ENVIRONMENTAL ASSESSMENT OF A HIGH-GRADE URANIUM MINE

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ABSTRACT

The McArthur River uranium ore body was discovered in 1988. By February, 1991, sufficient ore reserves had been identified to proceed with mine development and the Atomic Energy Control Board (AECB) was notified of this intention by the McArthur River Joint Venture. The AECB referred the project to the Federal Environmental Assessment Review Office, which initiated an environmental assessment process which has taken over six years to complete. That assessment process has solicited public opinion on nine occasions, three of these being public hearings, generated 13,000 pages of environmental impact statement and thousands more pages of intervenor presentations, technical consultants reports and expert witness statements, resulting in a report from the assessment panel in February, 1997, and culminating in recommendations from the federal and Saskatchewan governments in May, 1997, that the project should proceed. At this point the formal licensing process could begin, which should result in an operating licence for the project in the third quarter of 1999. The authors are firmly committed to environmental protection in the development of natural resources, but question the necessity for scrutiny at the level to which this project has been subjected.

INTRODUCTION

The McArthur River project is the world's largest known high-grade uranium deposit, with reserves and resources of 160,000 t U of U_3O_8 (416 million pounds) at an average grade of 13% U. It is presently being developed to allow the start of production in late 1999. The deposit is between 500 and 600 m underground in the eastern part of the Athabasca Basin in northern Saskatchewan, Canada, 80 km northeast of Key Lake and approximately 620 km north of Saskatoon.

Cameco Corporation, through one of its predecessor companies, Saskatchewan Mining Development Corporation, began operating the McArthur River exploration joint venture in 1980. After several changes in joint venture partners, the project is now owned by Cameco (55.844%), Uranerz Exploration and Mining Limited (27.922%), and Cogema Resources Inc. (16.234%).

Because the uranium grades at McArthur River are roughly ten times those at Key Lake and Rabbit Lake and a hundred times the average grades elsewhere in the world, non-entry mining and remote ore-handling techniques will be used. Planned production from the McArthur River underground mine is 6,924 t U of U_3O_8 (18 million pounds) per year. The ore will be transported 80 km by road to be milled at the existing Key Lake operation.

In addition to the challenge presented by the high grade of the ore, there are ground water at very high pressures and ground conditions that vary from excellent to wholly unconsolidated clays and gravels. The protection of workers and the environment has been the first priority in the design and development of the project.

HISTORY

In 1988, the ore body was discovered following eight years of systematic exploration in the area. Improved electromagnetic methods allowed the identification of a graphitic conductor in the basement fault structure that controls the location of the ore. Several years of core drilling from surface resulted in the outlining of high-grade mineralization over 1.7 km of strike length. By 1991 sixty holes were completed, of which thirty-seven holes intersected uranium mineralization at a depth of 500 to 600 metres. Based on this information, a resource of 100,000 t U U_3O_8 (260 million pounds) at an average grade of 4.2% U was estimated. However, the mineralized zone was very narrow and seventy per cent of the estimated resource was based on only seven drill holes, with eighteen per cent based on a single hole, which graded 36% U over 25 metres. Consequently, in 1992 it was decided to undertake an underground exploration programme to provide detailed information about the shape of the individual ore bodies.

The Atomic Energy Control Board (AECB) had been notified of the intention to develop the project in February, 1991. The AECB referred the project to the Federal Environmental Assessment Review Office (FEARO), which initiated the environmental assessment process. FEARO and the government of Saskatchewan appointed the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan to look at five uranium projects (Cluff Lake expansion, McClean Lake, the Midwest Project and Cigar Lake, in addition to McArthur River).

Although underground exploration did not require a full environmental assessment under either the Uranium and Thorium Mining Regulations or the various regulations under the Canadian Environmental Assessment Act (CEAA), the Panel felt that allowing the underground exploration to proceed without a detailed examination would harm the credibility of the main hearings. Consequently, the underground exploration was referred to the Panel for review in 1992 and approved in early 1993. A shaft was sunk in late 1993 and early 1994, with underground development on one of the two approved levels. The underground drilling over the first 300 m of strike length identified a significant new ore zone, which increased the reserves and resources to the current 416 million pounds U_3O_8 (160,000 t U). During the drilling programme, work proceeded on the environmental studies, and the environmental impact statement (EIS) for the main project was issued in December, 1995. Hearings proceeded in 1996, with approval of the project being obtained in 1997.

PROJECT DESCRIPTION

At the present time there is one shaft at McArthur River, with a second one being sunk and a third planned. The 530 m level has been developed for detailed drilling and the 640 m level is under development. Ultimately underground drilling will proceed over the full 1.7 km strike length of the deposit to fully define the ore reserves. Because of the high radiation levels from the high-grade ore and the poor ground in some of the ore zones, non-entry mining will be employed. To stabilize the ground and control water, freeze holes will be drilled into the ore zones and brine will be circulated to freeze and stabilize the ground. Seven mining methods that would not require entry into the stope were seriously considered, with the three preferred methods being raise boring, box-hole boring and remote box-hole stoping. Raise boring has been selected as the initial mining method.

Raise-Bore Mining

The raise-bore machine is set up in non-radioactive waste rock above the ore zone. The machine drills a 300 mm pilot hole from the upper chamber, through the ore zone into the lower extraction chamber, also in waste rock. The drill bit is replaced with a 2.4 m diameter reaming head, which then reams upward through the ore. The reamed ore is funnelled downward through a sizing screen and crusher to the underground ore-grinding area. The raise-boring machine is removed and the raise filled with concrete. By overlapping the raises, a high percentage extraction of the ore zone is achieved.

Box-hole Boring

The box-hole boring machine is set up below the ore body and pushes the reamer upwards through the ore. The ore falls down the raise to a chute above the box-hole machine and is diverted to the sizing screen and crusher.

Remote Box-hole Stoping

This mining method combines the productivity improvements offered by stoping with the control and containment provided by box-hole boring. The raise is reamed as described in the box-hole boring method. Blast holes are then drilled to intersect the raise from drill drifts in waste rock lateral to and above the raise. The reamer head controls the size and regulates the flow of blasted ore to the sizing screen and the crusher below.

During the initial years of mining, each raise will produce approximately 190,000 pounds of U_3O_8 (73 t U). Due to the high grade of the ore, an average of only 125 t must be mined per day. The total time necessary to mine and fill a raise is expected to be about 10 to 11 days, of which only one day will likely be spent reaming ore. Four raise-bore machines are planned for full production.

Waste Rock Management

Waste rock from mine development and ore production will be minimal due to the low tonnages of ore required each day. Potentially problematic material (waste rock containing >0.03 % U_3O_8 or with acid-generating potential) will be hoisted conventionally via the main service shaft and stored on lined pads at McArthur River. During the development phase, 215,000 tonnes of potentially problematic material are expected. This material will be either used for back-fill underground at the mine site, or transported to Key Lake for final placement in existing, approved storage areas.

A total of 900,000 tonnes of inert waste rock is expected from underground development including ventilation shaft sinking. This will be placed on surface at approved, un-lined sites.

Ore Processing

The ore from the underground grinding circuit will be pumped to surface in a slurry pipeline using positive displacement pumps, eliminating the need to hoist the high-grade ore in the shaft used to move men and material and to supply fresh air.

On surface the ore slurry will be blended by grade, thickened to 50% solids and placed in purpose-built containers. The containers will be shipped, four to a truck, to Key Lake, carrying 18 t of ore (21.2 m^3 of slurry) per trip. Approximately eight trips per day will be required.

At Key Lake, the ore will be diluted to 4 % U_3O_8 by blending with mineralized waste rock prior to milling. This reduces the grade to levels that have been processed without radiation exposure problems at Key Lake in the past and also allows the recovery of uranium from material that would be uneconomical to process on its own.

The new tailings system in the Deilmann pit is being converted from a subaerial to a subaqueous system, which has decided advantages from the water management, operational safety and environmental release points of view. The tailings will be injected into existing tailings in the pit by tremie pipe. By pumping water from the bottom drain in the pit, tailings consolidation will be promoted. At decommissioning, a low-permeability mass of tailings will have been created within a highly permeable groundwater regime. The groundwater will take the path of least resistance, around rather than through the tailings, minimising advective removal of contaminants from the tailings and leaving only molecular diffusion as the predominant contaminant release pathway.

Radiation Protection

Radiation protection has been the primary factor in the designs for mining and processing McArthur River ore. Extensive efforts were put into modelling work situations to demonstrate compliance with the recommendations of ICRP Publication 60. To minimize exposures the following steps are being taken:

- Radon gas and progeny controlled by
  - a dual ventilation system, supplying fresh air to all active work areas with secondary exhaust to remove contaminated air from point sources.
  - the freezing and grouting techniques used to control ground water.
- Ore fully contained at all stages.
- Gamma radiation controlled by shielding, distance and time. Heavy-walled steel pipes, thick vessel walls, concrete and sometimes lead sheeting are standard practice.
- Remote mining, handling and processing with computer control.
- Low tonnages required allow a long period between scheduled maintenance work.

Every job has been analysed for exposure time, and distance and shielding calculations have been done to ensure acceptable radiation doses. Design calculations have been confirmed by physical measurements of radiation fields around pipes filled with high-grade ore from the test mining at Cigar Lake, and at the existing Key Lake and Rabbit Lake mills. The radiation exposure calculations included estimates of exposures arising from equipment maintenance and spill clean-up. The predicted annual doses for the workers are well under the regulatory dose limit.

Actual experience with radiation control, the treatment of radon-rich mine water, and waste rock management during the underground exploration phase have shown that the techniques used provide excellent results with minimal exposures.

ENVIRONMENTAL ASSESSMENT

After the five projects were referred to FEARO for environmental assessment, FEARO and the province of Saskatchewan developed terms of reference and applicants were considered for the panel to conduct the hearings and assess the projects. The objective was to form a panel with the necessary expertise to assess the many different aspects of the projects, including mining engineering, occupational health and safety, the physical and biological environment, mill chemistry and northern native issues. Assembling the panel took about six months, because the panellists not only required the necessary expertise but also should have had no past connection with the uranium industry nor have expressed any views about the uranium industry. The Panel started with a familiarisation tour of operating, decommissioned and proposed new uranium mines, in the fall of 1991. The Panel held scoping meetings in nine northern and three southern communities in Saskatchewan in early 1992 to garner public input into the assessment process, resulting in one of the most comprehensive sets of guidelines yet developed for an environmental assessment. After a public review of the draft, the guidelines were issued in September, 1992, in the form of 78 single-spaced pages of issues to be dealt with by the proponent plus an additional 22 pages of information requests to government agencies (Joint Federal-Provincial Panel, 1992). Field work to develop the necessary information had actually started before the project was referred to FEARO and continued through the assessment process. Before these studies were complete, 17 different consulting firms were used with specialties ranging from hydrogeology, through aquatic biology, air dispersion analysis, environmental pathways analysis and radiation protection, to socio-economic impact assessment.

When the decision was taken to have the Panel review the underground exploration, an EIS was assembled from the environmental studies to that time (Wittrup, 1992). The Panel conducted hearings at five northern and two southern communities in December, 1992. After a favourable report from the Panel (Joint Federal-Provincial Panel, 1993) and licensing by both the AECB and the province of Saskatchewan, shaft sinking commenced in the spring of 1993.

The main EIS (Wittrup, 1995), assessing the impacts of construction, full underground production, ore transportation, milling and tailings disposal at Key Lake, and decommissioning of all facilities, in 15 volumes totalling 12,000 pages, was issued for public review in December, 1995. Panel information sessions were held in March, 1996, to familiarize the Panel with the documentation and to identify issues requiring further information. After these sessions, the Panel issued a request for further information which was supplied in an addendum of two volumes totalling 800 pages in June, 1996 (Wittrup, 1996). After a further public review period, the public hearings were conducted between September 4 and October 7, 1996, at two southern and two northern communities. (Sessions had been scheduled in more northern communities, but some of these opted out in an effort to force the government into bargaining on resource revenue sharing.) The Panel issued its report recommending approval of the project with conditions in February, 1997 (Joint Federal-Provincial Panel, 1997). After a public comment period for the Panel report, the federal and provincial government approvals were received in May, 1997 (Government of Canada, 1997; Government of Saskatchewan, 1997). The licensing of various details of the construction by the AECB and the province of Saskatchewan is proceeding.

The topics covered in the EIS included the expected ones such as the baseline aquatic and terrestrial environment, rare and endangered species, regional geology and mineralogy of the ore body. Because this is an extremely high-grade ore body, mining methods, radiation protection and waste management were of prime importance. An economic assessment was required to demonstrate that there would be a net benefit from the development. However, in addition to these topics, impacts on community health and community vitality, and cumulative impacts also had to be assessed, despite the fact that the nearest community is well over 100 km away and the nearest other development is some 50 km away.

The assessment of the operation included a regional ecological risk assessment (SENES, 1994a, 1994b, 1995a, 1995b) to identify those factors of greatest significance, and environmental pathways analysis to predict the impacts during operations (SENES 1995c, 1995d) and on potential future occupants of the area long after the operations are decommissioned (Beak, 1994).

DISCUSSION

While the outcome of this assessment has been a happy one for the joint venture partners, the authors question the need for such a microscopic examination of what is really a relatively small mining project. It appears that the environmental assessment process has become so detailed and so all-encompassing that only extremely rich ore bodies could afford to support the costs that this work entails.

Northern Saskatchewan is an area of some 250,000 km^2 with a population of only 35,000. There are three producing uranium mines and four others either planned or under construction. The nearest community to any of these mines is Wollaston Lake, which is 35 km from the Rabbit Lake mine. In many cases there is no road access between the mine sites and the communities. The uranium is generally found at the contact between the Archaean basement rock and the overlying Athabasca Sandstone. The earlier mines have been on the edges of the Athabasca Sandstone basin, where the contact is close to the surface. Later discoveries have been further into the Basin as evolving geophysical techniques allowed the discovery of deeper deposits. The Basin itself is not particularly productive, being sandy with low rainfall and low nutrient levels in the soil. Hence, the Basin does not produce abundant food and there are no permanent settlements in the middle of the Basin. Despite this situation, great concern has been expressed about the impacts of mines on communities and the cumulative impacts of the mines. The EIS guidelines required detailed examination of these issues.

In the past, the feasibility study and financial analysis that a company would do to satisfy its board of directors was considered sufficient justification for the economic basis of a project. A company was unlikely to invest money in a project that was not going to be profitable, and directors' due diligence would not permit this to happen. However, for this project an extensive economic analysis was required to publicly demonstrate that a market existed for the uranium, that the project was going to profitably recover that uranium and that all interested parties would get their share of that profit. It was pointed out by more than one intervenor that the Panel was asking these questions but had no one with business credentials in its membership to provide the necessary financial assessment. Fortunately, this project had such clear economic benefits that it did not take a high level of business acumen to reach a proper conclusion. The problem that this type of analysis presents for the proponents is that much of its business is opened to public scrutiny, which can be very detrimental in a highly competitive business.

Socio-economic issues have also become extremely important. However, the examination of these issues has gone far beyond what has traditionally been required. Because of the remoteness of the mine sites and the lack of roads, all the northern mines operate fly-in camps. Workers are picked up from small communities all over the north and flown into the mine sites, where they work for one week before returning home for a week off. These communities have grown beyond the capabilities of the local environment to support them by a traditional hunter-gatherer lifestyle, but because of their remoteness, there is little opportunity for wage-earning. The mines are one of the few sources of employment and (quite rightly) the provincial government through its surface lease agreements with the mines encourages the preferential hiring of northern residents. However, in assessing the McArthur River project, the Panel asked that extensive information be gathered on the impact of hiring northerners for mine jobs. Naturally it was known and expected that fly-in camps were disruptive to family life and do not work well for everyone. However, when one considers that the traditional lifestyle required a trapper to be away from home for days, even weeks, at a time, there is little difference, except that the transportation is more reliable and the camp accommodation more comfortable than a trap line affords. Nevertheless, the impacts of this type of employment had to be examined, with questions even being raised as to whether or not it is a good idea to create economic divisions within the community by giving people the well-paid mining jobs.

Questions such as the advisability of building roads were debated. Without exception the northern communities want roads to improve communication with the south and reduce the cost of bringing in supplies. But others, frequently not from the north, complained that building roads would open the north more and result in increased hunting and fishing pressure on limited resources. They also questioned the impact that easier communication would have on northern lifestyles. This debate did point out the generation gap, with many elderly people preferring the old ways (although recognising that these would no longer support the larger community), while the youth clearly wanted the modern lifestyle that they see on television.

The net effect of all this microscopic examination has been a number of Panel recommendations for monitoring socio-economic impacts, community health and community vitality. This has resulted in the formation of several committees to examine these issues and develop monitoring protocols for matters which the committees themselves do not fully understand.

For all its value to the uranium business, McArthur River is a very small mine. At full production, it will produce only 125 tons of ore per day, compared with 1,000 to 2,000 t/d at earlier Saskatchewan mines such as Rabbit Lake and Beaverlodge and up to 8,000 t/d at some of the Elliot Lake mines. Unless the material being mined has some particularly nasty properties, the environmental impact of a mine is primarily a function of the mine production, both ore and waste rock. Ore transport impacts are also in proportion to production. An underground mine produces proportionately much less waste rock than does an open pit mine. In the case of McArthur River, much of the waste rock will be used as back-fill underground, further reducing the amount of waste rock to be left on surface at the end of the operation.

In situations where a mineral zone spawns several mines on adjacent properties, cumulative impacts are a serious consideration, e.g., the Sudbury nickel-mining area in Ontario. The impacts of several operations discharging effluent into a single stream can be significant and should be considered in the environmental assessment. However, in the northern Saskatchewan context, where mines range from 40 to 300 km apart and are generally discharging effluents into different water bodies, although possibly part of the same drainage basin, the concept of cumulative impacts is overworked. And yet, this has become another buzz word in modern environmental assessment; companies are asked to assess the cumulative impacts of operations which are hundreds of kilometres apart with no reasonable expectation of having anything other than a very localised impact. Cumulative air emissions had to be examined, despite the fact that no changes can be measured in airborne radionuclides at more than a couple of kilometres from any operating site. The cumulative impacts to air and water then had to be translated into dose and risk estimates for the distant northern communities.

The employment will be small. Because Key Lake is running out of ore, McArthur River ore will be processed there, meaning no new mill is required. The cessation of mining at Key Lake reduces the work force there. McArthur River will supply new jobs to replace those lost, but the net additional employment will only be about 125 jobs.

Certainly McArthur River will have an economic impact which is far out of proportion to its physical size and environmental impact. It will generate large amounts of revenue for the federal and provincial governments in the form of taxes, royalties, and lease and licence fees. But these are positive impacts, which were more than adequately dealt with in the economic analysis.

Not only was the process long, but the regulatory requirements changed over the period with the net result that the hurdles continually got higher. Some of this change was as a result of the Panel process itself (through recommendations in reports on projects that were assessed before the McArthur River assessment was complete) and some was from normal regulatory/political evolution. We started the process believing that we were providing more information than was required by any regulation; “going the extra mile”. This was a conscious decision to produce the best EIS possible in order to minimize negative regulatory impact. Because of the changes in regulatory and panel perception, in the end we had done just enough work to meet regulatory and panel expectations.

A further bizarre development arose after the Panel process ended, when applications were made for approval of construction of bridges and culverts on the road between McArthur River and Key Lake. Despite the fact that the road had been part of the assessment process and the subject of specific recommendations by the Panel, the regulatory agencies involved felt compelled to do a further environmental screening of the road-building for potential referral to another Panel!

CONCLUSIONS AND RECOMMENDATIONS

Intensive environmental assessment is a phenomenon of the late twentieth century. Our society is demanding ever more stringent examinations of new developments. If major impacts are not identified, then the assessment effort is blamed and additional examinations are demanded. Canada is a wealthy country, blessed with mineral resources rich enough to support this level of effort, but how long can we afford to continue along this path? Under the present assessment approach, small ore bodies, which would have been economical to develop 20 years ago, are no longer viable, because they cannot support the level of effort required to go through environmental assessment and licensing.

We must temper our environmental ardour and make assessment effort commensurate with the size of the project and its ability to do damage. We must more severely limit the matters which can be opened in an environmental assessment. Some consideration of socio-economic issues is justified, but a project which is going to create 125 new jobs in an area with 35,000 people, most of whom are unemployed, is not capable of an enormous impact and does not justify the depth of study which has been employed.

Although these comments refer specifically to the Canadian regulatory regime, in general they would apply elsewhere. The case for public hearings is best made for completely new technology, for which there are no regulations and no industrial or regulatory experience. The uranium industry is a mature industry, regulated by agencies that have long experience and detailed knowledge of the industry. Recent developments have been in areas where there have already been uranium projects, which have been assessed in detail and are closely monitored. Under such circumstances it is difficult to justify a full-blown environmental assessment, as conducted for McArthur River. The licensing of such projects should be allowed to proceed through the normal regulatory process, without the need for extended studies and public hearings.

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KEY WORDS

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