

THE COBALT OPTIONS PROJECT - Rehabilitation of an old Silver Mining Town in North-Eastern Ontario, Canada ¹

by

W.O.Mackasey ²

Abstract

In June 1987, Highway 11B collapsed into abandoned mine workings at the entrance to the Town of Cobalt. Although subsidence problems were not unknown to the town, this cave-in managed to cut off access to three communities and gained widespread attention of the media, government officials and politicians. Geotechnical investigation revealed a network of shallow unmapped mine workings beneath the highway. The possibility of similar shallow workings occurring elsewhere beneath the town had to be considered.

Mounting concern for public safety led some officials to believe that the town ought to be abandoned and this led to the establishment of the Cobalt Options Project in 1988. Four options were developed by a multi-agency provincial government committee:

- 1) maintain
- 2) buy-out
- 3) relocate
- 4) maintain and investigate, repair, relocate or buy-out

An abandoned mines inventory of the town was prepared as part of the Cobalt Options Project. A total of 17 areas designated for "caution status" were identified. This information, when combined with the geology of the area, influenced the committee to recommend option four.

This option was accepted by the Government of Ontario. A prioritised testing and remedial work program was initiated in the spring of 1989 and is expected to be completed by 1993.

Key Words: abandoned mines, rehabilitation, geotechnical testing, subsidence, public safety.

1.0 Introduction

The town of Cobalt is located in northeastern Ontario approximately 450 kilometres north of Toronto. (Figure 1) The area is underlain by Precambrian meta-sedimentary and metavolcanic rock forming the southern part of the Canadian Shield.

The town was founded with the discovery of high grade silver deposits in the early 1900's. Over 100 producing mines were

created, some with spectacular native silver veins. The town grew from a bush camp to a full fledged metropolis by 1910, complete with electric trams and regularly scheduled railway service. Many of the Cobalt developments have since become Canadian folklore.

The discovery of high grade veins up to 12 inches wide and grading over 5,000 ounces silver per ton attracted miners and

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² William O. Mackasey is Provincial Supervisor, Abandoned Mine Hazards Abatement Program, Ontario Ministry of Northern Development and Mines, 933 Ramsey Lake Road, Sudbury, Ontario, Canada, P3E 6B5

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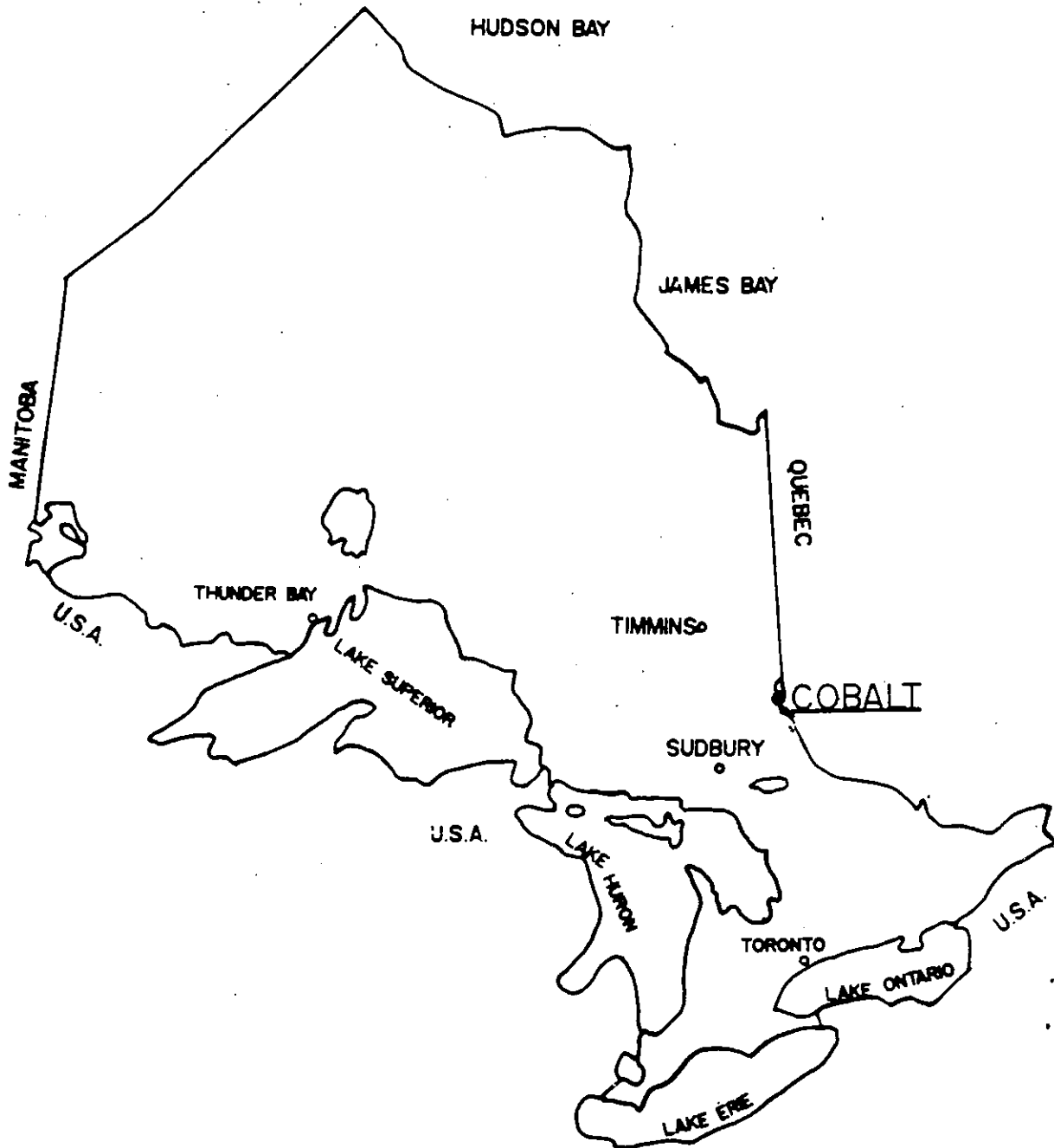


FIGURE 1 LOCATION MAP

prospectors from around the world. The development activities in Cobalt laid the foundation for much of Canada's existing mining infrastructure. Many prominent Canadian prospectors, geologists, mining engineers and metallurgists have Cobalt as part of their family history.

Silver mining peaked in Cobalt in the 1920's. The last of the mines in the area closed in 1990. Cobalt is now a residential community with a population of 1480 people, of which many are retired miners and engineers from past mining operations.

2.0 Public Safety

Many of the steeply dipping silver veins were mined close to or through to surface. As a result, safety fences, erected by mining companies and/or government agencies criss-cross throughout the community. In 1981, the Ontario government issued a study of underground workings in the municipality (Cunningham and Hurst, 1981). This study was used in the development of the town's official plan, in which zones of "mining use only" were designated. Reports exist of cave-in problems over the years. Due to the narrow nature of the mine workings, the cave-ins were generally small and quickly repaired by local mining companies.

3.0 Highway 11B Collapse

On June 22, 1987, a part of Provincial Highway 11B collapsed into abandoned mine workings. As a result, southern access was cut off into, not only Cobalt, but to two other towns as well. These three towns, Cobalt, Haileybury and New Liskeard form what is known in the province as the "Tri-town" area. The Ministry of Transportation quickly realized that a major crisis existed as road access was cut off for thousands of residents in the region.

The author was given the assignment of heading an action committee to investigate and develop recommendations. A multidisciplinary committee was struck, in the next few days, consisting of provincial government agencies, municipal officials and a geotechnical consultant.

As the cave-in was beneath a provincial highway, very rigid standards had to be met

for both investigative work and reconstruction. Of particular concern was the fact that the Cunningham and Hurst Study (1981), did not report any near surface mine workings in the vicinity of the collapse. Cunningham did show, however, that suspicious areas occurred elsewhere along the highway corridor.

4.0 Highway 11B Corridor Investigation

It was agreed by the above committee that a five-fold geotechnical investigation be mounted. The five tasks (Carter et al, 1988) included:

- i. Using data from old mine drawings, plans and sections, plot zones of potential concern onto a topographic map,
- ii. Assembling old mining records and additional hearsay data from old miners and town officials to delineate other uncharted problem zones,
- iii. Undertaking composite surface geological and geophysical surveys (including ground penetration radar) to delineate anomalous areas requiring further attention,
- iv. Carrying out drilling investigations (air track and diamond drilling) to determine thickness and quality of rock mass in crown pillars overlying problem zones, and
- v. Where possible, undertaking downhole camera and / or ultrasonic profiling to delineate geometry and extent of problem zones.

Investigative work at the highway cave-in revealed the presence of a maze of underground workings (Figure 2). A major advance was the discovery of an uncharted near-surface level of mine workings that had been established in the 1930's. Interviews with retired miners and examination of old sketch maps revealed that during the 1930's depression years, many of the abandoned workings were reactivated by lessors who exploited the remaining high grade surface crown pillars. The committee learned that excavation by the lessors was commonly taken right to the overburden interface. In

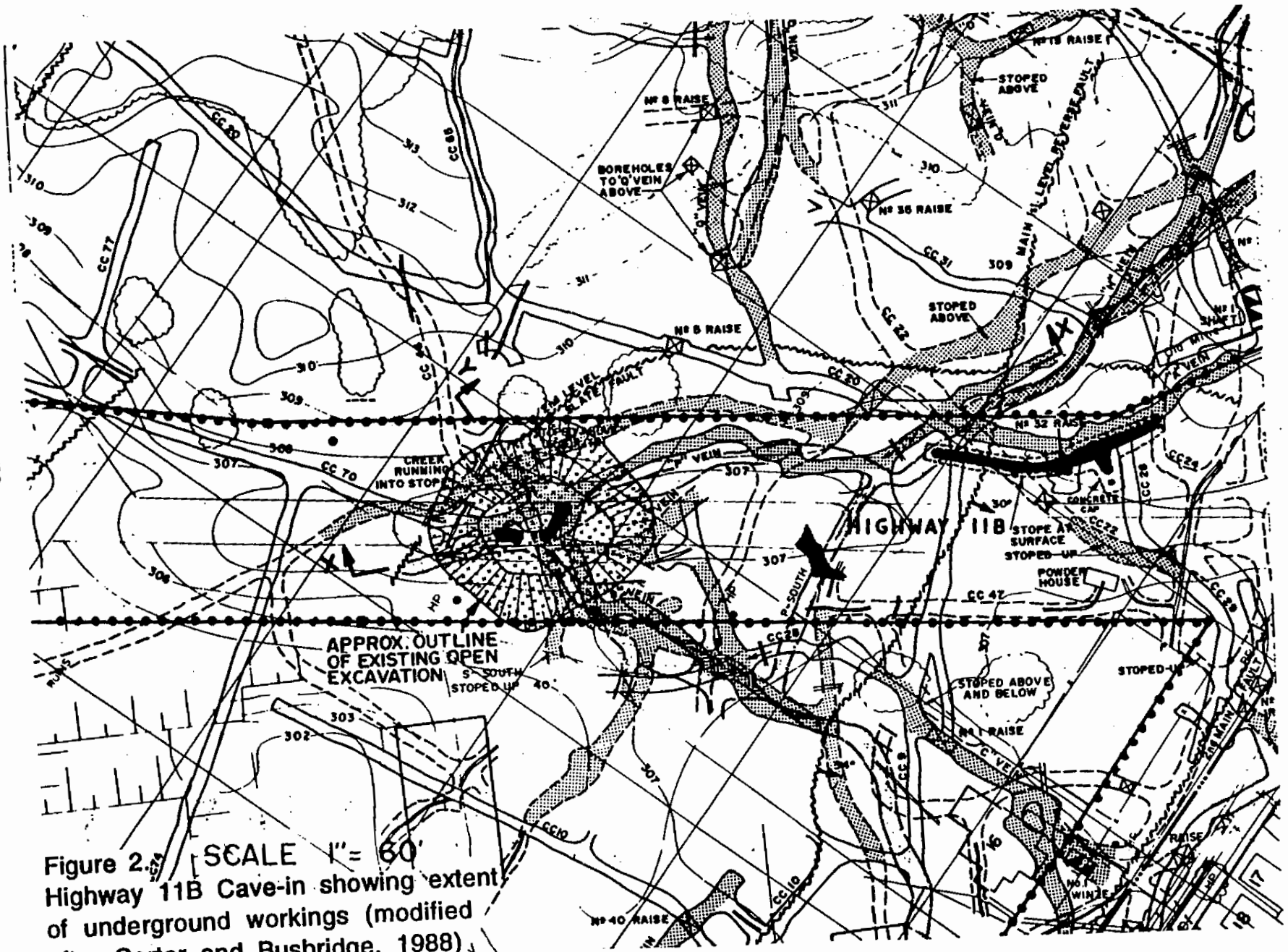


Figure 2.5 SCALE 1" = 60'
 Highway 11B Cave-in showing extent
 of underground workings (modified
 after Carter and Busbridge, 1988)

some cases, timbering had been used to support the overburden.

As the geotechnical investigation progressed eastward along the highway corridor through the town, more uncharted mine workings were encountered. Of particular concern was the discovery of expansive empty workings adjacent to and beneath a home for senior citizens.

5.0 Concern for Public Safety

Maps produced by the Cunningham and Hurst Study (1981) showed that mine workings were widespread beneath the town. Most, however, were shown to be at sufficient depth to pose no public safety concern. The committee was faced with a dilemma in that the extent of the lessor's mining activity was largely unknown. It could easily be argued that if unsafe workings occurred beneath Highway 11B, then they certainly could or would be found elsewhere in town. Timber supports, now a half a century old may no longer be stable.

After several months of witnessing drilling, excavation and survey crew activity, some town residents and public officials began to question the wisdom of continuing residency in the town.

The Provincial government established a formal committee, the Cobalt Abandoned Mining Hazards Committee, to examine public safety issues, with representatives from the town (including the mayor), and the Ontario Ministries of Northern Development and Mines, The Environment, Transportation, Housing, Labour and Municipal Affairs. Members of this Committee soon began to realize that in addition to the public safety issues, the widespread presence of abandoned mine hazards seriously affected a number of government programs. For example the Ministries of Transportation and the Environment were working toward multimillion dollar improvement programs for road reconstruction and a new water and sewer systems respectively. These ministries were faced with potential for extreme cost over-runs on their projects if mine workings were encountered and had to be bridged. The blasting required for construction work could possibly induce

collapse of unmapped nearby workings and pave the way for civil lawsuits. There was also risk that some sections of the town might have to be abandoned if serious large hazards were found. This would have the potential of rendering useless the millions of dollars expended collectively by the many government agencies on public works projects. The Cobalt committee thus became an interdisciplinary body whose real strength came from working together on a common front to solve each other's problems.

6.0 Cobalt Options Study

The Cobalt Abandoned Mine Hazards Committee was able to demonstrate that a formal review of the town's future must be done before any further public works projects be attempted.

A Cobalt Options Study was initiated in the fall of 1988 to analyze the pros and cons of:

- a) Continuing remedial action in order to maintain and service the existing settlement,
- b) Buying out the town, and
- c) Relocating the town.

A task force of seven Ontario government ministries was formed and a critical time path established with completion date targeted for the spring of 1989. The following points formed part of the analyses:

- * Feasibility of adoption
- * Direct costs
- * Social and economic consequences
- * Municipal financial viability
- * Co-ordination with other provincial initiatives
- * Implications for other municipalities with similar abandoned mine hazards problems
- * Funding of action

Specialists from Ontario ministries of Treasury and Economics, the Environment,

Municipal Affairs, Housing, Transportation, Government Services, and Northern Development and Mines, formed a synergistic problem solving group which met together on a regular basis. Tasks varied from a review of market value of residential dwellings in the town by the Ministry of Government Services Real Estate Group, to water works cost projections by the Ministry of the Environment project engineers.

A central question which impacted all facets of the study was the abandoned mines issue. What was the extent of mine workings beneath the town? What was the potential for further cave-ins? Would abandoned mine workings interfere with municipal improvement projects? What would the public cost be to locate, test and remediate abandoned mine hazards? Because of this it was agreed that an abandoned mines inventory study be prepared for use by the committee.

7.0 Inventory Study

A geotechnical engineering firm was hired through the Abandoned Mines Program of the Ministry of Northern Development and Mines to prepare a map of the abandoned minesites within the town showing the relationship of mine workings to civic structures. This approach had been used successfully elsewhere in the province (Mackasey, 1989). Cost estimates on remedial action were also to be prepared.

The resulting study (Carter, 1989) outlined a total of seventeen "Areas of Sensitivity" within the town (Figure 3). These were plotted on a 1:2000 scale map for comparison with municipal planning maps. A description of each "area" was listed along with required investigations and scope of potential remedial measures. First order cost estimates were provided for each site.

Three basic hazard categories were used in the report:

- i) areas recommended for mining use only,
- ii) areas recommended for "caution" or "on notice" status, and
- iii) sensitive areas and/or areas recommended for safeguards.

7.1 Areas Reserved for Mining Use Only

These outline areas of extensive past mine development and/or favourable mineral potential and are not recommended for multi-land use. Many of these areas are reflected in the town's official plan. As a result few land use conflicts occur.

7.2 Areas Recommended for "Caution" or "On Notice" Status

These areas differ from the former in that residential and commercial buildings exist in close proximity or on top of mining workings. "On Notice" status would be placed on areas where mining workings were known to be beneath buildings and roads. Owner would be notified. "Caution Status" applies to those areas not presently known to be hazardous, but are potentially hazardous because of:

- a) Lack of information on geometry of underground workings, surface crown pillar thickness, etc.
- b) Adverse rock mass conditions or geology (faults, parallel veining, etc.)
- c) Existing mining operations in proximity to mine workings related structures
- d) Planned or ongoing surface infrastructure or development.

7.3 Sensitive Areas and/or Areas Recommended for Safeguarding

This is a subdivision of the "Caution Status". These are areas where existing conditions have the capacity to cause personal injury or property damage and occur outside of areas restricted to mining use only. These areas should be tested by drilling and protected as required. Included in this category are:

- * Open shafts and raises in publicly accessed areas which should be concrete capped.
- * Open stopes and near surface stopes which should be enclosed by fencing or backfilled.

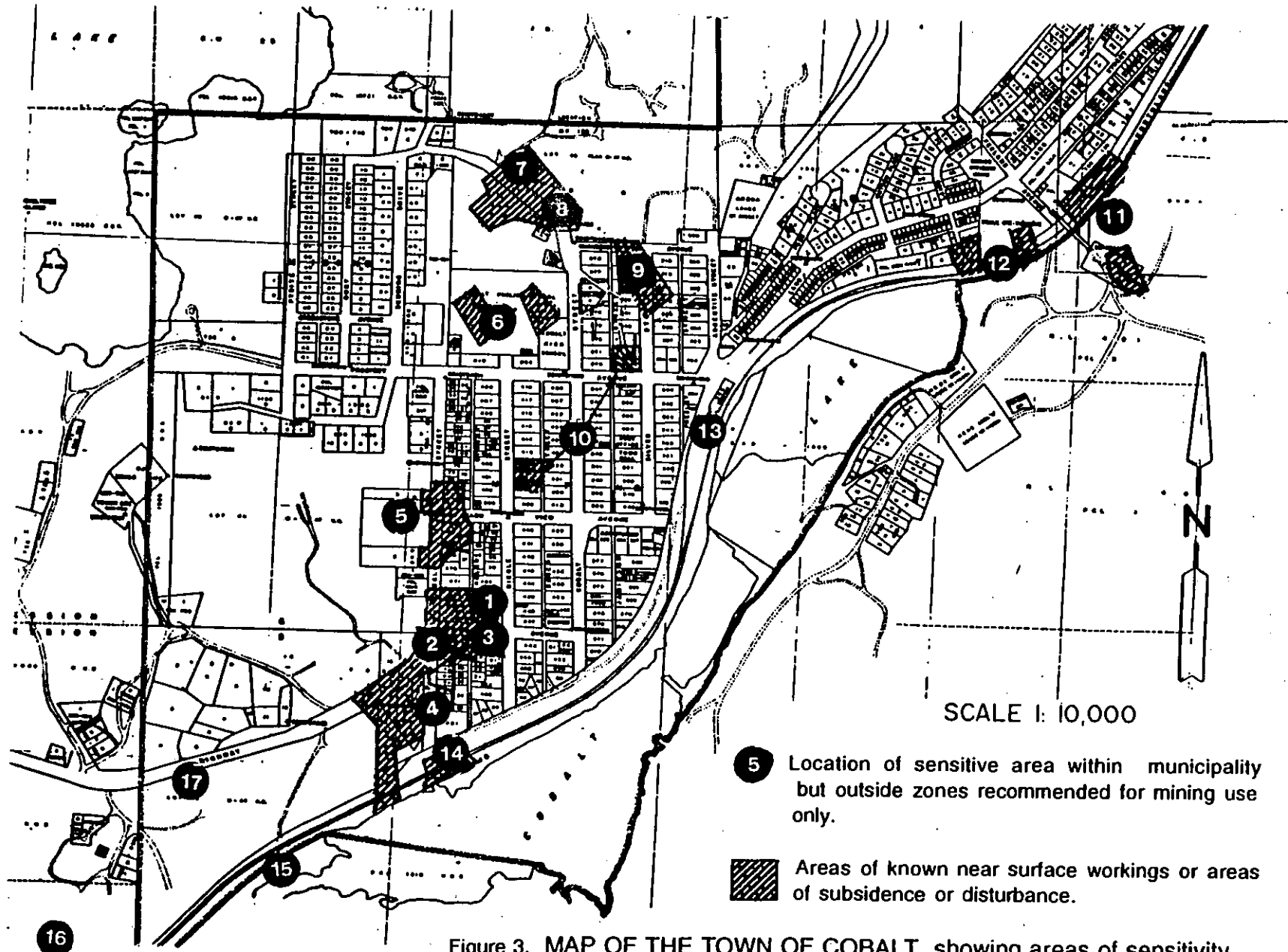


Figure 3. MAP OF THE TOWN OF COBALT showing areas of sensitivity.

* Adits, pits and isolated shafts in areas that may also be accessible to the public and which should also be filled.

* Public areas where workings occur under or in close proximity to highways, streets, schoolyards, and/or dwellings.

* Public areas where underground workings are known to extend within three to ten metres of surface.

* Public areas where the depth of overburden and/or the thickness of surface crown pillars are unknown or limited.

7.4 Mining Geology

Native silver mineralization in the Cobalt area occurs as narrow veins filling in criss-crossing fractures within the rocks along the contact between archean ("Keewatin") metavolcanic rocks and proterozoic ("Huronian") metasedimentary rocks. As described by Petruk, (1971, p.79) "The deposits occur as veins in fissures, fractures, minor faults and major faults in sedimentary rocks of the Coleman Member, which is the lower part of the Cobalt Group, Huronian System." He also indicates that the zone of silver mineralization follows the archean-proterozoic unconformity in what has been interpreted to be sediment-filled erosion troughs in the metavolcanic (Keewatin) terrain. The mineral bearing zone in the vicinity of the town of Cobalt is separated by the Cobalt Lake Fault (see Figure 4). Cobalt Lake (and the fault zone) parallels the eastern town boundary. As can be seen by Figure 4, the silver zones to the east and west of town are close to the surface. (To the east, a result of reverse faulting and to the west due to shallow dip of mineralized zone.) The silver veins beneath the main part of town were at a depth of 100-200 feet in highly competent Cobalt group metasedimentary rocks.

Access to these deposits was mainly by vertical shafts. Some adits were driven into the sides of cliffs and ridges. The shrinkage mining method was employed. Rock competency is high and as a result little or no backfill was used.

The fault line scarp east of town prominently displays many visible open cuts where the shrinkage stopes had been mined through to surface. The western part of town has many mined out areas recognizable by chain link safety fences. Any visitor to town would be quick to draw the conclusion that the central part of town was also underlain by close to surface mine workings. As Figure 4 illustrates, however, the likelihood of any major close-to-surface stopes is low.

8.0 Application Of The Inventory Report

This report became a useful tool in the Cobalt options exercise in that it provided the following information:

* a map showing limits of areas of concern

* a geological explanation of location of mine workings

* a list, complete with cost estimates, of required geotechnical testing and probable remedial work.

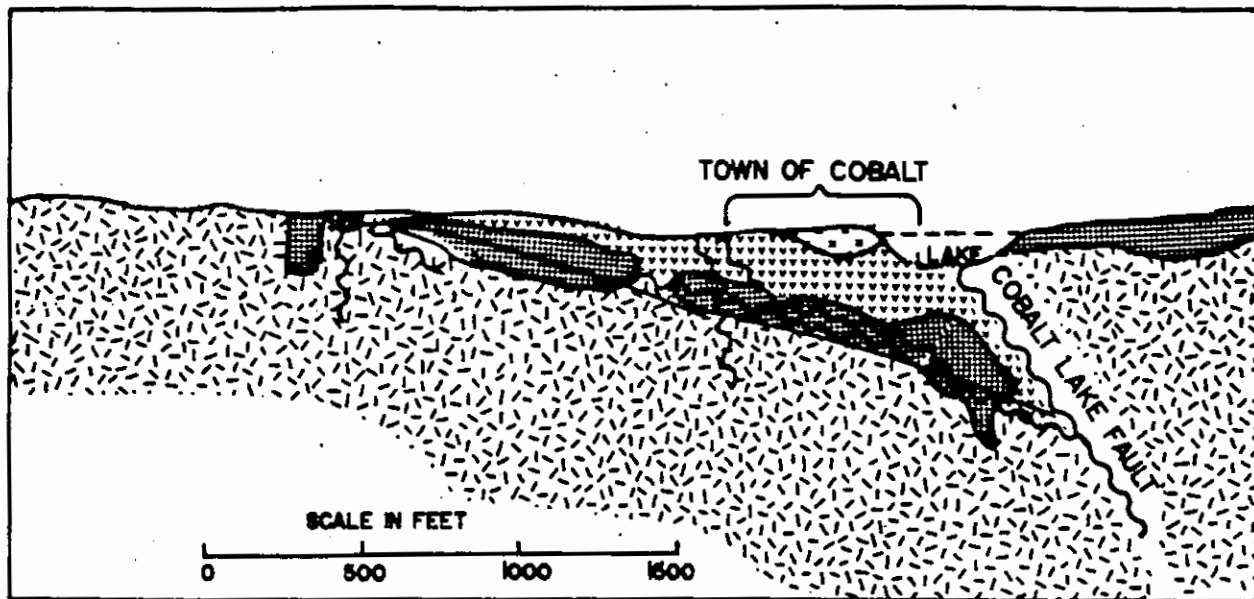
8.1 Factors to Consider

Tangible Factors

The various government agencies had to weigh out direct and indirect costs for each of the options. For example the town consisted of 500 households. To relocate the town would require the establishment of 300 single family dwellings, 200 townhouses, 2 senior citizen homes and a number of non-residential properties. On the other hand, if the town remained, the 17 hazardous areas would have to be investigated and dealt with, water and sewer system project completed, Highway 11B corridor reconstructed and a new bridge constructed.

Intangible Factors

To relocate or buy-out the town would place a significant strain on many of the residents, especially the seniors, who might feel a deep sense of loss. Again, if the town remained, the possibility existed that many residents would continue to be fearful of personal injury or loss of property due to subsidence.



LEGEND

NIPISSING DIABASE 

COLEMAN FORMATION 

KEEWATIN ROCKS 

GEOLOGICAL CONTACT 

ZONE OF SILVER MINERALIZATION 

FAULTS 

FIGURE 4. CROSS SECTION (LOOKING NORTH) THROUGH COBALT MINERALIZED ZONE (AFTER PETRUK, 1971)

9.0 Four Options

The Cobalt Options Task Force tabulated four options.:

- 1) Maintain
- 2) Buy-out
- 3) Relocate

4) Maintain and investigate, repair, relocate or buy-out on a case by case basis.

Direct costs along with pros and cons of each option were tabulated. The estimated direct costs for options 2 and 3 were identical and approximately 100% higher than options 1 and 4.

10.0 Recommending the Right Option

A key item in options 1 and 4 was that in both cases the planned public works (sewer, water and roads) would go ahead. The estimated cost of option 4, which included geotechnical testing and case by case relocation of affected residents amounted to 15% more than option 1.

Option 4 was recommended by the task force and accepted by the government May 9, 1989. This option was not only one of the lowest direct cost options, but also would present minimal disruption to the people of Cobalt.

11.0 Implementation

Upon receipt of the inventory report (Carter, 1989) the task force agreed that monitoring and communications programs were required immediately with testing and remedial work to follow.

11.1 Communications

An open house was held in the Town of Cobalt Council Chambers March 28, 1989. Residents were advised of this through advertisements in local newspapers and radio. Representatives of the geotechnical engineering consulting firm, along with municipal and provincial government officials were in attendance to answer questions. Photographs and maps were on display. Several residents came forward with positive suggestions for the testing program.

11.2 Monitoring

Monitoring within the town had been continuous since the Highway 11B cave-in. The inventory study helped focus attention on the 17 areas of caution. Monitoring has ranged from visual inspection, pre-condition and building surveys, to installation of crack gauges and pins, extensometers, time domain reflectometry (TDR) cables, vibrating wire devices and survey pins.

11.3 Testing

Testing has been conducted on a prioritized basis as recommended by Carter (1989). Techniques used, to date, include diamond, auger and air track drilling; geotechnical mapping; magnetic, seismic, ground penetrating radar and sonic surveys; video cameras were utilized with success at several sites. Applications varied from hand held and cable suspended, to bore-hole camera. For one project, a mini-submarine was mounted with video camera, aircraft lights, infra-red sensors and sonar. This vessel was lowered down the flooded shaft of an abandoned silver mine and by means of umbilical cord controls was used to map out the geometry of workings beneath a building.

11.4 Remedial Activity

Reinforced concrete caps have been designed and emplaced at several sites in town. Backfill has been used at two sites as a means of support for poured concrete capping plugs. A pneumatic blower was used for one backfill operation. A geogrid mat has been placed over one surface crown pillar where TDR monitoring has detected movement.

Two homes have been purchased by the municipality and demolished. In both cases the cost of acquisition of the home was substantially less than the cost of further drill testing and projected remediation. Care was taken to ensure the residents were treated in a fair and equitable manner.

A final technical review of all 17 sensitive areas is scheduled for the 1993 field season as part of the project finalization phase.

12.0 Summary

A task force with specialists from seven Ontario government agencies worked over a period of five months to review the various options for maintaining or abandoning one of Canada's most famous mining towns. During this period a study of the current demographic and economic conditions of Cobalt was completed. An inventory study of abandoned mine hazards in the town was compiled. Cost estimates made for geotechnical testing and probable remediation were calculated. This study played a key role in the task force's recommendation to maintain the town and to test, remediate or relocate on a case by case basis.

13.0 Acknowledgements

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