved having regard to all relevant matters including:

- a) *the environmental standards achieved by uranium operations elsewhere in the world with respect to*
 - *level of effluent control achieved; and*
 - *the extent to which environmental degradation is prevented;*
- b) *the level of environmental protection to be achieved by the application or adoption of the technology and the resources required to apply or adopt the technology so as to achieve the maximum environmental benefit from the available resources;*
- c) *evidence of detriment, or of lack of detriment, to the environment;*
- d) *the physical location of the Ranger Project;*
- e) *the age of equipment and facilities in use on the Ranger Project and their relative effectiveness in reducing environmental pollution and degradation; and*
- f) *social factors including the views of the regional community and possible adverse social effects of introducing alternative technology."*

Historically, BPT assessments at Ranger have directly addressed these six matters by following a method developed by the Supervising Scientist Division (SSD) and published in its 2000-2001 Annual report (Supervising Scientist, 2001). In development of this method, the National Strategy for Ecologically Sustainable Development was used to provide the national context for understanding best practicable technology as applied to the Ranger Project Area.

ERA has recently refined this method to develop a more detailed set of criteria against which BPT could be assessed.¹ These new criteria were developed to address the much more detailed requirements contained within the primary and secondary environmental objectives specified in the Environmental Requirements. The new criteria remain consistent with the original six broad matters in the formal definition of BPT and continue to embed the principals and objectives of ecological sustainable development. Implicit within the criteria for "Traditional Owner Culture and Heritage", "Protection of People and the Environment" and "Rehabilitation and Closure" is an assessment of the option against the various National Environmental Significant (NES) matters protected by the controlling provisions of Part 3 of the EPBC Act triggered by the Project. This new method was used for the Project BPT assessment.

4.2.2 BPT Assessment Criteria

The BPT assessment was conducted against 22 assessment criteria within six different issues of significance. These issues, criteria and the question that was posed as part of the assessment of each criterion are:

1. Traditional Owner Culture and Heritage:

¹ The new method was presented to the Minesite Technical Committee in February 2012.

- **Living Culture:** Would the adoption of the option have adverse impacts on the cultural practices, traditions and customs of the local Aboriginal communities?
 - **Cultural Heritage:** Would the option threaten in any way the integrity of sacred sites, rock art or any other aspect of the cultural heritage of the region?
2. Protection of People and the Environment – Operational Phase:
- **Community Health and Safety:** Would the option give rise to adverse impacts on the health and safety of Aboriginal or non-Aboriginal members of the local community?
 - **Socio-economic Impact on Local Communities:** Would the option have any adverse socio-economic impacts on the communities in the town of Jabiru or in the broader Kakadu National Park and Alligator Rivers Region?
 - **World Heritage Ecosystems:** Would the option achieve protection of the natural World Heritage and Ramsar values of Kakadu National Park?
 - **Ecosystems of the Ranger Project Area:** While some level of disturbance or environmental impact is inevitable on the Ranger Project Area, would the option minimise such on-site impacts?
 - **Long-term Environment Protection:** Would the option ensure long-term protection of people and ecosystems of Kakadu National Park following rehabilitation?
3. Fit for Purpose:
- **Proven Technology:** Does the option use proven technology? Proven and demonstrated technology would be ranked higher than very new, unproven or theoretical technology.
 - **Technical Performance:** How effective is the technology for an option to meet its desired output objective and how robust in response to variations to inputs (i.e. ore characteristics, consumables, or a range of upstream and downstream interfaces)? Effective, highly robust options would rank highly.
 - **Environmental Protection Standard:** Does the standard of environmental protection achieved by the option meet the highest standards achieved in uranium mining elsewhere in the world?
 - **Capital Cost:** Does the capital cost of the option ensure that its adoption would contribute significantly to the overall Project value?
4. Operational Adequacy:
- **Occupational Health and Safety:** Would adoption of the practice ensure the ongoing health and safety of the workforce?
 - **Operability:** Would the option require extensive control and support effort to ensure its continued viability?

- **Availability and Viability:** Is the process operationally reliable? That is, will it have high availability or will it be sensitive to the failure of single plant items?
 - **Maintainability:** Would the option be difficult to maintain?
 - **Operating Costs:** Would the operating costs associated with the option have a large impact on overall Project value?
5. Rehabilitation and Closure:
- **Post-rehabilitation Environmental Protection:** Would the option give rise to impacts that would make it difficult to rehabilitate the site to the standards required for incorporation of the site into Kakadu National Park following closure?
 - **Closure Costs:** Would adoption of the option result in closure costs that significantly detract from overall Project value?
 - **Closure Schedule:** Would adoption of the option extend closure beyond Traditional Owner expectations and, in particular, beyond the requirements specified in the section 41 Authority?
6. Constructability:
- **Construction Occupational Health and Safety:** Would the option introduce significant health and safety risks to the workforce during the Project construction phase?
 - **Construction Environmental and Cultural Risks:** Will the option need significant land disturbance during construction, significant off-site environmental impact or require construction work near sites of cultural significance?
 - **Construction Complexity:** Would the option lead to high construction complexity through difficult scheduling, complex logistics or significant manpower requirements?

4.2.3 Ranking System

The BPT assessment was conducted using a 5-level ranking system to assess an option under each criterion. The ranking system was as follows:

- **Rank 1** – Inadequate; the option does not meet current standards and it is unlikely that modifications could reverse this assessment.
- **Rank 2** – Poor; the option does not meet current standards but options for modifications exist that could reverse this assessment.
- **Rank 3** – Acceptable; the option meets current standards.
- **Rank 4** – Good; the option exceeds current standards.
- **Rank 5** – Excellent; the option exceeds current standards by a substantial margin and the option is recognised as international best practice.

To assist in assessing each option against the criteria, a BPT assessment matrix, including ranking definitions, was developed. For each criterion, the issues to be addressed were listed and the expectations for acceptability were specified. The ranking descriptors are given in **Appendix 4**.

If insufficient information was available to allocate a rank to a criterion in the early stages of the BPT process, the criterion was given an Unable-to-Evaluate (UTE) assessment. This prompted the development of actions to address the lack of knowledge, to ensure that sufficient information would be available for evaluation prior to completion of the assessment. Where it was assessed that the criterion was not applicable to the particular option being considered, a "NA" result was recorded.

The final BPT score for an option, S , was then calculated by summing the individual rank using the following equation:

$$S = 100 \sum_{i=1,N} (s_i - m) / (N.F)$$

- Where:
- S_i = the score for criterion;
 - m = the median score (3 for this 5-rank system);
 - N = the total number of criteria for which a score was recorded; and
 - F = the factor to adjust to scale of +/- 100 (2 for this 5-rank system).

The BPT score summarises performance of the option against current international performance standards.² Thus, the score that would be recorded for an option which achieves the highest rating for all criteria would be 100; an option that simply meets standards for all criteria would score 0, and an option that achieves the lowest rating for all criteria would score -100.

The assessment process allowed for two types of "*Showstopper*" results for each option.

- A *Hard Showstopper* was allocated to an option when it was clear from the initial assessment that the option was unacceptable and therefore required no further assessment. This might occur, for example, if an initial assessment demonstrated that the option could result in intrusion on a sacred site.
- A *Soft Showstopper* was allocated to an option if a rank equal to 1 or 2 was attributed to any criterion involving occupational health and safety issues, off-site environmental protection issues, or cultural issues. The recording of a *Soft Showstopper* against an option would not necessarily rule out that option; however, it indicates that performance of the option against the particular criterion would need to be reviewed and improved before the option could be considered acceptable.

² Only criteria for which a score has been recorded (rather than a UTE or NA result) shall be included in the summation process.

4.2.4 BPT Assessment Results

The BPT assessment for the Project was conducted via a set of workshops, with attendees having the required competency and experience to fully understand the Project and options being assessed. At least one attendee had relevant expertise in each of the following required disciplines:³

- Traditional owner culture and heritage;
- Community and other socioeconomic issues;
- Environmental protection;
- Knowledge of similar projects elsewhere in the world (best practice);
- Rehabilitation and closure (including revegetation);
- Health and safety (including radiation if relevant); and
- Technical representatives with knowledge of:
 - Technical details of the project design elements;
 - Operability;
 - Maintainability;
 - Constructability;
 - Costs (capital and operational); and
 - Schedule.

The workshops assessed 71 options covering 17 different elements of the Project; results of the BPT assessment are provided in **Appendix 4**. Of the 71 options assessed, 34 were found to have initial hard show stoppers and were rejected. These options were not considered feasible alternatives, and therefore are not discussed further in this chapter.

Following the initial assessment, some elements of the Project were found to have only one option remaining. These options are listed below and were progressed as default best practicable technology options:

- the mineral resource will be retrieved using underground mining techniques;
- access to the underground mine will be via the current exploration decline;
- underground mine development will be undertaken using Jumbo drill and blast techniques;
- haulage to the surface will be via trucks up the current decline; and

³ Note: some attendees possessed expertise from multiple disciplines.

- aggregate material will be sourced from existing operations category 2 low grade rock stockpiles.

The remaining options were subjected to the full BPT assessment process. The results are outlined in **Appendix 4** with a summary provided in **Table 4-1**. The preferred options that emerged from this process are:

- the orebody will be accessed from the footwall;
- the mining method will be transverse (long hole) open stoping - entry method;
- trucks will be diesel powered;
- ventilation raises will be installed using a raise bore method with a surface stabilisation method appropriate for the ground conditions, and will vary according to the installation location;
- emergency egress infrastructure will be installed in the fresh air intake shaft(s). The initial assessment identified the best options as plastic ladders with climb assist, with the winch and torpedo system ranking lower due to cost. ERA have re-assessed this and elected to install the more expensive system. Based on the ranking matrix this option delivers a better occupational health and safety outcome;
- mined out stopes will be backfilled with cemented tailings paste aggregate fill;
- tailings will be sourced directly from the processing plant;
- tailings for the backfill will be prepared by removal of fine material (de-sliming) followed by vacuum filtration or screening;
- the tailings dewatering and backfill plant can be located at either the mine or the existing processing plant, since a similar high ranking was obtained for both locations;
- aggregate for the backfill will be prepared by crushing and screening using a mobile plant;
- processing will use the existing Ranger mine processing plant with beneficiation to remove carbonate material from the high carbonate portion of the ore; and
- beneficiation will be undertaken using the existing ore sorter.

Full details of each of the selected Project options are provided in the project description, refer to **Chapter 3**. A summary of each feasible option assessed is provided in **Section 4.3**.

It should be noted that with the exception of the tailings dewatering and backfill plant, no options for locations were identified for any of the other infrastructure; their location was dictated by consideration of other Project or existing infrastructure. For example the power plant was located adjacent to existing power infrastructure.

Table 4-1: Summary of best practicable technology assessment results

Option ID	Option Description (see Section 4.3 for details on each option)	Overall rank
<i>Orebody access</i>		
C1	Hanging wall	17
C2	Footwall	38
<i>Mining method</i>		
E2	Long hole stoping -entry	19
E3	Long hole stoping – non-entry	16
E4	Vertical Crater Retreat-Shrinkage stoping	13
E6	Underhand long hole stoping	3
<i>Truck type</i>		
G2	Diesel	35
G3	Electric trolley assist	0
<i>Ventilation raise construction</i>		
H1	Raise bore with surface stabilisation	13
H2	Blind bore	3
<i>Emergency egress type</i>		
I1	Ladder way	21
I2	Plastic ladder way with climb assist	29
I3	Winch and torpedo	21
I4	Alimak	0
I5	Winch and cage with guides	8
<i>Backfill type</i>		
J1	Cemented paste aggregate fill (tailings)	21
J2	Cemented aggregate fill	-14
J3	Cemented rock fill	7
J5	Cemented hydraulic fill (tailings)	-14
<i>Tailings source for backfill</i>		
K1	Tailings dam transfer tailings	0
K2	Fresh tailings from the processing plant	21
<i>Tailings preparation method following de-sliming</i>		
L2	Pressure filtration (filter press)	5
L3	Vacuum filtration	24
L4	Vibrating dewatering screen	21
<i>Backfill plant location</i>		
M1	Tailings dewatering and backfill plant at current processing plant	20
M3	Tailing dewatering and backfill plant above underground mine	25
<i>Aggregate preparation method</i>		
O1	Mobile crushing and screening plant (existing)	28
O2	Fixed crushing and screening plant (new)	25
<i>Processing of high carbonate ore</i>		
P2	Use current processing plant with beneficiation to remove carbonate	50
P3	Use current processing plant no beneficiation	29
<i>Beneficiation method</i>		
Q1	Ore sorting (current)	39
Q5	Reverse flotation	-7

4.3 PROJECT ALTERNATIVES

4.3.1 Project Scale Alternatives

4.3.1.1 "No Proposed Action" Option

The no proposed action alternative assumes that the existing approved operations continues to process stockpiled, low grade ore until 2021 and the Ranger 3 Deeps resource remains unmined. Under this scenario, employment levels will remain similar to the current levels of employment until 2021, and then decline as decommissioning progressively winds down operations over a 5 year period to 2026.

Under the no proposed action option, the:

- Regional employment benefit of between 180 and 280 new jobs⁴ for the building and operating of Ranger 3 Deeps over a five year period will not be realised;
- Economic benefit (refer **Chapter 11**) from the capital development of Ranger 3 Deeps infrastructure and the increased production of uranium oxide will not be realised; and
- Environmental impact of existing operations remains very similar to the cumulative impact if the Project proceeds, since the various studies conducted for the Project only identified small incremental changes in each environmental aspect.

The reduced social and economic benefits from the no action option and the minimal environmental impact of the Project make the no action option less favourable than the proposed Project.

4.3.1.2 Open Pit Mining

An open pit mine is not considered feasible for developing the Ranger 3 Deeps resource because it would require significant surface disturbance to accommodate a pit large enough to access the ore. The projected disturbance area required for open pit operations is displayed in **Figure 4-1** and clearly illustrates the direct impact to Magela Creek and the portion of existing infrastructure that would need to be relocated to accommodate the open pit. In addition to the large surface disturbance required, the depth of the deposit makes it uneconomic to mine by open pit mining methods.

Underground mining is considered the only feasible mining alternative.

⁴ Excludes the ramp up during 2015 where workforce numbers are highly sensitive to the Project start-up date and cannot be reasonably predicted at this stage

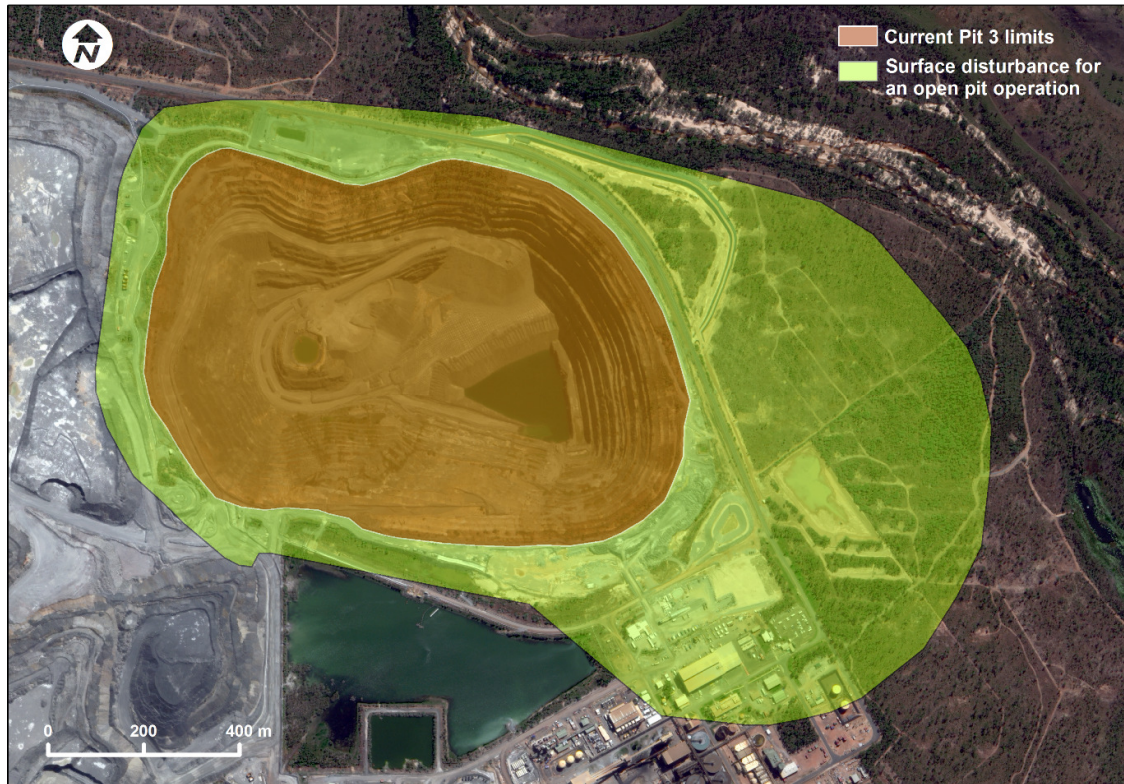


Figure 4-1: Projected surface disturbance required under an open pit mining scenario

4.3.2 Feasible Alternatives Assessed

Section 4.1 outlines how the technically feasible Project options were subjected to the full BPT assessment process and formally considered as potential Project alternatives. This section discusses the technically feasible alternatives considered and explains why the selected alternatives were chosen.

4.3.2.1 Mining Method

A large number of underground mining methods were assessed, but only four were considered as technically viable options. These were:

- long hole open stoping – entry method;
- long hole open stoping – non-entry method;
- vertical crater retreat shrinkage stoping (non-entry method); and
- underhand long hole open stoping (entry method).

These methods are illustrated and briefly described in **Figure 4-2**

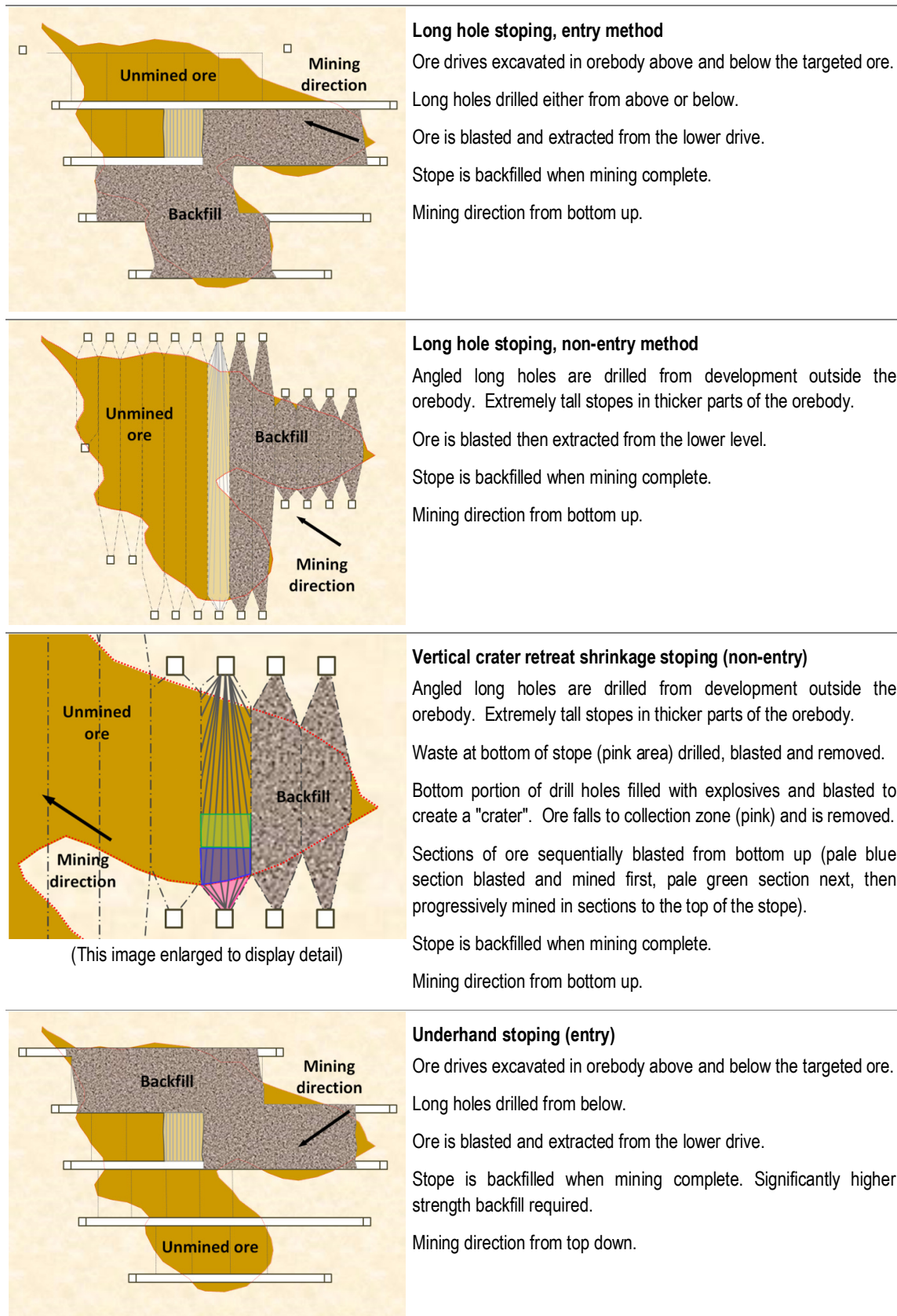


Figure 4-2: Alternative mining methods

When selecting the underground uranium mining method the key issues were geotechnical stability, orebody geometry (depth, width and dip) and radiation hazards.

All four mining methods were ranked as best practice for community health and safety and for ecosystems of Kakadu National Park. This is primarily because any underground mining technique significantly reduces surface disturbance. Underground mining is considered as best practice when mining in environmentally sensitive areas.

Both the long hole open stoping – non-entry method and the vertical crater retreat shrinkage method were considered unsuitable at Ranger 3 Deeps as they require extremely tall stopes. From a geotechnical perspective, the prevailing ground conditions make tall stopes potentially unsafe and impractical to mine in this manner.

From an economic perspective, the two non-entry methods require less development and less capital expenditure, but have significantly higher operating costs. The vertical crater retreat shrinkage method requires the upper portions of the drill holes to remain open while the lower portions are progressively loaded and blasted from the bottom up. This results in lower production rates and lower inherent availability and reliability because of the potential for drill hole blockages.

The underhand long hole stoping method was discounted because it would not be economically feasible to supply a paste backfill with sufficient strength to allow this method to be used.

The long hole open stoping – entry method was favoured for the following reasons:

- It is the most common type of underground mining method, with a wealth of operational experience provided from other mine sites;
- It is substantially less technically difficult under the assumed geotechnical conditions in the Ranger 3 Deeps underground mine where small stope sizes will be required;
- It generates considerably less waste material;
- It has lower operating costs than other methods; and
- From a risk perspective, the entry methods are considered to have a lower risk than the non-entry methods. The radiation risks of the entry methods can be managed (as is done in a number of Canadian mines) and are outweighed by the geotechnical risk posed by the extremely tall stopes required by the non-entry methods.

Entry methods can have potentially higher radiation exposure to workers (from gamma radiation) so they require detailed evaluation and justification before they can be adopted. A number of options were identified for reducing radiation doses to workers for the entry methods. These include additional shotcrete shielding on the walls, backs and face; shielding the floor with benign material; additional thickness of steel on equipment; cabins on equipment and remote operation for some equipment. Each of these options has been evaluated and the preferred options selected, such that radiation exposure will be as low as

reasonably achievable (ALARA)⁵ to enable the entry method to be progressed. Further details are provided in **Chapter 7**.

4.3.2.2 Emergency Egress

Emergency egress is required for any underground mine, so that the workforce has an escape route in case of emergency. Five options were assessed for emergency egress at Ranger 3 Deeps:

- traditional metal ladder way;
- plastic ladder way with climb assist;
- winch and torpedo;
- winch and cage with guides; and
- Alimak personnel lift.

Ladder ways are the traditional means of egress but employees are required to climb long distances to the surface. However, modular plastic ladder ways when fitted with "lift assist" can help with longer climbs.

The two alternate winch systems are very similar and deploy a surface mounted winch to lift personnel in a cage up a ventilation intake. Winch systems are easier for workers to egress long vertical distances but require the installation of a winch head frame and associated infrastructure at the surface. Winch systems have the advantage of having the machinery located at the surface where they can be powered and maintained independently of mine operations.

The Alimak system is a winch system similar to a conventional lift and is used extensively in road tunnel construction. However few examples of its use in underground mines can be found. It can be used on angles rather than just vertical climbs and does not require a ticket to operate compared to conventional winch systems.

The BPT assessment ranked the plastic ladder way with climb assist as the highest scoring system, with the standard ladder way and winch with torpedo⁶ equal second (**Table 4-1**). However, when total evacuation time and minimum workforce fitness requirements are considered, the winch with torpedo becomes the preferred system. Total evacuation time via winch and torpedo is estimated to be about 12% that of the assisted ladder climb system and is independent of workforce fitness.

The winch and torpedo was selected as the primary means of emergency egress after considering evacuation time, workforce fitness requirements and ease of maintenance and operation. To supplement the winch and torpedo system, the plastic ladder with climb assist and a system of refuge chambers will be installed between development levels to enable rapid evacuation between development levels and alternate egress by foot up the main decline.

⁵ Economic and societal factors taken into account.

⁶ A torpedo is a small personnel cage that can lift a mine worker to the surface via a ventilation intake.

4.3.2.3 Ventilation Shaft Construction

Two methods of ventilation shaft construction were assessed: raise boring with surface stabilisation and blind boring.

Raise boring uses a raise bore machine set up above the designated shaft location. The machine drills a small (pilot) hole down to an underground chamber where a reaming head is attached at the bottom of the drill string⁷. Tension and rotation are applied to the drill string by the raise boring machine and the reaming head is thrust against the rock face. The shaft is created as the reaming head is pulled upward.

Raise boring for the Project will require surface stabilisation in the weathered zone. Stabilisation can be provided by using piling with grout injection, or by conducting initial auger drilling from the surface with ground support provided by fibrecrete and steel liners. The piling method uses piles installed around the perimeter of the planned hole typically in conjunction with a surface slab of concrete to anchor the piles. In both methods the shaft is lined with shotcrete to provide more permanent stability.

Blind boring is a mechanised, top down, shaft sinking method that uses highly specialised equipment and requires the construction of two large drilling mud ponds next to the shaft. The method is applicable to a range of ground conditions and can create both large and small diameter shafts over a range of lengths. Excavations created by blind bores are typically cased with steel liners.

The raise bore method ranks higher than the blind bore method, mainly for environmental reasons (associated with the installation of the ponds) but also because blind bore equipment availability is poor, with up to a six month waiting period, and has a significantly higher cost.

Taking into account the considerable environmental benefits and cost effectiveness of raise boring, this method with surface stabilisation by piling and grout injection was selected for construction of the Project ventilation shafts.

4.3.2.4 Underground Mine Backfill

Four options for backfilling the mined-out stopes were considered technically feasible:

- cemented tailings paste aggregate fill
- cemented aggregate fill
- cemented rock fill; and
- cemented tailings hydraulic fill.

The cemented tailings paste aggregate fill option comprises a mixture of tailings, aggregate and cement made into a paste that is delivered underground through a cased borehole directly to the underground workings and piped to the required stopes. The paste has low moisture content and is quite viscous. Paste is delivered to the top of the stope and allowed to flow in and fill the void. The paste has a high strength and provides the required

⁷ The drill string comprises the set of connected drill rods linking the drill to the drill bit.

geotechnical stability to allow mining in adjacent stopes and therefore was selected as the preferred option.

Cemented aggregate fill is very similar to cemented tailings paste aggregate fill, but has no tailings and therefore has a larger grain size. The method of delivery requires a significant number of surface holes to direct the fill into the mined out stope. This would involve surface disturbance for the holes and associated service roads. Cemented aggregate fill may have lower strength than cemented tailings paste aggregate fill; therefore, will provide inferior ground support and present a potentially greater health and safety risk.

Cemented rock fill involves spraying a cement/concrete material over rock fill that has been delivered to the stope via back haulage. Cemented rock fill provides a very low level of geotechnical stability, presenting higher health and safety risk. Voids would also have increased permeability compared to other methods with water inflow and potential environmental implications.

Cemented hydraulic fill is made from tailings with ultrafine material removed and a proportion of cement added to allow the fill to set. It has poor material strength and does not provide sufficient ground support for worker safety and general operability. Furthermore, the excess water draining from the cemented hydraulic fill will mix with general mine water and potentially reduce the water quality from a pond water classification to lower quality process water.

4.3.2.5 Tailings Preparation

The use of cemented tailings paste aggregate as backfill for the underground mine was found to be BPT. To implement this method, tailings need to be prepared to reduce the moisture content to below 20%. Following de-sliming, three tailings preparation options were considered to be technically feasible:

- vibrating dewatering screen;
- vacuum belt filter with preliminary de-sliming; and
- pressure filtration.

Vibrating dewatering screens pass a suspension of tailings over a fine vibrating screen where the filtrate flows through the screen. Vacuum filtration units comprise long fabric belts through which liquid is sucked out of the tailings slurry as it is conveyed along the belt. Pressure filters are semi-continuous filtration units that typically force cloth-covered plates together to produce a cake and discharge fluid. Their operation requires cake discharge and wash cycles after each pressure sequence.

Vibrating dewatering screens and vacuum filtration both ranked highly in the BPT; therefore, both methods could be considered appropriate technology.

When assessing the options many aspects were ranked similarly. The following aspects were used to differentiate between the options:

- Proven technology: Vacuum and pressure filtration were considered to have proven operating performance at multiple sites with demonstrated results. Vibrating dewatering screens were considered unproven at the time; however subsequent Project test work has confirmed it as a viable method.
- Capital and operating expenditure: The vibrating screen has lower costs than other alternatives; pressure filtration is the most expensive option. Pressure filtration is complex and has a very high capital cost
- Occupational health and safety: All options satisfy ERA's occupation health and safety requirements but the health and safety controls for pressure filtration were considered to be lower in the control hierarchy than the other alternatives. This was due to the additional radiation exposure potential.
- Operability: Vacuum filtration is less complicated to operate when compared to other options.
- Maintainability: Pressure filtration will require marginally more maintenance than the other options.
- Construction complexity: Pressure filtration would have a much longer lead time for delivery than the other options.

4.3.2.6 Tailings Dewatering and Backfill Plant Location

Two technically feasible location options were considered for the backfill plant with adjacent tailings dewatering facility:

- tailings dewatering and backfill plant at the current processing plant; and
- tailings dewatering and backfill plant above the mine.

Placement of the tailings dewatering and backfill plant near the current processing plant would require that high density paste be pumped through the existing operational area and into the underground mining areas. The alternative location of above the new Project mining areas would require the pumping of process water and tailings slurry and gravity feeding the majority of paste backfill to the underground mined out areas. The relative ease of pumping fluid tailings from the existing mill to backfill plant, (a well-established and readily controlled process), compared to pumping a higher viscosity paste makes the location above the mine the preferred option.

It is noted that this places tailing and process water at a location near to the existing operational boundary and access road; however this location on the edge of Pit 3 is scheduled to soon become a process water catchment and tailings storage facility with associated tailings piping infrastructure as part of current operations.

4.3.2.7 Aggregate Preparation

Two options for crushing and screening of aggregate in preparation for mixing into backfill were assessed:

- the existing mobile crusher unit; and
- a new fixed unit located near the backfill plant.

The mobile crusher is considered the preferred option; however, both options are very similar and should be considered equally as BPT. The existing mobile unit ranked slightly higher, principally because it is existing infrastructure with minimal capital cost. It also scores highly on constructability aspects and is a less complex system, so has lower rehabilitation costs.

The fixed crusher performed better on environmental protection because of lower dust emissions, and also has lower operating costs.

The BPT assessment identified a potential issue with dust emissions from the mobile crusher; however, air quality modelling conducted since the assessment was completed (**Chapter 6**) demonstrates that both Project and cumulative dust emissions are all below relevant limits. ERA will maintain water sprays on the crusher to ensure dust emissions from crushing do not impact on worker health or the environment.

4.3.2.8 Processing of High Carbonate Ore

Ore from the Project will, on average, have higher carbonate content than previously mined Pit 3 ore, since ore in the lower mine sequence is known to have higher levels of carbonate. This has implications for processing.

Two processing options were assessed. Both options use the current processing plant, but one uses beneficiation to remove carbonate and the second uses no beneficiation. The no beneficiation option would involve processing some higher carbonate material, but any material with significantly higher carbonate would not be processed.

The option to use a beneficiation method was clearly the better option, as more of the uranium resource would be recovered and less acid would be required for processing.

The beneficiation option also ranks higher because:

- There is potential to generate greater royalties for the community since more uranium can be processed.
- Less greenhouse gas emissions and process water are produced with lower carbonate ore.

4.3.2.9 Beneficiation Method

A number of beneficiation options were assessed during the initial metallurgical test work, but only two were found to be feasible alternatives:

- continued use of the existing ore sorter; and
- reverse flotation.

Ore sorting requires an initial crushing and screening step to produce material of the correct size. The material is then fed into the sorter where uranium-bearing rock is detected and recovered, with the barren carbonate material being sent to waste.

Reverse flotation involves a fine grinding step and then a bank of floatation cells which mix the ore with water, frothing reagents, and collecting reagents. When air is blown through the mixture, mineral particles cling to the bubbles and rise to the surface for collection. This method has been shown by test work to effectively remove carbonate; however, it requires substantial new infrastructure and a supply of high quality water, which would have implications for the site water balance.

The ore sorter was clearly favoured over reverse flotation for the following reasons:

- The ore sorter is existing infrastructure, whereas reverse flotation requires an entirely new process flow circuit, would cause additional disturbance and would require significant additional capital cost.
- Flotation requires additional chemicals and water for processing.
- Flotation has not been specifically used for carbonate removal in uranium mining; so while it is a proven technology it will be more complex to commission.

4.3.3 Other Project Alternatives

4.3.3.1 Waste Management

Ranger mine has continually improved its waste management system over 30 years of operations and now has a very mature system. The waste streams generated by the Project will be the same as those from the existing Ranger operations. Apart from the placement of a portion of the tailings as a constituent of backfill in the underground mine stopes (**Sections 3.8.1 and Section 4.3.2.4**), no alternatives to the existing waste management systems are proposed.

4.3.3.2 Water Management

The Ranger mine water management system is a well-established system and will continue to be used to manage all water generated on site, including water streams from the Project. No new categories of water will be generated by the Project and, since the existing water management system is highly effective, no new water management alternatives were considered.

4.3.3.3 Rehabilitation Methods

The small Project footprint means that relatively little additional surface rehabilitation will be required. Other than the backfill methods used to rehabilitate the underground voids discussed in **Section 4.3.2.4**, no alternative rehabilitation methods were considered for the

Project and the rehabilitation strategy for the Ranger mine will remain largely unaffected by the Project.

4.3.3.4 Energy Sources

A number of alternative energy sources were considered, including electrical power from the main Darwin/Katherine grid, gas supplied by pipeline, compressed or liquefied natural gas supplied by road tankers, wind power and solar power. None of these were considered feasible for the following reasons:

- Electricity supply from the Darwin/Katherine grid system and a gas pipeline were excluded due to the high capital cost for the required infrastructure, the lengthy payback period required and the short-term nature of the Project.
- Wind power to supplement peak loads was excluded due to the:
 - high capital cost for the wind turbines;
 - need to maintain an independent, alternate power supply for use during calm weather; and
 - unsuitable wind climate, as illustrated in the Commonwealth Government's Renewable Energy Atlas of Australia (Commonwealth of Australia, 2008), with the Jabiru region having some of the lowest average wind speeds in the nation.
- Solar supply was excluded due to the large area of land required for solar panels (75 to 100 ha of new land disturbed), the lengthy payback period required and the short-term nature of the Project.
- Natural gas supply by road tanker was excluded, for the Project, due to: financial considerations, construction and operating complexities associated with its co-use with current diesel power generation and the short duration of the Project.

It was concluded that diesel power generation is the only economically and practically feasible technology for the Project and is therefore the preferred power source.

4.3.3.5 Environmental Management Measures

Environmental management measures, along with health, safety, cultural and heritage criteria accounted for approximately half of the BPT criteria (**Section 4.2.2**). In this context, assessment of alternative environmental management measures for key risks/impacts identified during the Project risk assessment (**Chapter 5**) formed an integral part of the BPT process. Environmental criteria were particularly important for selecting the mining method, ventilation shaft construction, underground mine backfill, aggregate preparation and processing and beneficiation of high carbonate ore.

Appendix 4 provides details on the environmental assessment criteria and rankings against each of the alternatives considered.

4.4 REFERENCES

Commonwealth of Australia 2000. s.41 Authority, Environmental Requirements of the Commonwealth of Australia for the Operation of Ranger Uranium Mine. *In*: AUSTRALIA, C. O. (ed.).

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