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The development of a pit lake at Agrium Kapuskasing Phosphate Operations – an integrated geotechnical, geochemical and biological approach

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Abstract

Agrium's Kapuskasing Phosphate Operations (KPO) is an open pit mining facility located approximately 40 km southwest of the town of Kapuskasing, Ontario. In operation since 1999, three contiguous pits have been developed (North, Centre, and South) with mining activities expected to be complete in 2013. As part of the rehabilitation strategy the open pits will be transformed into a freshwater lake. Agrium KPO has had previous success in constructing and establishing a lake ecosystem. In 2006, in order to further access ore deposits, a small boreal lake was relocated which included the transplantation of fish, benthic invertebrates, plankton and aquatic vegetation. This paper will discuss Agrium KPO's integrative planning approach based on geotechnical, geochemical, and biological specifications, including lessons learned from the previous lake relocation, to ensure the successful establishment of the pit lake.

After closure, the pit will be flooded to approximately 239 masl in the North and South pits while backfill placed in the Centre pit will rise above the projected lake elevation. Geotechnical reports indicate that the safety factor of pit slopes will increase over time due to the stabilising force of the water weight on the slopes. To minimise erosion, rock cover may be required in areas potentially exposed to wave action. An assessment of geochemical loadings has also been completed to model the expected quality of water in the pit once flooded. Results suggest that concentrations of modelled parameters (such as metals) released from the submerged waste rock will be below applicable regulatory acceptability criteria after the lake has filled to capacity. As such, the final flooding of the pit can be done sequentially without in situ treatment of the water within the pit. In terms of biological development of the lake, the ultimate objective is to maintain a viable aquatic ecosystem. The construction of a littoral zone, including enhanced aquatic habitat features, will provide spawning and refuge areas geared towards the successful reproduction of sentinel fish species found in this area. It is predicted that once flooded, the open pit will provide a stable, deep cool water fisheries habitat.

1 Introduction

Agrium KPO is a subsidiary of Agrium located in Cargill Township in the District of Cochrane approximately 40 km south west of the Town of Kapuskasing, Ontario (Figure 1). The facility has been in operation since 1999 and includes an open pit phosphate (P_2O_5) mine from which approximately 1.8 to 2.2 million tonnes of raw ore are extracted annually, of which 0.8 to 1.1 million tonnes of phosphate concentrate are produced yearly at the on-site milling facility. The phosphate concentrate is transported by rail to Agrium's Redwater Phosphate Operations in Redwater, Alberta, for further refining. Three contiguous pits have been developed (North, Centre, South) since the beginning of mine operations (Figure 1). The North Pit is currently being used for the storage of fluid clay, while the Centre Pit is currently being backfilled with waste rock and overburden from mining activities in the South Pit.

In 2003, Agrium KPO confirmed that the South Pit orebody extended east and south of the original pit design under nearby Cargill Lake. Mining of these reserves would require the ultimate pit crest to be well into the footprint of Cargill Lake (Figure 1). In order to access these additional reserves the relocation of Cargill Lake was required. These supplementary reserves were essential to extending the life of the mine.

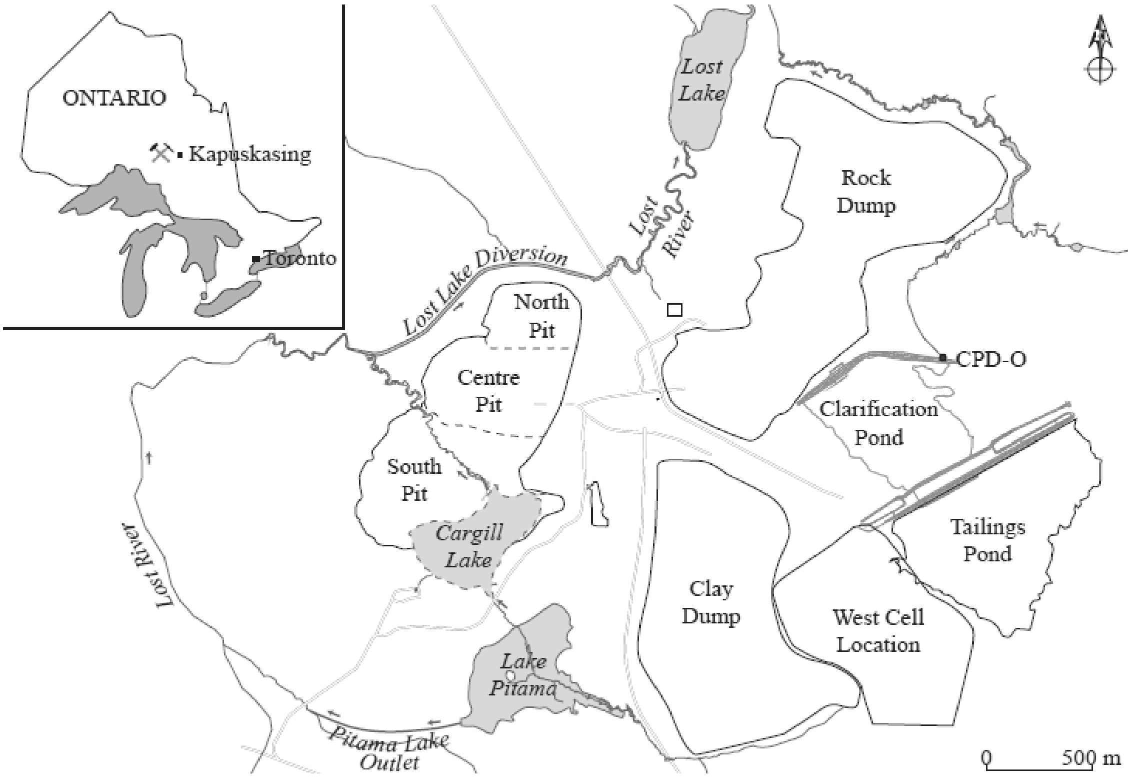

Figure 1 Location and site plan of Agrium KPO

In July 2004, following extensive agency, First Nation and public consultation, an application for *Fisheries Act Authorization* (FAA) to relocate Cargill Lake (compensation for the loss of fish habitat) was submitted to the Department of Fisheries and Oceans (DFO) (Minnow, 2006). Construction of the new lake (Lake Pitama, meaning "for now" in Cree) was carried out during 2005–2006 creating an earth fill dam located immediately upstream of Cargill Lake (Figure 1). The basin was excavated using existing contours to create a lake of similar size, trophic state, and functionality to Cargill Lake.

With the relocation of Cargill Lake, the pit expansion moved forward and allowed the mine to access the supplementary reserves. As per the FAA, the approved compensation for the loss of Cargill Lake included not only the construction of physical habitat features but also the effective transplanting of various ecosystem components in an effort to stimulate the establishment of the aquatic ecosystem in Lake Pitama. The transplanting activities were sequenced to allow for the best opportunity for the successful transfer of fish from Cargill Lake to Lake Pitama and included the transplantation of aquatic plants; relocation of benthic invertebrates; relocation of plankton; and the relocation of small and large-bodied fish (northern pike and yellow perch) (Minnow, 2006). Upon completing the relocation in 2006, Lake Pitama was monitored for several years to track the establishment of the lake ecosystem i.e. succession of aquatic plants, establishment of benthic invertebrate and fish communities. It was observed that physical habitat structures remained in place; macrophytes continued to flourish and establish in new areas; the benthic invertebrate community was well colonised within the littoral zone; and that fish populations remained healthy in terms of growth, abundance, and species diversity. In a very short time span (3 years) the lake has provided a suitable environment for viable macrophyte, benthic invertebrate and fish communities (Minnow, 2010a).

With respect to mine closure, the success of Lake Pitama has provided Agrium KPO with a knowledge base from which to begin the planning and preparation of the pit lake to be established upon the cessation of mining activities. Upon mine closure the open pit will be transformed into a self sustaining man-made lake. In general, the closure concept for the open pit will consist of flooding the open pit (from natural groundwater infiltration, precipitation and runoff, and intentionally diverted surface water sources), and reshaping and re-vegetation of the exposed slopes. In order to access ore, the Lost River was initially diverted around the pit (see Lost Lake Diversion, Figure 1). Once established, and acceptable water quality parameters have been achieved, the pit lake will be rejoined with the Lost River watershed, which will then join the previously interrupted upper reaches of the Lost River. Eventually the lake will join the Lost River which flows approximately 65 km northeast before draining into the Kapuskasing River. The Kapuskasing River in turn flows into the Mattagami River, which ultimately drains into James Bay via the Moose River.

In order to ensure the successful filling and establishment of a lake in the open pit several studies have, and will be carried out to examine all possible aspects of pit lake development at Agrium KPO. An integrative approach will be taken to attempt to foresee any major roadblocks in lake filling and the development of a successful freshwater lake ecosystem. The following is a synopsis of the geotechnical, geochemical, biological and preliminary design studies of the pit lake at Agrium KPO.

2 Study site

Agrium KPO is located in an undulating to gently rolling area, underlain by extensive deposits of glaciolacustrine silty clay and, locally, clayey silt till. The phosphate orebody found at Agrium's KPO consists of sands of the phosphate-bearing mineral known as apatite (P_2O_5), which are mixed and coated with iron oxide and silica materials. The ore deposit at the site is contained in a carbonatite rock complex covering an area of approximately 9.6 km^2, referred to as the Cargill Carbonatite Complex. Most of the ore (the apatite sands) and the waste materials occur as either loose sands or clays and can be simply loaded into trucks without the need for blasting (Agrium KPO, 2011).

Agrium KPO is located in the upper reaches of the Lost River (Figure 1). The Lost River is a low-gradient, warm-water system that meanders through sedge wetlands and/or lowland forests. The headwaters of the Lost River originate approximately 10 km upstream of the mine discharge point (CPD-O, Figure 1). In the vicinity of the mine site, the channel width is approximately 10 m wide and water depth ranges from 0.3 to 0.5 m under average flow conditions. Downstream of Lost Lake and the mine discharge point, the Lost River begins to widen, varying from 10 to 30 m in width with depths ranging from 1 to 2 m.

Table 1 Physical and chemical characteristics of Lake Pitama and the proposed pit lake

	Lake Pitama	Pit Lake[a]
Typical water surface elevation	255.0–255.5 (masl)	239 m
Surface area	21.5 ha	107.4 ha
Maximum depth	6 m	230 m
Mean depth	1.5 m	58.6 m
Hydraulic residence time	109.5 days	511 days
pH	6.9–8.1	n/a
Total dissolved solids[b]	148–365 $mg \cdot L^{-1}$	n/a
Dissolved oxygen[b]	6–10 $mg \cdot L^{-1}$ [b]	n/a
Total phosphorus[b]	<0.04–0.0.05 $mg \cdot L^{-1}$	n/a

a- Calder Engineering Technical Memo, 2008, b- top 3 m.

3 Geotechnical

A sound geotechnical understanding of the open pit is important for the successful formation of the pit lake at Agrium KPO. Open pit mining can result in pit walls that can be or become unstable during lake filling. The rebound in groundwater pressure after mine closure may increase the probability of a major slide by decreasing the effective stress borne by the walls (McCullough and Lund, 2006; Gammons et al., 2009). Pit wall stability monitoring, erosion protection measures, and surface water control are all key components in ensuring that the integrity of the pit structure remains intact during pit-filling and the establishment of the pit lake ecosystem. Monitoring should continue once the ecosystem is established to ensure long-term pit wall stability.

During current operations the pit walls are inspected regularly by on-site personnel, and an annual pit wall inspection is performed by a consulting engineer. As the mine progresses from an operational state to a state of temporary suspension and inactivity, the physical stability of the pit walls will continue to be inspected and monitored thus ensuring the safety of the public and those required to carry out work on-site. Several studies have been completed in the past few years which have examined various geotechnical components of the open pit including a stability analysis of the backfilling of the Centre Pit (Golder, 2010a), an as-built report for the North Pit dyke used to retain fluid clay (Golder, 2010b), and a geotechnical study on the slope design in the South Pit which will be the deepest portion of the pit lake (SNC-Lavalin, 2011).

Currently the South Pit is actively mined while the Centre Pit area is being used for the disposal of waste rock and overburden materials and the North Pit is used as a site for the deposition of soft (flowing) clay. The stability of the proposed Centre Pit slopes was analysed using a limit equilibrium method and the slope stability software Slope/W (Golder, 2010a). The minimum factor of safety against slope failure was calculated using the Morgenstern-Price Method. Slope stability analyses under static loading and pseudo-static conditions were carried out. For pseudo-static analysis the design earthquake was defined as an event with a return period of 475 years and a corresponding peak ground acceleration (PGA) of 0.023 g based on the 2005 National Building Code Seismic Hazard Calculation for Kapuskasing. Stability analysis design criteria were defined as follows: For static loading conditions a factor of safety >=1.3; for pseudo-static loading conditions factor of safety >=1.1. The slope stability analysis results indicate that the backfilled Centre Pit waste dump will be stable (Golder, 2010a). At closure, when the pit area is flooded, stability analyses also indicate higher factors of safety due to an increased resisting (i.e. stabilising) force provided by the weight of water on the submerged slopes.

Another factor to consider for closure is providing erosion protection on slopes exposed to wave action at the water line by means of providing a layer of rockfill cover. Sandy slopes, or waste materials back-filled in the Centre Pit will be susceptible to wave-induced erosion. It has been recommended that 1) all Centre Pit exterior slopes above elevation 200 m should be surfaced with waste rock, as much as possible, to provide improved resistance to erosion during flooding for closure; 2) exposed slope surfaces (i.e. not including horizontal benches) above elevation 200 m should have a layer of waste rock at least 0.3 m thick; and 3) exposed slopes between the expected post-closure low and high (i.e. minimum and maximum) water levels should have a layer of waste rock at least 0.5 m thick.

A final consideration in erosion control and ensuring the long-term stability of pit walls is to continue the implementation of surface water control measures to prevent the pit slopes from runoff erosion. The pit overburden slopes, especially of the South Pit are sensitive to surface runoff erosion. It has been recommended that surface water should be controlled to minimise the potential for surface water to enter tension cracks above the crest or within the slope, and to minimise surface water infiltration into the bench surfaces, which can create high transient, pore pressures. The recommended surface water control measures are as follows: 1) Diversion of rain water or snow melt around the crest of the slope – diversion ditches around the pit perimeter should be constructed to minimise the amount of water reaching the slope; 2) Collection of runoff water on pit benches—collection ditches are recommended to be installed at the toe of prominent benches to collect and remove the surface water runoff from the slope as soon as possible by either gravity drainage or pump to minimise the potential for ponding and infiltration into the slopes; and 3) Sump ponds or polishing ponds should be used for sedimentation or treatment if the water quality does not meet the relevant water quality criteria. It should be noted that these measures will be frequently evaluated for their long term sustainability and effectiveness in controlling erosion and stability issues caused by surface water flows.

4 Geochemical

The final water quality in a pit lake is difficult to predict as it depends on factors such as site hydrology, initial groundwater quality, the geological composition of the pit walls and surrounding landscape, the dynamics of evaporation and precipitation, and the resulting physical limnology of the lake (Doupé and Lymberg, 2005; Castendyk and Webster-Brown, 2007). Therefore, having solid predictive geochemical modelling of the pit lake water chemistry may be a powerful tool for the preparation and ongoing management of the final hydrology of the pit lake (McCullough and Lund, 2006).

Typically, water quality is perhaps the most critical component in the successful establishment of a pit lake at Agrium KPO. Several factors can influence the final quality of water which in turn will affect the establishment of plant and fish communities in the lake. The biggest water quality problems in the establishment of pit lakes are salinisation, acidification (low pH), high metal concentrations, and high total solids (Kalin et al., 2001). Therefore both groundwater (Genivar, 2010) and geochemical (Ecometrix, 2008, 2010) characterisation studies of mine materials, overburden, waste rock etc., have been completed to better understand the loading of potential chemicals into the pit lake. The pit will be filled from both surface and groundwater sources and therefore any chemicals or contaminants of concern found in either of these sources should be identified prior to filling and modelled in terms of their persistence in the final established lake.

In the current pit design waste rock and overburden materials from the South Pit are being backfilled into the Centre Pit. Therefore, these materials will be flooded and remain permanently underwater. The long-term release of metals from the submerged waste rock material will be diffusion controlled. Underwater tests were used to predict the flooded pit water quality after closure by providing an estimate of the flux of individual chemicals of potential concern (COPCs) from the submerged rock materials into the overlying water column in the flooded pit. However, some material will remain above the water in the Centre Pit; therefore the water quality in the pit was modelled to include loadings from both the submerged rock as well as the rock remaining above the water in the pit. Water quality was calculated using flow and mass balance relationships, considering average annual flow conditions after closure (Ecometrix, 2008).

Underwater column studies involved placing the waste material (rock) in columns and submerging them in distilled water. The tests involved the placement and immersion of material under water within a chamber and the subsequent measurement of constituent concentration in the porewater and overlying water over a 140 day test duration. The quality of the overlying water column was monitored over time as constituents diffuse out and are released from the waste into the overlying water. The leachate water quality results provide a basis for predicting pit water quality after closure by providing an estimate, through diffusion modelling, of the flux of individual COPCs from the rock into the overlying water column, calculated in mg-COPC per m^2 of waste per week. The loadings in kg/year were then estimated using surface areas of submerged waste and estimated flows (Table 2).

In theory, as the pit floods and waste material becomes submerged, the initial soluble constituents will be released to pore water within the submerged rock. The rate of release of constituents from pore water to the overlying water will be largest soon after the rock is covered by water and the rate of release or the loading to the pit water will decrease over time as flooding continues. Modelling of the release of constituents from the rock to the overlying water column was completed to estimate concentrations during flooding of the pit and after the pit is full and flow through begins in or to ensure that concentrations of COPCs do not exceed appropriate guideline values. The water quality in the pit during flooding will be monitored, and water will not be released from the pit until water quality is acceptable. Long-term diffusion flux of metals from the submerged rock will also continue during flow through. However, after several years of flooding the rates of release of COPCs by diffusion from the pore water in the flooded rock will be very small compared to those when the rock was initially inundated.

The water quality in the pit above the backfilled waste was calculated from the flux from the rock for individual COPCs and the estimated water balance for the pit after closure. The calculated concentrations are conservative because they do not consider any attenuation or losses of metals from the water column that would be expected in such systems. The estimated loadings pertain to the release of arsenic, cobalt, copper, nickel, selenium, uranium, and zinc, and only due to the diffusive processes after mine closure. The modelling was completed in a manner that predicts a flux over time representing a rate of release per unit area of flooded rock. The model results show that metal release from the submerged waste rock materials are largest after initial flooding and decline rapidly within a few days, but with a long-term slow release persisting over a time frame of decades.

Table 2 Estimated concentrations of COPCS in the pit after flooding and before discharge along with a summary of COPC loadings from waste sources in the pit lake

Parameter	Provincial Water Quality Objectives[1] (µg·L^{-1})	Estimated Concentration[4] (µg·L^{-1})	Metal Loadings (kg·a^{-1})	
			Submerged Waste Rock	Exposed Waste Rock in Pit
Arsenic (As)	5[2]	0.43	1.47	0.03
Cadmium (Cd)	1–5[2,3]	0.0005	n/a	0.004
Cobalt (Co)	0.9	0.072	0.13	0.02
Copper (Cu)	1–5[3]	0.44	1.47	0.06
Lead (Pb)	1–5[3]	0.002	n/a	0.02
Nickel (Ni)	25	0.71	0.66	0.06
Selenium (Se)	100	0.3	0.001	0.13
Uranium (U)	5[2]	1.34	4.29	0.18
Zinc (Zn)	20[2]	0.41	1.27	0.13

1- Ontario Ministry of the Environment 1999. Provincial Water Quality Objectives; 2- Interim Guideline; 3- Hardness Dependant; 4- Concentrations assume that the surface of the submerged waste is comprised solely of the respective material; n/a- no loadings were calculated because concentrations were below detection in samples collected for all rock types during underwater testing (Ecometrix, 2008, 2010).

The results suggest that concentrations of modelled parameters in the flooded pit will be below Provincial Water Quality Objectives (PWQO) at the expected time of pit water discharge to the Lost River, assuming a well mixed condition in the flooded pit. Therefore, the release of metals from the mine rock in the pit is not expected to represent an issue with respect to water quality in the Lost River. These calculations are based on conservative estimates and assume that the pit water is fully mixed. Waste or unused rock at KPO is generally carbonate-rich and contains iron oxide minerals such as magnetite, hematite, and goethite; carbonates such as dolomite and siderite, as well as other common rock-forming silicate minerals (Agrium KPO, 2011). The sulphide content of the rock was determined to be less than 0.1%. Therefore, the potential to generate acid is considered to be very low to nil.

The final major COPC to be addressed is phosphorus loadings from any exposed remaining ore and waste rock into the open pit that may cause water quality issues. Phosphorus is a critical nutrient for algal growth and therefore is a major contributor to eutrophication in aquatic ecosystems (Downing et al., 2001). While the humidity cell tests measured phosphorus along with the metals listed in Table 2, phosphorus was not specifically modelled for long term loadings. A 20 week test period phosphorus levels in almost all humidity cell tests from waste rock materials were < 0.05 mg·L^{-1}. While PWQO for phosphorus in lakes is currently 0.02–0.03 mg·L^{-1}, phosphorus levels in Lake Pitama and background stations in the Lost River and tributaries of the Lost River range from 0.01–0.08 mg·L^{-1} (Minnow, 2010b). Based on total phosphorus concentrations Lake Pitama is considered mesotrophic, however based on chlorophyll a concentrations it is considered oligotrophic. Water quality in Lake Pitama generally follows similar patterns to that in the Lost River headwater reference stations and Cargill Lake (Minnow, 2010a), therefore it is expected that the pit lake will follow a similar trend.

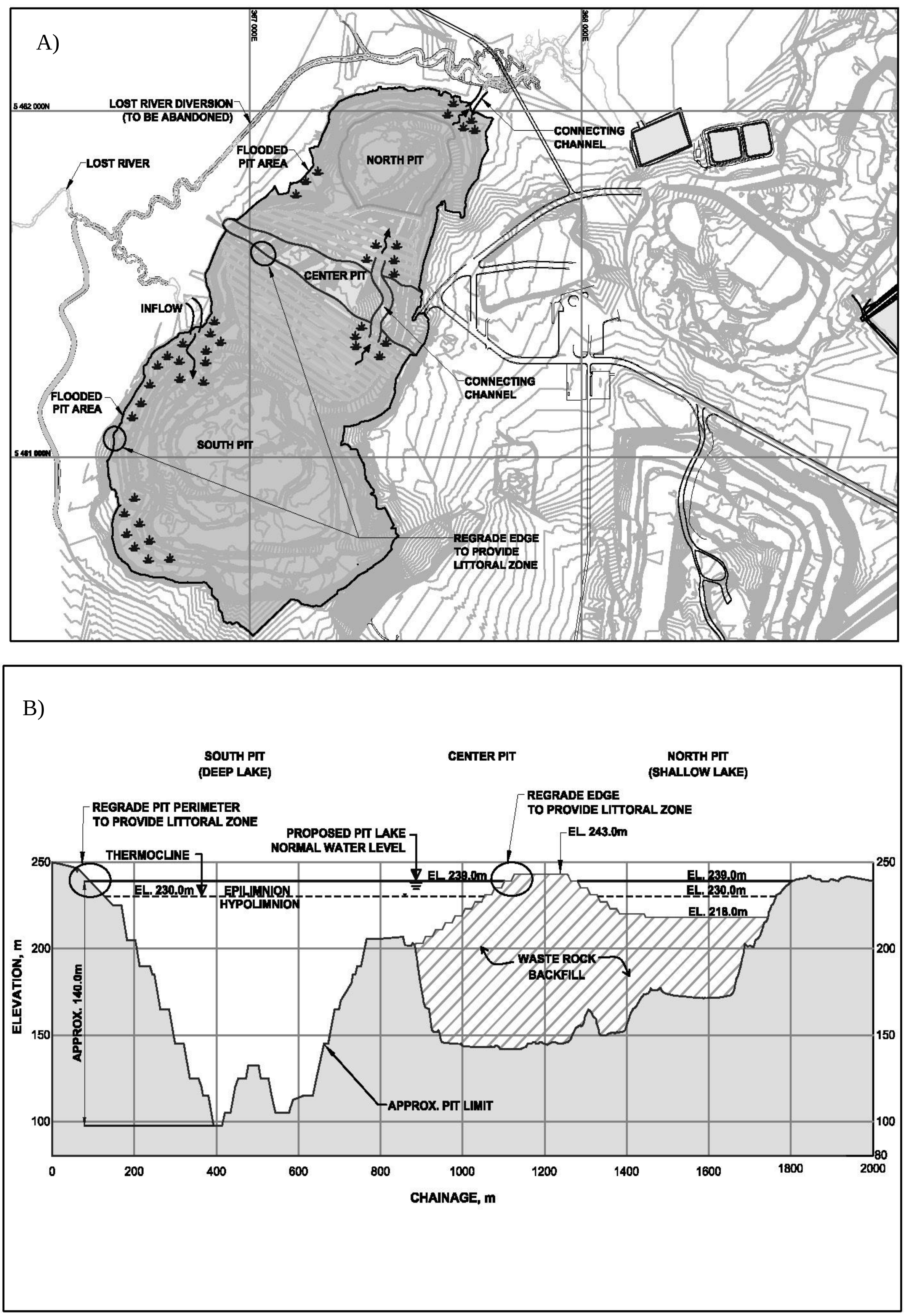

Figure 2 A) Site plan for pit lake at Agrium KPO; and B) Cross-sectional view of future pit lake at Agrium KPO

5 Biological

The original pit lake closure concept was described by Fenco MacLaren Inc. and SNC-Lavalin (1998). At the time the rehabilitation plan for the pit comprised flooding of the open pit, reshaping and re-vegetating the exposed slopes, and returning Cargill Lake and the Lost River to their natural drainage patterns. It was initially projected that the open pit would be flooded to an elevation of 239 m from the following sources: natural precipitation and runoff from the area surrounding the open pit; base flow and flood flows from the Cargill Lake sub-watershed i.e. Cargill Lake was not removed in the original mine plan; and flood flows from the Lost River. Once the pit has been flooded to its final elevation, 100% of the Lost River flows will be redirected from the Lost River diversion channel to the pit. Final configuration will allow the Lost River to naturally flow through the pit lake, discharging back into the Lost River channel at the pit outlet (Figure 2). When the period of pit filling is complete, the Lost River diversion channel will be sealed with an earth fill berm and the flow diversion structure on the natural channel will be removed.

The design features of the lake indicate a final elevation of 239 m with a surface area of approximately 107 ha (Figure 2). The littoral zone in the pit lake would encompass a minimum of 31.5 ha and be located between elevation 235.0 and 239.0 m. As required, the perimeter of the pit would be re-shaped and graded to create the littoral zone and the bottom of the pit lake (maximum depth approximately 230 m) would follow the final pit configuration at the end of mine-life. During pit filling the work along the shorelines will also include re-vegetation efforts in and around the pit to reduce erosion which ultimately would affect the levels of total dissolved solids in the pit lake.

Aquatic habitat features will be constructed in key areas of the pit lake to provide spawning and refuge areas for fish populations. Based on the past success that Agrium KPO has had in constructing a man-made lake, the steps taken to establish a healthy aquatic ecosystem in the pit lake will be based on those used for the re-location of Cargill Lake in the creation of Lake Pitama. Ultimately, the design objective for the Pit Closure Lake is to maintain a viable aquatic ecosystem, particularly, in the upper 10 m along the shoreline and littoral zone (considered as the top 5 m for this study) where a combination of re-aeration through natural processes and biological activity will maintain dissolved oxygen levels. It will not be continuous around the lake perimeter and will vary in lateral extent. With respect to the aquatic habitat features, they would be predominantly located in or in close proximity of the littoral zone and be geared more to the typical fish species found in the Lost watershed (e.g. yellow perch, northern pike, and white sucker).

Upon commissioning, the Pit Lake will be monitored to assess the success of developed fish habitat and the fish community within the new lake. The fieldwork data collection component will include an aquatic habitat assessment to be implemented following the filling of the pit and stabilisation of water quality. Fish and other biota (benthic invertebrates, amphibians, plankton) collected in Lake Pitama will be transferred to the Pit Lake once water quality is deemed acceptable and the pit lake is connected to the Lost River. As with the creation of Lake Pitama, transplanting activities will be sequenced to allow for the best opportunity for the eventual successful transfer of fish from Lake Pitama to the pit lake and will include: the transplant of macrophytes; relocation of benthic invertebrates; relocation of plankton; relocation of small-bodied fish and relocation of large-bodied fish (northern pike and yellow perch). Water quality in the newly established pit lake will also be monitored closely. Eventually, Lake Pitama will be removed and restored back to the head waters of Cargill Creek and the Lost River.

Follow-up monitoring will be conducted over a number of consecutive years following the transfer of biota and the commissioning of the new lake to ensure success of the newly established fish habitat relative to the life history requirements of the resident fish community. Monitoring will include: Basic limnological characterisation of the pit area lake, including bathymetry, temperature and dissolved oxygen (DO) profiles, and Secchi disc readings**.** Biological aspects (flora and fauna) will also be monitored. Fish community and health will be evaluated to determine if the population is comparable to the fish community transferred from Lake Pitama. Should the population or fish health as demonstrated by growth and recruitment be impaired then monitoring will continue and remedial options considered.

6 Conclusions

Developing a pit lake is often the most cost-effective solution for remediating an open pit mine site. However, the consequences of improper and insufficient planning and preparation may result in the implementation of extensive long-term remediation measures in order to manage the pit lake in terms of its water quality and environmental impact. Pit lakes have the potential for numerous benefits to a community including recreation and tourism, wildlife conservation, aquaculture, irrigation, livestock water, potable water, industrial water, and chemical extraction (Doupé and Lymberg, 2005). The geology of the area is actually a ‘good fit’ for creating a pit lake at Agrium KPO as the waste rock is minimal in its acid generating potential. The potential liabilities of developing a pit lake include contamination of surface waters, pit wall fails, contamination of groundwater, groundwater losses, and metal bio-accumulation (McCullough and Lund, 2006). Pit lakes are considered ‘young’ lakes as they are new features to their surrounding landscape and therefore are typically in a non-equilibrium state with respect to their rate of filling, water quality, and biology (Gammons et al., 2009). Because pit lakes are dynamic systems, assessments of water chemistry and quality along with an evaluation of the stability of the structure of the lake (Bowell, 2002) are critical to developing pit lake closure programs.

Along with the studies reviewed thus far, several further studies are currently in progress which will add to our knowledge base and better predict the outcome of the pit lake at Agrium KPO. A pit lake filling assessment is being undertaken to further refine the estimated final elevation of the lake along with the time it will take for the pit to fill. An updated and more detailed pit lake concept design is also being developed based on the most recent mine plan which indicates an end of mine life in mid 2013. Routine site monitoring will also continue which includes a site-wide groundwater sampling program, along with the Lost River Watershed Monitoring Program which examines water quality parameters at upstream, downstream, and on-site locations (tailings pond, sedimentation ponds etc.).

It is the hope of Agrium KPO that by combining the knowledge and recommendations provided by the studies completed thus far we can best ensure the successful establishment of a pit lake. It is imperative that all aspects of lake development be considered as each will have an impact on the other. By taking a geotechnical, geochemical, and biological integrative approach to pit lake development, along with relying on the knowledge base from previous success in re-locating a lake, Agrium KPO is committed to undertaking the necessary steps for ensuring the establishment and restoration of a healthy aquatic ecosystem.

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