

# **SAFETY AND SUSTAINABLE HABITAT CONSIDERATIONS FOR THE LAKEVIEW DIVIDEND MINE CLOSURE - BATS IN THE ADIT**

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## **ABSTRACT**

The Lakeview Dividend Mine near Osoyoos, B.C. operated intermittently from 1898 to the 1940's, and was closed before reclamation legislation was in place. In 2007, The Ministry of Energy, Mines and Petroleum Resources prioritized this project for reclamation due to hazards posed by the remaining adits, shafts, unstable rock ledges, and a stope which had partially caved to surface. Reclamation plans for the site included many unique and complex components. The property has significant historic importance to the community of Osoyoos and is located adjacent to a residential neighbourhood, providing challenges related to community engagement and public safety. The mine's location is within the fragile and endangered Great Basin Ecosystem, and the mine has been recognized as an area of environmental importance due to habitation of the abandoned adits by red- and blue-listed bat species. Technical challenges in this project included preserving the bat habitat in the adits through the installation of bat gates and a ventilation raise, stabilization of a high rock face above the homes in the adjacent residential community, infilling of the open and partially collapsed stope, and regrading and revegetation of the site.

## **INTRODUCTION**

The Lakeview Dividend Mine Site (LDMS) is an abandoned mine located adjacent to the township of Osoyoos, BC. The Ministry of Energy Mines and Petroleum Resources (MEMPR) retained EBA Engineering Consultants Ltd. (EBA) to provide engineering design, project management, and construction supervision of site reclamation.

The site contained extensive underground workings, including a 120 m long by 50 m wide "glory hole" where the stope had partially collapsed to surface. On the north side of the stope, a precarious 20 m+ wide overhanging portion of the hanging wall remained, supported by slender, 10 m tall pillars of weak ore. The higher south side of the open stope was near vertical, but also had large overhangs associated with mined out areas of the ore body. Numerous open passageways leading to the underground development workings existed around the perimeter and floor of the glory hole. Three main access adits exposed in the hillside below the mine provided ready access into the glory hole.

There were several public safety issues at this site. The glory hole was encircled by a fence to prevent access, however access routes through adits and development drifts were not secured. Within the glory hole, there were extensive areas of overhanging, potentially unstable rock as well as partially blocked ore passes to haulage drifts below. The underground workings contained caved areas, ore passes and

unmarked raises. Subdivision development in Osoyoos is encroaching on the mine site, and frequent public access to the site was becoming a significant public safety concern.

Inspection of the site to develop a remediation plan revealed that the mine adits provide over-wintering habitat for several species of bats including Townsend's big-eared bat and Western small-footed Myotis, which are on the blue list for endangered species. Post closure inspections also revealed habitation by a third endangered species, the Palid bat which is a red-listed species. Mine remediation planning needed to consider methods to maintain climate and ventilation conditions within the adits to preserve this bat habitat.

The scope of work for this mine closure was unusual in that in addition to the safety concerns regularly associated with an abandoned mine, there was a challenge to also preserve the bat habitat by providing post closure access to the adits for bats, while inhibiting public access. Maintaining adequate ventilation to the closed adits was essential to provide sustainable habitat for the rare and endangered bat species within the former mine workings.

Preservation of the habitat was accomplished through installation of custom built bat gates on each of the three adit entrances, as well as the installation of a vent shaft and cap installed through an ore pass in the floor of the glory hole, to maintain convective air flow through the adits.

A second opportunity within this project to improve the environment occurred in the reclamation phase, whereby re-vegetation was completed with input from the Osoyoos Desert Society, with the objective of promoting growth of native and endangered plant species.

## **SCHEDULE**

The MEMPR was working to a strict deadline of March 31<sup>st</sup>, 2008 for the completion of all closure and remediation work. EBA was authorized to proceed in mid-September. Preparation and approval of the work plan and specifications for reclamation were completed by the week of October 22<sup>nd</sup>, 2007 allowing selection of contractor(s) to commence the following week. Initial community relations activities were carried out concurrently with the tendering process.

Site preparation, including upgrading existing site roads and construction of new access roads to the adits and glory hole began on November 26<sup>th</sup>, 2007. Infilling of the glory hole, stabilization of the adit portals, installation of bat gates, and rock slope stabilization were carried out concurrently when possible. The heavy construction work was completed on March 17<sup>th</sup>, 2008 and final site grading and re-vegetation work was completed in the final two weeks of March with the project completed on schedule.

## **SITE INSPECTION**

Full time site inspection by an EBA mine manager was provided for the duration of the project. The mine manager monitored site safety and ensured compliance with the Mines Act and Worksafe BC regulations.

Daily site inspection included monitoring the progress and adequacy of the work, recording daily work progress and costs, and addressing engineering issues. The Regional Manager for MEMPR from Kamloops was a regular visitor to the site and a contributor to the safe execution and successful completion of the project. For the project duration of approximately 2000 man days, there were no accidents and only two near misses recorded.

## **GLORY HOLE INFILL**

The glory hole was accessed from the south via an existing dirt road that joins a residential road (Fairwinds Drive) southeast of the project area. The single lane dirt road was upgraded to allow for travel of heavy equipment and to prevent washout through the winter season. Lower grades were established as well as passing bays to accommodate larger trucks and equipment.



Photo 1: Before Remediation



Photo 2: After Remediation

Given the proximity of residential development to the site, and public concerns over the use of explosives for rock excavation, the work plan included the use of clean rock fill rock from an adjacent subdivision development, and use of rock breakers to remove overhangs and flatten the steep rock faces surrounding the glory hole. Blasting was only to be considered as a last resort, and turned out to be unnecessary. Two excavators (Hitachi 350 and Hitachi 370) equipped with 10,000-kg rock breaking hammers, along with a D8K dozer with ripper were used in lieu of blasting.

The glory hole was filled from the west end progressing towards the east end. The volume of fill consisted of approximately 30,000 cubic meters of imported rock fill and approximately 12,000 cubic meters of broken rock from the edges of the glory hole.

A primary concern during the design phase of the project was safe removal of the large overhangs around the glory hole by rock breaking equipment. Even following partial filling of the glory hole with imported material, it was not possible to safely place fill beneath the large overhangs. To alleviate this concern, a ramp was constructed to allow the rock breakers to safely reach the overhangs, which were progressively

removed as the ramp was advanced. In some instances, the rockbreakers were used to remove pillars supporting overhanging portions of the stope roof, causing portions of the roof with volumes as great as 2,000 cubic meters to collapse into the mined out stope.

The highest overhangs on the south side of the glory hole were handled by benching down from the top of the slope using the excavator's 10-m reach to keep the equipment well back from unstable areas.

## **ROCK SLOPE STABILIZATION**

Stabilization of a large cracked rock pinnacle at the northeast corner of the glory hole where it intersected a high rock cliff above the adjacent subdivision, as well as stabilizing adjacent areas of the cliff, was addressed using several methods. At the base of the cliff there was an existing rock fall catchment to protect the subdivision; this was formed by an excavated 2-m wide ditch with adjacent 2-m high berm. Prior to rock stabilization work, the catchment was deepened, and widened to more than 8 m to greatly increase its effectiveness and capacity. Towards the north end, below the highest section of the cliff face, an existing gravel stockpile (for construction of a new subdivision road) also provided added protection against rock fall. Once most of the glory hole was filled, rock breakers safely removed the cracked pinnacle of rock.



Photos 3 & 4: Rock Breakers working in glory hole.

The success of the rock breakers in removing the cracked pinnacle led to the adoption of similar methodology for scaling and stabilizing adjacent areas of the cliff face above the subdivision north and south of the glory hole. The breakers were also used to establish a construction access ramp down to one of the adit portals exposed in the hillside approximately 20 m below the glory hole. Alternative options for access to this adit were either costly (requiring the use of helicopters or large cranes) or had environmental and aesthetic concerns (slash a 300 m access road across a steep slope in an area visible to the town). During removal of the rock pinnacle and stabilization of the adjacent areas, approximately 7,000 cubic meters of rock was removed, and the catchment ditch had to be cleaned out regularly to maintain its effectiveness.

The safety of houses below was successfully protected during this phase of the work, with one exception. A rock fall originating from the natural bluff south of the glory hole reached the back yard of one house in the sub-division. Investigation determined that the rock originated from a natural rock face outside of the active work area and was unrelated to the work. However, as the risk of rock fall in this area was deemed to be a safety issue, and a rock fall from this area would likely be perceived by the City of Osoyoos and the neighbourhood to have come from the mine site or remedial works; remedial actions were planned and carried out. A rock stabilization contractor, BAT Construction Ltd. (BAT) provided several experienced rock scalers to complete this work. Roped access was required, and scaling bars, jacks and pneumatic splitters were used to remove loose rock. Most of the work was done in frozen ground conditions (not ideal for scaling) and it was estimated about 3,000 cubic meters of loose rock were removed.

## **TUNNEL PORTAL CLOSURES**

### **Adit el. 147 m (Lower Development Access) Adit #1**

The lowest level adit portal on the site was accessible by a deteriorated gated road located to the north of the LDMS property. Permission from the local landowner was granted so that this road could be upgraded to support vehicles and to provide access for portal closure independent of other work on the site. This adit was the first to undergo stabilization and installation of a bat gate; however, the requirement for shotcrete delayed full closure and decommissioning of the access road until late February. Following adit closure, the road was blocked with boulders placed to prevent vehicle access to the portal area.

Initially sloughed rock and soil debris partially blocked the portal, and excavation to expose the adit invert was completed using a small back hoe. The approximate portal dimensions are 3 m wide (reducing to 2 m wide about 1 m into the adit) and 2 m high. After exposing the rock invert, a low concrete sill secured with dowels grouted into the rock was poured to form a level base for installation at the bat gate. A perimeter of rock dowels was installed to secure the gate to the rock. After intensive machine and hand scaling of the portal area, rock bolts and dowels were installed, followed by a heavy 100-mm square welded wire mesh. Shotcrete was pumped 200 m from adit 2 eliminating the need to further upgrade the existing road to handle concrete trucks. Eight cubic meters of shotcrete was applied in thicknesses varying from 50 to 75 mm.

The bat gate for this adit was partially prefabricated in WEB Manufacturing's (WEB) facility in Osoyoos. The vertical posts and horizontal bars were field cut to fit the portal. The gate was secured to the concrete sill and rock using 25-mm diameter threaded dowels grouted into the rock. The dowels were located on the inside of the gate, and nuts were threaded onto the dowels and welded to secure the gate in place and to prevent removal.



Photo 5: Adit #1, Bat Gate Installation.



Photo 6: Adit #1 Shotcrete.

#### **Adit el. 174 m North (Mid Level Access) Adit # 2**

The mid level adit to the north of the property is on a side slope above the waste rock pile and below the glory hole. An existing trail to the base of the waste rock was considered for upgrading; however, an access ramp from the partially filled glory hole was easier to construct. The new access ramp was approximately 80 m long at a nominal 10% grade, which was required to bring in the cement trucks for the shotcrete work.

Adit #2 had existing timber supports at the portal and the entrance was mostly blocked by sloughed rock and soil debris. Access to the underground working was possible through a 1-m x 2-m opening within the debris. Following removal of timbers and debris the exposed portal dimensions were approximately 1.8 m wide by 2 m high.

A low concrete sill secured with dowels grouted into the rock was be poured to form a level base in the invert of the portal for installation of the bat gate. A perimeter of rock dowels was installed to secure the gate to the rock. After rigorous machine and hand scaling of the portal area, rock bolts and dowels were installed, followed by a heavy 100-mm square welded wire mesh in the portal area. Seven cubic meters of shotcrete were applied to the portal with a thickness of roughly 70 mm.

### **Adit el. 174 m South (Mid Level Access) Adit # 3**

This adit is situated below a 20 m high rock face which extends down from the western perimeter of the glory hole. Below the adit, a 35 m high, 75% colluvial slope extends down to the west portal to the subdivision below. Access to this portal was challenging as the existing access road was narrow and partially buried with ravelled material. The existing road traversed across the colluvial slope from the south terminating about 60 m south of the portal and required extensive upgrading to allow vehicular traffic and machine access. During the initial stages of the project, this portal was accessed on foot by traversing or climbing up the steep colluvial slope.

Preliminary design included upgrade to the existing road and excavation in rock to access the portal. This would have a prominent visual impact visible to the neighbouring residents, and in the desert environment vegetation could take a long time to re-establish itself. Other options for access which were considered, included use of a large 200-ton crane to lower and raise equipment and materials to the adit, and helicopter access. Successful access was established through use of the rock breakers. Access to this adit took four weeks of breaking rock, which impeded the schedule and eliminated the possibility of completing the project ahead of schedule.

Once access to the portal was established, a backhoe was mobilized to remove rock debris which had accumulated during stabilization and scaling of the pinnacle rock, obscuring the portal. Following excavation at the portal the backhoe cut its way down the talus slope to the catch ditch below leaving this portal inaccessible to the public once construction was complete.

The approximate dimensions of this adit are 2.5 m wide and 2.5 m to the high point at the apex of the portal, widening to 3.4 m wide and 3.1 m high at a distance of 1 m into the adit.. Bedrock at the invert of the portal was obscured by more than 2 m of overburden and rock fill, so a modified design was developed for the bat gate sill. This consisted of a reinforced spread footing secured to bedrock on each side of the adit with dowels. The width and depth of the footing below the adit invert are such that it would be extremely difficult for anyone to burrow underneath.

This portal was significantly larger than the other two; hence, rock bolting, mesh and shotcrete requirements were limited to the immediate portal area. A total of 25 rock bolts, 100 square meters of mesh, and 15 cubic meters of shotcrete were installed at this portal.

### **PRESERVATION OF VENTILATION IN ADITS**

A three week study of the air circulation within the adits from openings in the mid level adits to the glory hole indicated that a surface vent was necessary to preserve the overall climate within the underground. It was noted in recent bat studies that factors contributing to favourable climate suitable for bat habitat are currently unknown; hence the preservation of ventilation and maintenance of pre-remedial climate conditions were considered to be key elements to the preservation of bat habitat.

Preservation of ventilation was accomplished through placement of an inclined culvert centrally into the mid level adit, creating a clear pathway for airflow to the top of the infilled glory hole. The culvert was placed concurrent with the filling of the glory hole. After 6 m of infill the inclined culvert was converted to a near vertical 8 ft diameter inlet at surface and fitted with grills and grates to prevent access by people. The vent location was chosen to provide the greatest exhaust from the underground workings. The installed ventilation shaft consists of a 1.8-m diameter culvert installed in the surface opening at roughly a 75 degree slope for 12 m. Then five concrete culvert rings of 3-m diameter were placed in near vertical position to bring the vent to the final grade elevation.

A vent cap was designed to allow bats to escape and minimize tampering from the public. The design utilized the basic bat gate forms with features to obstruct attempts to throw rocks in the vent or set fires on top of it.



Photo 7: Installation of ventilation cap.

## RECLAMATION

During site preparation, native soil was stripped from new access road construction and excavation areas. This material was stockpiled for use during the reclamation phase of the project. Additional local topsoil was incorporated with the stripped native topsoil.

The surface of the backfilled glory hole was contoured to promote shedding of precipitation, and covered with 200 to 300 mm of salvaged topsoil and fine-grained material stripped during the site preparation phase. The upper layer of rock fill within the pit was graded to prevent downward migration of topsoil materials. The cover was seeded and fertilized with an erosion control mix that will not compete with native species colonizing the cover.

In addition, all disturbed overburden and filled areas were reclaimed by re-contouring (maximum 2H: 1V slope) and revegetation. Rock slopes too steep to reliably retain a soil cover were not covered or revegetated.



Access roads constructed to provide access to portals and to the glory hole and to facilitate remedial activities were also decommissioned following construction activities.

## **PUBLIC CONSULTATION**

Public consultation was conducted throughout the reclamation and stabilization process to provide timely information to residents, stakeholders and First Nations and to create opportunity for engagement due to the historical and ecological project elements and the type of site activities required. The mine site activities, while designed not to create additional road traffic, still produced noise and dust from rock-breaking, rock-scaling and moving equipment. Visual impacts from the changing landscape, and altered land use would also impact the community.

Throughout the process, a variety of engagement methods was used to involve key members of the community as well as the residents in the adjacent subdivision, including meeting with the Osoyoos Town Council, the Osoyoos Indian Band and local media.

An open house was held at the onset of remedial work to elicit public input and provide awareness to the community with regard to the project scope and schedule. Display boards presented information on the historical site use and its importance to the community, wildlife and ecosystem information, the remediation work plan, and proposed next steps. Participants were invited to complete a survey examining several aspects of the project including plans for revegetation, end site use and plaque installation.

Communication with the public was maintained throughout the project, including two public notices which were distributed to residents of the adjacent neighbourhood, stakeholders, Osoyoos Indian Band, and Town of Osoyoos. The first notice was distributed in advance of construction, and described the project rationale, proposed activities and schedule, as well as contact information. The second notice provided a progress update. The local newspaper, The Osoyoos Times, ran several articles, providing progress updates to the community. While work was in progress, signs were posted at the project office located at the entrance to the site, with contact information for the on-site project manager.

Throughout the project the on-site project manager visited with nearby residents to discuss the project, answer questions and maintain communication with key community members. Midway through construction a site tour was conducted to provide a progress update, discuss upcoming activities, and identify any concerns. Several key stakeholders including the local Member of the Legislative Assembly, Town Councillors and Planner, Osoyoos Indian Band, and media attended.

In addressing the unique environmental challenges at this site, the project team engaged with local experts and stakeholders, including the Osoyoos Desert Society and the Osoyoos Museum Society. The Osoyoos Desert Society participated in planning and implementation of the reclamation process. The Osoyoos Museum Society provided historical information and photographs of the area for the open house and

plaque. In addition, a bat expert was consulted during documentation and assessment of the bat population and habitat.

At completion of the remedial works, a plaque was mounted on the central ventilation shaft to commemorate the mine site and its place within the community. The ceremony was attended by residents, stakeholders, Town Council, First Nations, members of local parliament including Honourable Bill Barisof and by the Minister of State for Mining, Kevin Krueger. Through active public engagement and good communication practices, the project was completed without complaint from the public.



Photo 8: Opening Ceremony May 2, 2008.