URL CLOSURE: WHAT IT TAKES TO DECOMMISSION AN UNDERGROUND RESEARCH FACILITY

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ABSTRACT

Atomic Energy of Canada Limited's (AECL) Underground Research Laboratory (URL) was built to provide a facility where concepts for long-term management of Canada's nuclear fuel waste in a deep geological repository could be studied. Construction of the URL began in 1982 with completion of the construction phase in 1990 followed by the experimental phase.

In 2003 a decision was made to discontinue operation of AECL's URL and ultimately decommission and permanently close the underground portion of this facility. Following the completion of a number of underground experiments, closure activities commenced in 2005. Decommissioning was managed and planned by AECL with support from J.S. Redpath Ltd., a mining contractor who had provided long term construction and operations support to the URL. From 2006, the URL decommissioning was funded under the Nuclear Legacy Liability Program (NLLP), through Natural Resources Canada (NRCan). All underground-related closure activities were completed in late 2010.

As part of a carefully planned decommissioning process, a comprehensive closure plan was developed and submitted to the Manitoba Provincial government for approval in 2006. The closure plan included the decommissioning of all surface and underground boreholes and the safe removal of all underground infrastructure and equipment where technically and economically feasible to do so. Surface and underground boreholes were decommissioned and grouted to limit the upwards migration of deep, saline groundwater at the site. The final stage of closure was sealing the access and ventilation shafts with concrete caps.

Decommissioning an underground facility to the extent and completeness the URL was decommissioned has never been undertaken in Canada before now. Extensive planning and the development of unique methodology and equipment were keys to the success of the project.

1. INTRODUCTION

The URL was situated in the Lac du Bonnet Batholith, in eastern Manitoba near the Whiteshell Laboratories (Fig 1). The Lac du Bonnet batholith is composed of pink and grey granitic rock with several near-surface faults.

The access shaft and ventilation raise intersect an ancient thrust fault (Fracture Zone 2 – FZ2) at approximately the 271 m to 275 m depth in the main shaft and 265 m to 268.5 m in the ventilation raise. FZ2 is an active hydraulic pathway in the Lac du Bonnet batholith and this feature is the dominating structural and hydrogeological feature at the URL site.

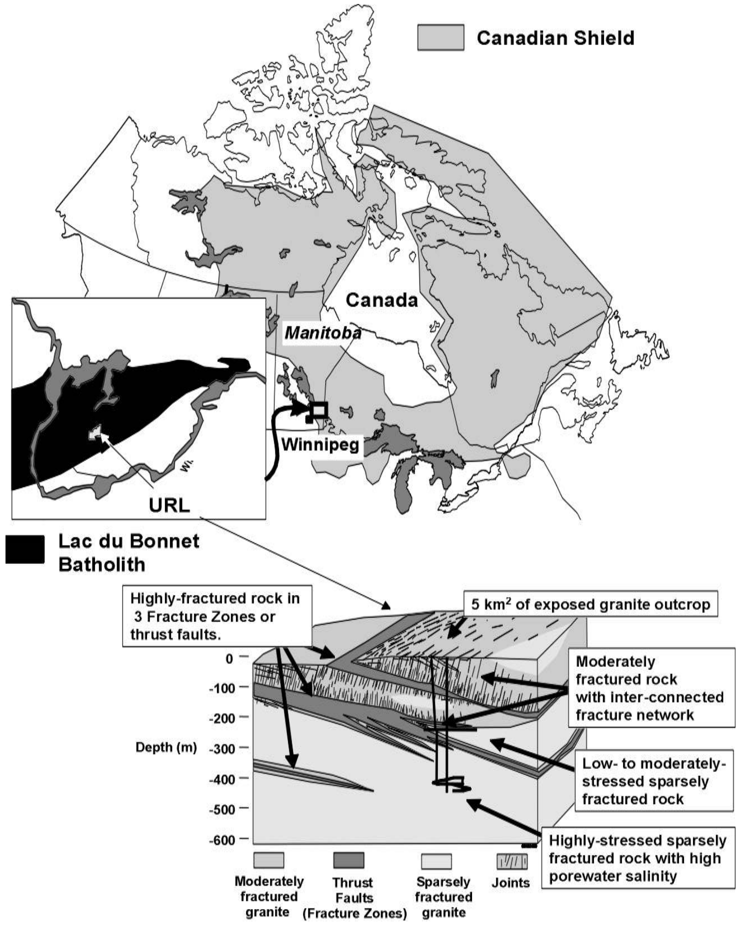

Figure 1. Location and geology of the URL site.

Construction of the URL commenced in 1982 and was completed in 1990. The experimental phase followed completion of construction. During the experimental phase the URL provided much of the technical information used in developing the deep geological repository concept submitted by AECL to the Government of Canada in 1994 [1] and continued to provide valuable technical data after that submission.

The URL consisted of two major levels (240 and 420 Levels) and two drilling stations (130 and 300 Levels) accessed by a 443-m-deep shaft (Fig. 2). The upper part of the shaft from surface to 255 m depth is rectangular (2.8 m x 4.9 m) and the lower part is circular (4.6 m in diameter). Exhaust air ventilation raises/escape ways connected the surface and 240 Level, and the 240 and 420 Levels. The ventilation raises were excavated by raise boring. The access shaft and the majority of the tunnels were excavated by drilling and blasting. The shaft, raises and tunnels totaled approximately 2.5 km in length.

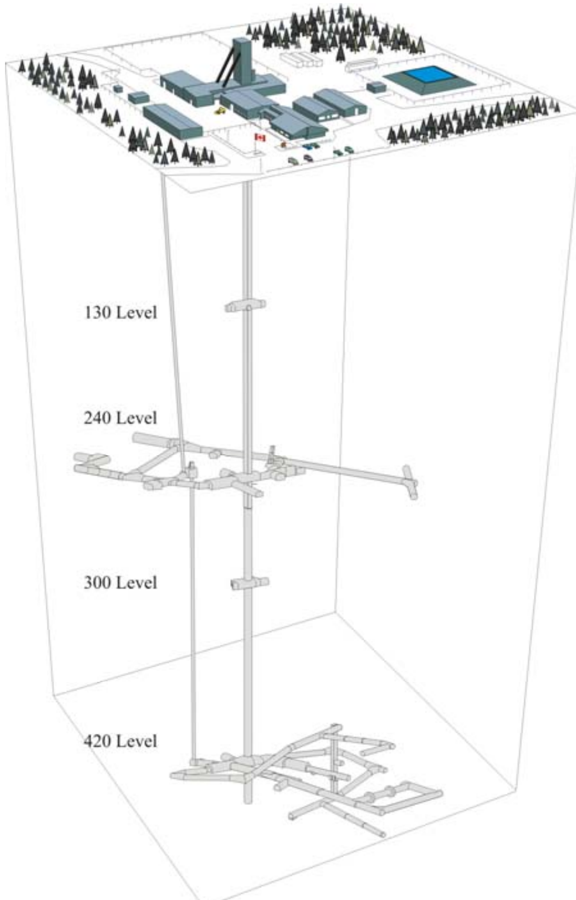

Figure 2. URL isometric.

The experimental phase continued until 2003 when closure of the facility was announced. The closure phase continued until 2010 when the underground access points were sealed at surface.

2. CLOSURE PLAN DEVELOPMENT

In 2003 February, AECL management announced the permanent closure of the URL. The planning process was started and a closure plan was developed. In the development of the URL Closure Plan, the health, safety, and protection of the workers, public, and environment were recognized as the highest priorities. The principle of reduce, reuse and recycle was also adhered to where ever possible to minimize materials destined for landfill sites. The plan and associated cost estimates underwent extensive review by AECL and was accepted by senior management in 2004 November.

The URL Closure Plan was developed around several key Provincial and Federal regulations. As the URL was considered a mine, closure was regulated under the Province of Manitoba's Mines Act. The plan had to meet Provincial government mine closure regulations, and Provincial approval was required before final closure activities could take place. The plan included the decommissioning of all surface and underground boreholes and the removal of all underground infrastructure and equipment where technically and economically feasible to do so.

The key Provincial and Federal regulations and their requirements listed below:

- The Mines and Minerals Act: Mine Closure Regulation 67/99
  - Preparation of a Mine Closure Plan,
  - Assurance of finances for closure, and
  - Annual reporting to the Province.
- Groundwater & Water Well Act: Chapter G110
  - Prevention of vertical movement of water (URL boreholes were sealed per Mines Act Drilling Regulation 63/92).
- Canada - Manitoba Agreement for Environmental Assessment
- Mine Closure Regulation 67/99 - General Closure Plan Guidelines
  - Eliminating unacceptable health hazards and ensuring public safety,
  - Limiting the production and circulation of substances that could damage the receiving environment and, in the long term, eliminate the need for maintenance and monitoring,
  - Restoring the site to an acceptable condition,
  - Where technically and economically feasible to do so, underground infrastructures and equipment must be removed, and
  - Sealing the access and ventilation shafts with concrete caps.

The URL Provincial Closure Plan was completed and submitted to the Province of Manitoba Mines Branch in 2006 July.

In 2007 November, NRCan, as the responsible federal funding authority, requested an Environmental Screening of the URL Closure Project to be carried out by the Canadian Environmental Assessment Agency (CEAA) under the Canadian Environmental Assessment Act. The Environmental Screening Assessment was prepared by AECL and submitted to NRCan for review during 2008. In 2009 January the CEAA decision stated the authority may exercise any power or perform any duty or function with respect to the project because, after taking into consideration the screening report and taking into account the implementation of appropriate mitigation measures, the authority is of the opinion that the project is not likely to cause significant adverse environmental effects [2].

The URL Provincial Closure Plan was revised based on comments received from Provincial Departmental review, and text was added regarding conduct of the Environmental Screening. The revised URL Provincial Closure Plan was submitted to the Province of Manitoba Mines Branch in 2009 December and Provincial acceptance was provided in 2010 April, with the caveat that the Province reserves the right to extend the post-closure monitoring period beyond the currently envisioned three-year timeframe.

While the planning and review processes where underway, efforts began to decommission and remove unused and unnecessary underground equipment and installations. Between 2003 February and 2006 January, several underground installations were removed as time and resources permitted. These included the Tunnel Sealing Experiment [3], as well as two Canadian Nuclear Safety Commission (CNSC) licensed laboratories. Prior to the request to have CNSC licensing revoked, free-release surveys of the two underground CNSC licensed laboratories were conducted in 2003 August to demonstrate no residual fixed or loose contamination existed above AECL free-release limits.

The decommissioning of main tunnels and removal of underground furnishings commenced in 2006 as part of NRCan's funding of the NLLP, which allowed implementation of the URL Closure Plan.

By 2007 December, the decommissioning of all tunnels, services, and underground boreholes had progressed to the point where shaft decommissioning could commence. Preparations for shaft decommissioning started in 2008 January and shaft decommissioning commenced 2008 December.

Shaft decommissioning was completed with the capping of all underground openings in 2010 October. Significant decommissioning dates are summarized in Table 1.

Table 1: Significant URL decommissioning dates.

2003 February	URL closure announcement, commencement of URL Closure Plan development, commencement of underground decommissioning
2004 November	AECL risk review of URL Closure Plan completed
2006 January	Commencement of main tunnel decommissioning
2006 July	Submission of URL Provincial Closure Plan to the Province of Manitoba
2007 November	NRCan request for URL Closure Plan environmental screening
2008 January	Commencement of shaft decommissioning preparations
2008 December	Commencement of shaft decommissioning
2009 January	CEAA decision on URL Closure Plan environmental screening
2009 December	Submission of revised URL Provincial Closure Plan to the Province of Manitoba
2010 April	Province of Manitoba acceptance of URL Closure Plan
2010 October	Completion of underground decommissioning, capping of underground openings

3. CLOSURE METHODOLOGY

3.1 Borehole Decommissioning

To limit the vertical movement of fluids and prevent the mixing of groundwater with differing chemistries, surface and underground boreholes were decommissioned and sealed (Fig. 3). Cement grout, clay pellets, or a combination of both were used to seal the boreholes depending on conditions. Where boreholes intersected hydraulically active zones, they were equipped with AECL designed multiple packer systems. A total of 177 surface boreholes, ranging in length from 3 to 1500 m, and 120 underground boreholes, ranging in length from 30 m to 700 m, were decommissioned.

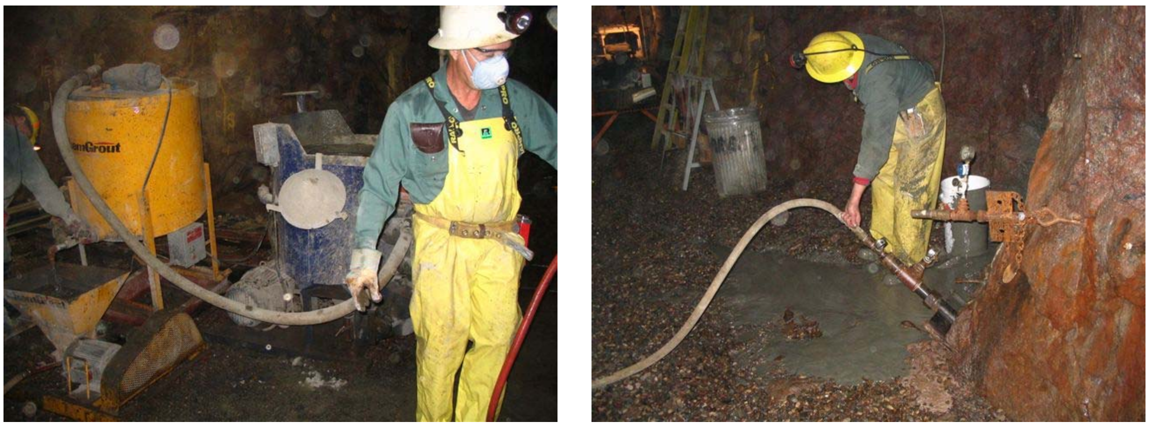

Figure 3. Borehole grouting.

Twenty-two surface bedrock boreholes within a 500-m-radius of the access shaft were retained and instrumented to monitor post-closure geochemistry and groundwater levels. These boreholes will be monitored for a minimum of three years post-closure. The monitoring equipment will be removed and the boreholes sealed upon completion of the monitoring period.

3.2 Tunnel Decommissioning

Tunnel decommissioning included the removal of all infrastructure (such as service water, fire water, and potable water lines, compressed air lines, electrical cables, cable tray, pipe hangers, data acquisition and phone lines, ventilation ducting, and lighting) and equipment (such as electrical transformers, fans, and pumps). The only materials left behind were rock bolts, borehole instrumentation seized in dry or grouted boreholes, rails/track embedded in concrete, and concrete structures such as equipment foundation pads, walls, and travel-ways (Fig. 4).

Figure 4. Tunnel decommissioning – before and after.

The two main horizontal developments (240 Level and 420 Level), and minor developments (130 Level and 300 Level) totaled approximately 1600 m in length. Generally, decommissioning activities progressed upwards from farthest from the shaft to closest. Ventilation and emergency egress requirements were considered in the sequence of tunnel closure planning.

3.3 Shaft and Ventilation Raise Decommissioning

The URL access shaft is vertical with a total length of 443 m. The shaft was excavated in two stages. The upper portion of the shaft, from surface to 255 m depth, had a rectangular cross section (2.8 m x 4.9 m) and a timber framework. The lower portion, from 255 m depth to 433 m depth, was excavated with a circular cross section (4.6 m in diameter) to better accommodate the higher stress conditions encountered at depth. The lower shaft was furnished with galvanized steel framework.

Raise bored exhaust ventilation raises connect the 420 Level to 240 Level, and the 240 Level to surface. The vent raises also functioned as emergency escape ways.

Shaft decommissioning required a much higher level of planning and preparation than tunnel decommissioning. Working at heights, working in close quarters, and the relatively limited emergency egress were much more of an issue in the shaft than in the tunnels. To identify potential problems and dangers, a comprehensive project hazard analysis was carried out cooperatively by AECL and J.S. Redpath Ltd. To mitigate the hazards, unique methodology and procedures along with specialized equipment had to be developed.

3.3.1 URL Hoist Reconfiguration

For shaft decommissioning, the URL hoist and shaft conveyance system had to be reconfigured. The cage conveyance normally used for travel in the shaft was removed and replaced with a sinking bucket to facilitate transport of personnel and decommissioned material (Fig. 5). The URL hoist was converted from a double rope system of cage and counterweight, to a single anti-spin rope with a clevis for attaching the bucket.

Figure 5. Sinking bucket and bird cage.

Hydraulic shaft safety doors were installed at surface and in the shaft. When closed, the safety doors blocked the shaft and provided overhead protection for personnel working in the shaft while the sinking bucket was loaded or unloaded at surface.

The sinking bucket would travel up and down the shaft within the framework of a crosshead. The crosshead provided stability for the bucket and prevented it from coming in to contact with the shaft furnishings during travel. The crosshead would chair just above the working level, allowing the bucket to descend unencumbered.

For protection of personnel while traveling in the bucket, a wire mesh "bird cage" was mounted in the crosshead. The bird cage could be lowered to mate with the sinking bucket, enclosing the personnel. A radio signal system and phone was installed on the bird cage to allow personnel in the bucket to communicate with the hoist operator on surface to direct the movement of the bucket.

3.3.2 Galloway Stage and Shaft Decommissioning

The main piece of equipment used in the shaft decommissioning was a movable, three-deck platform called a Galloway Stage (Fig. 6). The Galloway Stage was suspended on four wire ropes, each connected to a separate winch located on surface (Fig. 7). The four winches could be operated independently to allow precise leveling of the Galloway.

The Galloway Stage had several unique design features. The lowermost deck was heavily built and designed to be detached and anchored in the shaft to function as the bottom form for a concrete shaft seal. The mid deck was used for the storage of equipment and gas cylinders and was designed to fit in both the lower (circular) shaft and the upper (rectangular) shaft. The top deck was reconfigurable with removable wings to provide a close fitting working platform in either part of the shaft. The openings in the center of the Galloway allowed the sinking bucket to pass through.

To install the Galloway in the shaft, the shaft below the 420 Level was stripped of furnishings and services. The Galloway was then assembled at shaft bottom and connected to the wire ropes.

Shaft decommissioning was carried out from the bottom of the shaft towards surface. The Galloway would be raised to the bottom of the shaft furnishings. The shaft decommissioning crew would then work from the top deck to cut away sections of the shaft framework, cables, pipes, and other services in the shaft. The material would be placed in the sinking bucket, which would be located in the center of the Galloway. When full, the bucket was raised to surface and replaced with an empty bucket. Upon completion of the removal of a section of shaft furnishings, the Galloway would be raised against the next section of furnishings.

As the shaft decommissioning process was several months in duration, considerable emergency planning was carried out. The URL Mine Rescue Team purchased additional rope rescue equipment and conducted practice exercises based on shaft emergency scenarios. The Galloway was equipped with a shaft phone, fire extinguishers, a first aid kit, and enough self-contained breathing apparatus (with a 90 minute oxygen supply) for each crew member. As the shaft furnishings above the Galloway were always intact, the shaft ladders could be reached for emergency egress should the sinking bucket be unusable.

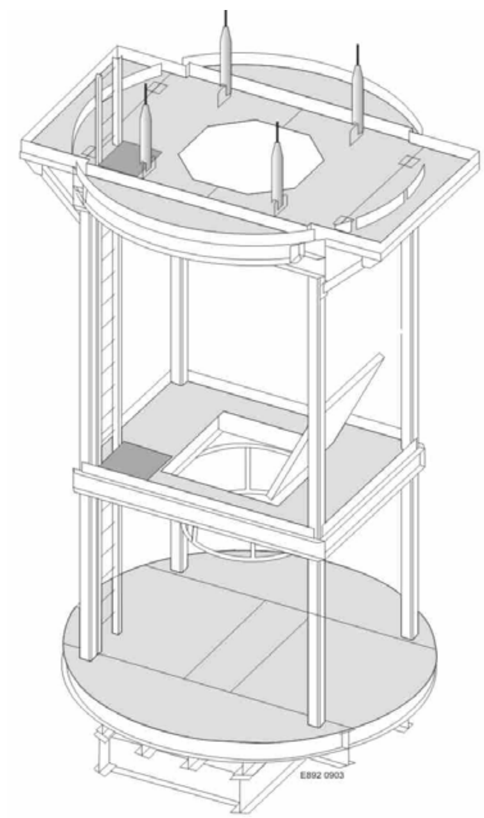

Figure 6. Galloway Stage.

Figure 7. Galloway Stage winch installation.

3.3.3 Ventilation Raise Decommissioning

The 420 Level to 240 Level, and 240 Level to surface ventilation raises were raised bored to a 1.8 m diameter. They were bored on a slight inclination to allow easy collection of any water that may flow down the raise. In addition to providing exhaust ventilation, the raises also functioned as an emergency escape way should the shaft conveyance or shaft ladders be unavailable and were fitted with galvanized steel landings and ladders.

To facilitate installation, the raise furnishings were designed to be assembled in 6-m sections and lowered from the top of the raise. A 6-m section, consisting of a lower landing connected to an upper landing by four hanging rods and a ladder, would be assembled and lowered into the raise. It would be blocked in place and another section would be added. This process would be repeated until all the landings and ladders were hanging in the raise. The landings would then be secured to the rock walls. It was decided the safest way to decommission the raises would be to simply reverse the order of installation. Prior to decommissioning, all hanging rods and attachments underwent non-destructive testing and inspection to ensure safety.

3.3.4 Fracture Zone 2 Shaft and Ventilation Raise Seals

As one of the goals of the URL Closure Plan was to limit vertical movement of water, significant effort was put into sealing underground and surface boreholes. To limit the potential for mixing of deeper saline and shallower less saline groundwater, seals were installed at the intersection of the shaft and ventilation raise with FZ2 (Fig. 8).

The construction of each seal involved the installation of heavily reinforced low alkalinity concrete component keyed into the surrounding rock. The concrete supported and restrained a central clay-sand component, which was capped by an un-reinforced concrete component. The clay-sand component spanned the exposure of the thrust fault in each shaft. Descriptions of the shaft and ventilation raise seals are provided by Martino et al. [4].

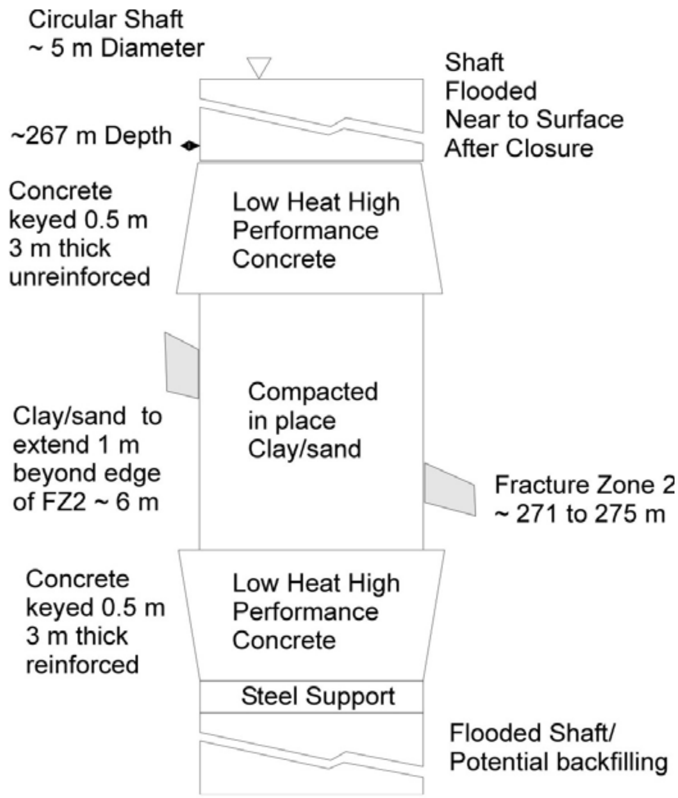

Figure 8. FZ2 shaft seal.

3.3.5 Underground Access Caps

The final stage of underground closure was the installation of concrete caps on all underground access points. Steel reinforced concrete caps were installed in the ventilation raise and access shaft at surface. The fresh air plenum, an inclined concrete duct intersecting the access shaft just below surface, was capped by filling it with concrete.

4. SUMMARY

In 2003 February, it was publicly announced the URL would be closed. Federal closure funding was announced in 2006 June, and in 2010 October, the closure of the URL underground facilities was completed with capping of the underground accesses.

Decommissioning underground facilities such as the URL are uncommon. Abandonment of mines and other underground structures is typically done with limited stray material recovery or removal of underground fixtures. Decommissioning an underground facility to the extent and completeness of the URL has never been undertaken in Canada before now. New and unique methodology, procedures, and equipment had to be developed.

During the closure of the 34,270 m^3 underground facility, 291 boreholes, 1,600 m of horizontal tunnel and 863 m of vertical shaft and ventilation raise were decommissioned. Approximately 499,000 kg of steel and timber that were installed in the URL underground were removed from the shaft and ventilation raises, reducing the potential environmental impact of the closed facility.

The main underground closure work took almost 4 years from the start of main tunnel decommissioning to shaft capping. Two years and over 48,000 contractor hours were spent in the difficult and high risk task of shaft decommissioning. It was a testament to the planning effectiveness and diligence of everyone involved that not a single loss time accident occurred during the closure process.

ACKNOWLEDGEMENTS

The URL closure activities were made possible by NLLP funding through Natural Resources Canada and successfully and safely carried out by AECL staff in cooperation with J.S. Redpath Ltd. mining personnel and support staff.

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