REGULATORY CONTROLLED DESIGN - LOUVICOURT PROJECT - A CASE STUDY[1]

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Abstract: The Louvicourt Project, a base metal mining development near Val d'Or, Québec, Canada, is currently the largest new mining project under construction in Canada. The deposit discovered by Aur Resources Inc. in 1989 is a polymetallic orebody of copper, zinc, gold and silver. The tailings produced will have a high acid generation potential. Six potential sites for the future tailings basin were identified and compared against a series of criterion. The main objective in the site selection process was to identify sites that could permit flooding of the tailings from day one during and after operation. The selected site was retained on the basis that it satisfies sound environmental review, permits flooding of tailings during and after operation, facilitates closure and was not expected to cause delays during the approval process based on the current regulatory environment in the province of Québec. The construction of Phase 1 of the proposed basin was completed during the fall of 1993 and filling of the basin is currently underway.

Additional Key Words: tailings basin, water cover, acid mine drainage, site selection, regulatory environment.

Introduction

This paper discusses the site selection process and engineering design considerations for the new Louvicourt tailings area located near Val d'Or in northern Québec, Canada. The site selection process involved an examination of the various physical, environmental and permitting constraints related to the potential sites identified. An important factor in the overall site selection and engineering design was the environmental design philosophy established by the project participants during the early stages of project development. These factors resulted in the selection of a site which conformed to environmental requirements, minimized impact on the environment and fell within the economic constraints of the project.

The Louvicourt Project is a joint venture between the operator Aur Louvicourt Inc. (a wholly owned subsidiary of Aur Resources Inc.) (30%), Teck Corporation (25%) and Novicourt (a subsidiary of Noranda) (45%). The project is the most significant new base metal mine development in Canada with undiluted geological (in-situ) reserves in excess of 27 Mt averaging 4.3% Cu, 2.1% Zn, 27.4 g Ag/t and 1.06 g Au/t using an equivalent cutoff grade of 2% copper based on surface drilling data. The orebody was discovered in 1989 and start-up of the 4000 t per day mill is expected to occur in July 1994. The brief amount of time elapsed between discovery and start-up could not have been possible without the economic development policies of the Government of Québec and what we have termed regulatory controlled design. Total capital cost of the project has been estimated at 349M$ including working capital and capitalized interest, totalling 30M$. The mine will employ 340 people at full production and will be in operation for 18 years. Operational assumptions are summarized in Table 1. General design criteria for the tailings basin used in the tailings site selection study are given in Table 2.

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Table 1. Summary of operational data.

	Quantity
Reserves (assumed)	24.0 M t
Concentrates (18%)	4.3 M t
Tailings backfill (50%)	12.0 M t
Tailings disposal (32%)	7.7 M t

Table 2. Tailings area design capacity (assuming an in-place dry density of 1.7 t/m^3).

	Tailings (M t)	Volume (M m^3)	Percent (%)
Assumed reserves (24 M t)	7.7	4.5	55
Assumed additional reserves (3 M t)	1.0	0.6	7
Mine water sediments	0.5	0.3	4
Placement inefficiencies	-	1.7	21
Contingency	1.9	1.1	13
Total design capacity	11.1	8.2	100

Constraints

Tailings Properties

The typical mineralogical composition of the tailings is characterized by a sulphide content (mostly pyrite) that will be on average about 40% and a carbonate content which will vary from about 11 to 23%. Some acid base accounting tests have been carried out on samples of the future ore and waste rock. From these results and experience with similar tailings in the area, it is expected that the tailings will be a net acid generator. Depending on the zone of the orebody, it is believed that the theoritical acid production will vary from about 10 to 1000 kg/t and the buffer capacity will vary from 0.5 to 35 kg/t. The waste rock will also have variable theoritical acid production potential and buffer capacity (< 0.3 to 370 kg/t and 5.9 to 98 kg/t, respectively).

Physical Constraints

The area surrounding the mine site is characterized by low topographic relief, generally poor drainage, frequent swamps, and a few scattered, small, relatively shallow lakes. The main topographic relief through the area is a southwest-northeast esker ridge located on the east side of the mine site that is a local source of fresh water, sand and gravel.

The area has moderate net positive precipitation. The average annual precipitation for the Val d'Or area for the recorded period (1961 to present) is 954 mm. If the average annual evaporation or evapo-transpiration is subtracted, the net annual precipitation is about 413 to 465 mm.

The watershed boundaries and drainage patterns for the project area are shown on figure 1. The area is interesting because it contains the drainage divide for three principal watersheds. The mine site is located in the Harricana River watershed which flows northward toward James Bay. Immediately over the esker ridge to the east of the mine is the Nottaway River watershed which also flows to James Bay. About 11 km south of the mine is the drainage divide between northward-flowing rivers and the southward-flowing Ottawa river watershed, which eventually drains into the Saint-Lawrence River.

In the Val d'Or region, the Harricana River watershed has historically been heavily impacted by mining operations. Mining activity in the Nottaway and the Ottawa River watersheds has been minimal. West of the mine, in a radius of 20 km and within the Harricana River watershed, at least 6 old or active tailings basins can be identified. In particular, two rivers west and north of the mine site (Bourlamaque and Colombière) are known to have been seriously impacted over the years by mining activity.On this basis, the Harricana River watershed was the preferred one in which to locate a large tailings basin.

There are no towns or communities in the vicinity of the mine site. There are some cottages along the lakes located east and north of the mine site. The area does not contain exceptionnal habitats for wildlife. However, virtually all of the creeks and small rivers have been occupied by beaver communities. The recreationnal usage of the area is limited mainly to hunting and fishing.

Regulatory Considerations

At the beginning of the project, the design team met to discuss the permitting procedures in Québec and to delineate an overall schedule of activities. A major constraint to the project was set by the fact that the construction of the tailings dam and other major project components, such as the mill, had to begin during the spring of 1993 if the major project milestones were to be met on schedule. This therefore allowed a total of 14 months for the environmental assessment documents to be completed including baseline studies (which had been already initiated), feasibility studies and detailed engineering designs. Project start-up was scheduled for July 1994.

In Canada, major projects are subject to environmental requirements established by the Federal Government as well as the provinces. The laws and regulations for the federal and provincial jurisdictions contain a number of constraints which can trigger detailed environmental impact statements and full public consultation. Since these processes can result in time delays of at least 18 to 24 months in the overall permitting procedure, the design team set out to identify all possible triggers with the objective of designing an environmentally sound project while avoiding potentially lengthy delays in the process.

Federally, impact assessments are administered through the Environmental Assessment and Review Process (EARP). This process is currently under formal review and will be replaced by the Canadian Environmental Assessment Act (CEAA) probably in 1994. However, during the process of defining regulatory requirements it was assumed that the draft regulations based upon CEAA might apply in some form to the development. A thorough review of the draft regulations identified two potential triggers which might require that a detailed impact assessment be undertaken on the Louvicourt Project:

- diversion of a navigable water way; and
- building of a railway spur.

Environmental assessment requirements in the province of Québec are detailed in the Environmental Quality Act (Government of Québec, 1989, Q-2 r.1, Q-2 r.9). The triggers pertinent to the Louvicourt Project which would require, beside the necessary environmental study, the preparation of a detailed environmental impact statement with consequent possible public hearing, included:

- diversion of a named river;
- placement of waste materials in a lake;
- construction of a railway spur greater than 2 km in length;
- creation outside the main tailings basin of a pond greater than 5 ha in surface area; and
- construction of a permanent access road greater than 2 km in length.

At all stages during the planning and design of the project the above triggers were kept in mind and avoided.

The Québec Ministry of Environment (MENVIQ) has established several administrative regions or districts. Under the Environmental Quality Act, each regional director of the administrative districts has the authority to issue Certificates of Authorization for different phases of project development. For mine developments, environmental requirements and submissions are administered through Directive 019 (Government of Québec, 1989, Directive 019). The principal components of Directive 019 include:

- application of the provincial liquid effluent regulations at the final point of discharge; and
- detailed guidelines as to the information requirements to be submitted for the various types of Certificates of Authorization (COA) to be issued.

Four authorizations are specified as requirements in Directive 019; COA-exploration, COA-tailings site selection, COA-ore extraction and COA-mineral treatment. Of these four authorizations the two most significant to Louvicourt were approval of the tailings site selection document and mineral treatment. The COA for mineral treatment allows for the construction of the tailings area and milling facilities.

The Québec Government recognizes that the time frame for the development of new grass roots projects can be shortened by allowing the construction of certain aspects of the facilities in parallel with the environmental approvals process. Thus, separate approvals can be obtained for certain project components such as: exploration shafts and headframes; production shaft and headframe; mine surface facilities such as electrical substations, generator stations, wharehousing, hoist rooms, underground ventilation facilities, administration and maintenance facilities. In addition, with appropriate environmental documentation, it was possible to obtain phased approvals for clearing and logging a preferred tailings site; clearing and preparing borrow sites; construction of small access roads and pipelines; installation of construction camps prior to tailings dam construction; construction of the concrete foundation for the mill; and construction of Phase 1 of the tailings facility. All of these approvals were obtained prior to the issuance of the final certificate of authorization for mineral treatment. The resulting net benefit to the overall project was a time saving of over two years in relation to an impact assessment procedure which precludes any construction prior to completing the process. In the end, the total number of approvals required for the Louvicourt Project from inception to the beginning of operations totalled 46.

Environmental Design Philosophy

Because the environmental approval process allows for the expenditure of hundreds of millions of dollars prior to receiving operating approval, an aggressive position was taken with respect to the environmental design of the overall facilities. The fundamental design philosophy that was established for the project was intended to reduce regulatory uncertainties in receiving approval and to maximize protection of the environment. Upon review of the available technologies, it was considered that permanent storage underwater from day one could be an effective way to inhibite tailings oxidation as confirmed by recent works (Robertson, 1991; Morin, 1993 and Pedersen et al., 1993). Taking into account current and projected regulatory requirements in Canada, the design philosophy established for Louvicourt is summarized as follows:

- design for closure and operate for closure;
- tailings will be acid generating and will be managed as such; best available technology economically achievable (BATEA) will be used to prevent acid rock drainage (in the case of the Louvicourt project BATEA meant placement of fresh tailings under water in a man-made facility);
- minimize the quantity of ARD producing waste materials generated by the facility. (i.e. maximize the placement of waste materials underground);
- maximize water recycle; and
- use mother nature to advantage wherever possible.

When taken as a group, the design philosophy had a significant overall effect on all decisions related to site selection and design. In practice, this meant that a tailings site had to be selected so as to provide good topographic relief and hydrogeological containment sufficient to maintain a permanent water cover over the tailings; a watershed of sufficient size to ensure maintenance of a water cover even during drought conditions and to obtain seepage losses and flows through the tailings that were relatively small. The design philosophy also governed: dam design (geometry, slopes, erosion protection), the requirements for both operational and emergency water control structures and management of the upstream watershed.

Site Selection Study

A site selection study was carried out to identify possible sites that would allow flooding of tailings during and after operation. A total of 6 sites (sites 1, 2-A, 2-B, 3, 4, and 5) were identified in the area surrounding the mine site (figure 1). A list of selection criteria was prepared and each of the sites were evaluated and reviewed with respect to:

Technical and Economic Considerations

- minimum storage of 4.5 M m3 of tailings (7.7 M t at 1.7 t/m3) to accommodate at least the in-situ reserves;
- distance from the mill (the maximum distance - radius was set to 15 km);
- area of the tailings basin - to be minimized;
- expansion potential - to be maximized;
- maximum length of dykes - to be minimized;
- maximum elevation of the dykes - to be minimized;
- difference of elevation between the mill and the basin - to be greater than 0 if possible;
- accessibility around the basin with existing roads and with future roads; and
- mineral potential under the basin had to be shown to be poor or non existent;

Geology and Physical Features

- foundation conditions which effect dam stability; and
- topographical containment.

Hydrology and Hydrogeology

- location with respect to major watersheds;
- drainage area of the basin to allow flooding during and after operation;
- diversion required;
- length of diversion channels;
- flows to be diverted;
- tailings basin proximity to rivers or lakes;
- water recirculation potential; and
- ground water infiltration potential;

Ecological Considerations

- type of vegetation;
- clearing requirements;
- aquatic background;
- recreational use; and
- unique or exceptional habitats.

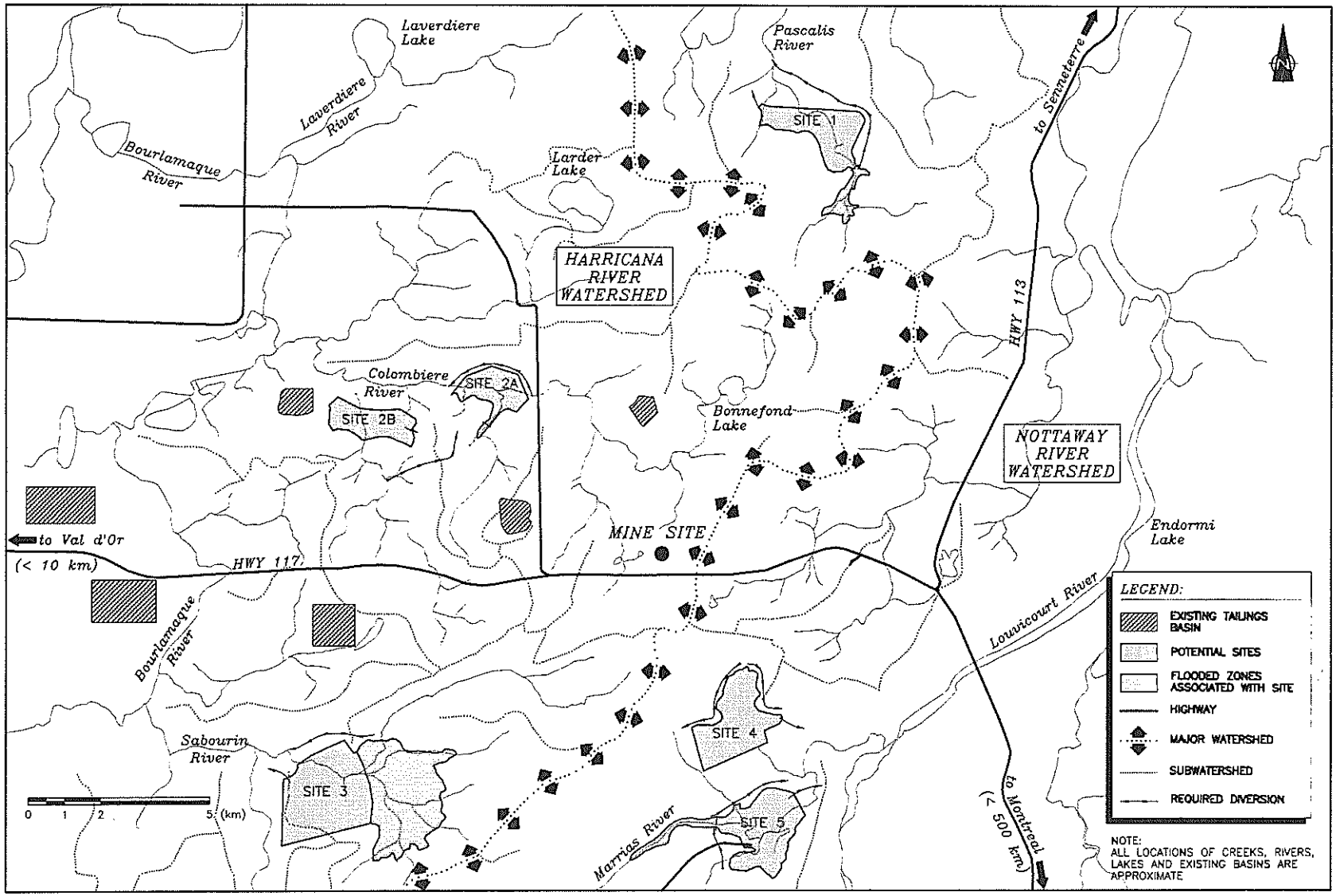

Figure 1. Location of six potential tailings basin sites in a 15 km radius of the Louvicourt Project. Also shown are major watershed and subwatershed limits as well as existing tailings basins.

Social Considerations

- distance from nearest houses;
- land use and ownership prior to operation;
- land use after operation; and
- aesthetic impacts;

Others

- mining rights on the properties;
- implications on pipeline path; and
- compliance with environmental design philosophy.

The following paragraphs review the characteristics of the 6 different sites and present a summary of the comparison between them.

Site 1 is far (13 km) from the mill. It is in the Pascalis river basin located in the Nottaway river watershed, which has not been much affected by mining operations. The area is swampy. Natural topographical confinement is good but the basin would have to be shallow. Therefore, long confining structures, most likely built through peat, would be required. The operator does not control mining rights in this area. Site 1 requires the diversion of the Pascalis river valley for a distance of 4.5 km.

Site 2-A is the closest to the mill and is situated in the Colombière River valley in the Harricana river watershed about 6 km from the mine. There are important upstream watersheds that could provide water for flooding in the post-operational period. Diversion of the Colombière river would be required as well as the development of a significant flooded area upstream of the basin. Topographical confinement is good, expandability is good, and this site is located on lands partially controlled by the operator.

Site 2-B is also located in the valley of the Colombière river about 8.5 km from the mill. The basin corresponds to a topographical low in the river sub-watershed. Topographic confinement is good and the subwatershed upstream of the basin can be diverted during and after operation. Expandability is good, a river diversion is not required, and the property is controlled by the operator.

Site 3 is located within the watershed of the Harricana river, more than 11 km from the mill, on property controlled by the operator. A large sub-watershed is present upstream of the basin to enable flooding at closure but because of a lack of topography the tailings placement would be shallow and therefore the site would be difficult to manage and would cover a large area. Development of site 3 could require the diversion of a river.

Site 4 is located about 6 km from the mine in the Nottaway river watershed which is currently not significantly affected by mining operations. The site offers poor topographical confinement. Upstream watersheds for future submergence of tailings are limited. The ground surface elevation of this site is about 13 m higher than the mill. The site is located on lands partly controlled by the operator.

Site 5 is located about 8 km from the mill in the Nottaway river watershed. The site has good potential for a small tonnage of tailings but is most likely too small to accommodate the design tonnage and offers little expandability without having to resort to extensive confining structures. The site would require the diversion of the Marrias River and the lands are not controlled by the operator.

Only Sites 2-B and 4 were considered to be compatible with the overall environmental design philosophy selected for the project.

Site Selection

Following the application of the previously described selection criterion, Site 2-B was considered to be the most attractive in terms of storage capacity, overall impacts, ease of closure, and compliance with the environmental design philosophy. The layout of the basin is given on figure 2. The main difficulty associated with this site was the diversion of the unnamed creek draining the area south of the basin. This creek, at the time of the design had a heavy contaminant load caused by acidic drainage from tailings south of the subwatershed limits. Diversion alignments to the east and west of the proposed tailings facility were examined.The option selected was the easterly diversion of the unnamed creek into the subwatershed to the east, resulting in the discharge of the unnamed creek into the Colombière River some 4 km upstream of the original location. A west diversion channel was also considered but the east diversion was found the most secure, since it offers natural topographic containment between the diversion channel and the basin. The west diversion would require the construction of a channel close to the proposed tailings basin and the existing Aurbel tailings basin west of the selected basin.

Despite the magnitude of the confining structures the site offers, with the available external watersheds, good potential for flooding during and after the operating life as well as acceptable foundation conditions under the basin and the dams; good expansion possibilities and no indication of important mineralization . It also allows construction of water control structures founded in rock which allows for more secure operation and simplifies the closure works. The final development scheme for the basin involves the development of the basin in two Phases. Phase 1 includes the construction of the east cell and the polishing pond. Phase 2 involves the construction of the west cell and the east diversion channel.

In order to minimize seepage losses to a level considered accepable, construction of low permeability dam cores and key trenches, and the construction of low permeability blankets and bedrock grouting were included in the design.

Construction of the east cell was completed on time and within budget during the fall of 1993. Flooding of the basin is currently underway. It is expected that the water cover will be adequate when operation starts to enable submergence of the tailings from day one. The water management strategy may require, for some years, short duration exposure of the tailings beaches during the coldest months of the year, December and January (average temperature -13.2 and -16.8°C). It is not believed that this short exposure during operation will be sufficient to trigger AMD generation. Table 3 provides a summary of the design characteristics of the tailings basin. An equivalent average infiltration rate is also provided for information.

Table 3. Summary of tailings basin characteristics.

	(Phase 1) East cell	(Phase 2) West cell	Whole basin
Total solid capacity (M t)	7.1	4.8	11.9
Total solid storage (M m^3)	4.2	2.8	7.0
Expected operating life (years)	12	8	20
Minimum water cover (m)	1.0	1.0	1.0
Free board of dykes(m)	2.0	2.0	2.0
Tailings basin area (ha)	96	68	164
External watershed draining to basin (ha)	76	50	126
Estimated seepage losses (M m^3/year)	0.4	-	0.5[1]
Average infiltration rate (m^3/m^2/year)	0.4	0.3	0.3
Discharge period (april to november - 8 months)	yes	yes	yes
Effluent discharged of the system (M m^3/year)	3.1	2.7	3.6[2]

[1] The estimated seepage losses include both east and west cells.
[2] During operational period only.

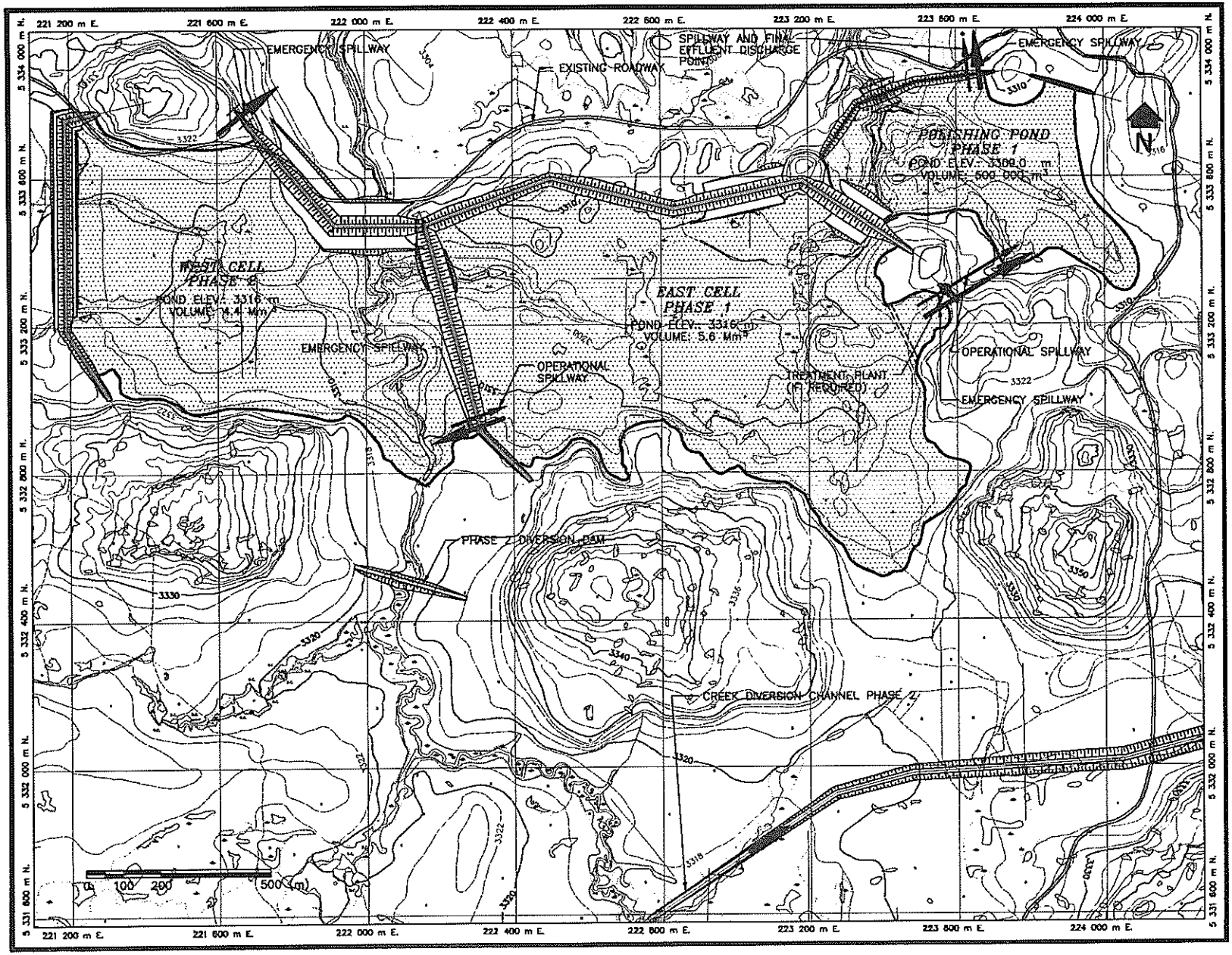

Figure 2. Louvicourt Project tailings basin (Site 2-B) configuration (Phase 1 & 2), with location of confining structures, operational and emergency spillways and the east diversion channel.

Conclusions

The Louvicourt Project is an example of a modern mine development designed to meet stringent environmental criteria established by both the regulators and the proponents. The design of the facilities has been undertaken using the best available technologies which have been established through operational experience and research conducted under the National Mine Environment Neutral Drainage (MEND) program. The speed with which the project was designed, approved and built could not have been achieved without the pro-active policies established by the Québec Government. These policies allow for the construction of key components of a project while permitting is underway. Since construction can proceed in parallel with the permitting process, the time frame for development of grass roots projects can be reduced by up to two years. This process requires significant commitments by the developers since the expenditure of hundreds of millions of dollars cannot be risked by submitting inadequate environmental design information. The process includes an expectation that approvals will be granted subject to conforming to environmental requirements and requires cooperation, faith, goodwill and trust of all participants. On the negative side, if operating approvals are not granted within established time limits the developers could be forced to accept conditions they would not otherwise agree to. In addition, the prescriptive approach provided in Directive 019 can reduce the flexibility in preparing environmental documents which address the site specific concerns of a facility. We believe that it is impossible for regulatory agencies to include in one regulatory document all of the potential variables which need to be considered, particularly with respect to the site specific nature of mine developments.

Literature Cited

Government of Québec (MENVIQ), 1989. Règlement relatif à l'administration de la loi sur la qualité de l'environnement L.R.Q. cQ-2, r.1.

Government of Québec (MENVIQ), 1989. Règlement sur l'évaluation et l'examen des impacts sur l'environnement, L.R.Q. cQ-2, r.9.

Government of Québec (MENVIQ), 1989. Directive 019, Industries minières.

Morin, K. A. 1993. Rates of sulfide oxidation in submerged envrionments:implications for subaqueous disposal. 17th Annual Mine Reclamation Symposium, Port Hardy, British Columbia, May 4-7, 1993.

Pedersen, T. F. , B. Mueller, J. J. Mcnee, and C.A. Pelletier, 1993. The early diagenesis of submerged sulphide-rich mine tailings in Anderson Lake, Manitoba. Can. J. Earth Sci. 30, 1099-1109 (1993).
http://dx.doi.org/10.1139/e93-093

Robertson, J.D. 1991. Subaqueous Disposal of reactive mine waste: An overview of the practice with case studies. p. 185-200. In Proceedings of the Second International Conference on the Abatment of Acidic Drianage. (Montréal, PQ, September 16-18 1991).