Special Effects Monitoring Program

Panda Diversion Channel

2004 is the sixth consecutive year that fish habitat within the channel has been monitored subsequent to habitat creation and enhancement. Improvements to the program in 2004 included modelling grayling winter survival, estimating the size of the entire Koala-North Panda grayling population, and, in a preliminary manner, determining the implications to fish habitat from closing the Panda Diversion Channel (PDC).

The number of fish that used the PDC in 2004 was almost identical to the previous year (759 in 2004, 764 in 2003). The PDC served as a migration corridor between Kodiak Lake and North Panda Lake for Arctic grayling, lake trout, round whitefish and burbot. Most returned to their lake of origin, while 5% migrated through and did not return.

More grayling spawners entered the PDC in the spring of 2004 (402) than in 2003 (351). In fact, for the first time in the life of the PDC, a majority of the fish using it were spawning grayling (54%). Sixteen percent of these grayling had spawned in the PDC in previous years, up from 11% in 2003. After spawning, almost all grayling returned to their wintering lake (Kodiak or North Panda). Grayling using the PDC appear to become sexually mature at 5 to 6 years of age, which is the same for grayling populations in other areas of the arctic. BHPB's consultant estimates the PDC has almost reached its carrying capacity for grayling spawners.

The density of grayling spawners in the PDC in 2004 was greater than in the two reference streams (see Table 2). As a result, densities of grayling eggs were also greater than in the reference streams. However, a lower *fry* survival rate kept grayling production lower in the PDC than in Pigeon, consistent with 2003 results (see Table 2).

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Monitoring at the Panda Diversion Channel

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Fish hatched in the Panda Diversion Channel

Table 2: Grayling Spawning Density, Survival and Production: Comparisons Between PDC and Control Streams.

Stream	Density of Spawners/Eggs (#/100m^2)	Egg-to-Fry Survival (%)	Egg-to-Outmigrant Survival (%)	2004 Annual Fry Production (gm/m^2/yr) (2003 in bracket)
PDC	18 / 1340	2.1	0.6	0.12 (0.28)
Pigeon	16 / 1230	4.0	3.9	1.43 (0.75)
Polar-Vulture	5 / 370	6.3	1.4	0.04 (0.11)

Fry survival and production is expected to increase in future years. Currently, there is less protective cover offered by in-stream and riparian vegetation in the PDC than in the reference streams. Plantings of vegetation in the stream and on the banks will take time to grow to levels comparable to the reference streams.

Mean *fry* growth rate in the PDC (0.7-0.9 mm/day, depending on estimation method used) was comparable to *fry* in the reference streams (0.7 – 1.0 mm/day). But overall, growth plots show grayling in the PDC grow at a slower rate than the other two streams.

PDC Closure

The PDC may be kept open until the Koala and Panda Pits fill with water (through precipitation and runoff) and surface water has resumed its pre-mining flow course through the pits and into Kodiak Lake. It is expected that grayling would then colonize the margins of the pit lakes and the spawning streams between the pit lakes. Alternatively, the pit lakes may be flooded using outside water sources, colonization will be quicker (periods of months and years instead of decades) and the PDC could be closed a short period of time after mine closure.

BHPB has developed a model to determine what effect the resulting increase or decrease in habitat will have on the Kodiak-North Panda grayling population, estimated at a total of 1659 fish. This model will provide a tool for BHPB to use in its decision-making on the fate of the PDC.

Agency's Assessment

The key question of the success rate of young-of-the-year arctic grayling over wintering has not been fully answered. BHPB suggests that PDC-hatched *fry* do survive their first winter but a university study suggests there may be a higher over wintering mortality of young-of-the-year PDC grayling than those in the control streams. In coming years, the results of mark-recapture data from fish that were fin-clipped as *fry* in 2003, should give us more empirical data to determine the survival rate of PDC-hatched *fry* in their first winter. This is a key indication of the utility of the PDC as stream fish habitat.

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Monitoring at the Panda Diversion Channel

Tailings and Wastewater Management

Two notable events related to the operation of the Long Lake Containment Facility (LLCF) occurred in 2004. First, in the spring of 2004 BHPB observed that eight water quality parameters were unexpectedly elevated in cell E of the Long Lake Containment Facility. The findings were discovered prior to the public hearing for the company's water licence renewal. The company took the proactive move of distributing this information to interested parties in advance of the hearing. The company has since initiated a study to investigate the causes of these elevated concentrations.

Second, the company initiated an evaluation of the overall operation of the facility. Monitoring results, plus some field tests undertaken as part of the water licence requirements, indicated that a second look at the management plan for Long Lake was in order.

Regulators at the Long Lake Containment Facility Tour

For several reasons, *tailings* deposition in the upper cells was using up storage capacity more rapidly than originally predicted. The company was not getting full use of the upper cells before having to switch deposition to the lower cells.

A review of the available information led BHPB to the following observations:

- *Tailings* are not moving from the discharge spigot as far as originally anticipated. Steeper than predicted slopes of the beaches are preventing the *tailings* from reaching lower points in the internal parts of the cells, resulting in poor utilization of the cell capacity. Current *tailings* discharge practices would have to be adjusted in order to optimize storage in Long Lake.
- The ultra-fine portions of the *tailings* are not consolidating as sediment on the bottom of the *tailings* ponds, remaining in suspension and quite mobile if disturbed. These are settling in depressions that will coincide with portions of the cells where natural drainage will be re-established when mining is finished. Instead of removing water and slurry from each cell when it is filled, as originally planned, it may now be necessary to retain a 'remnant lake', or water cover, so as to prevent downstream mobilization of the *tailings* fines. Successful stabilization of these ultra-fine clays after post-closure is likely to be a formidable challenge.

Over the past year, a series of workshops were held by BHPB to explore options for

adjusting the operation of the LLCF to deal with these issues. In broad terms, the options evaluated were:

- to proceed according to the original *tailings* management plan that guides the current operation of the *tailings* facility. Deposition to cell D would be required much earlier on in the mine operation for this option than for the others proposed;
- to maximize *progressive reclamation* of the cells; and
- to maximize storage in upper cells and delay deposition into cell D as long as possible.

The re-evaluation exercise tried to determine which option was best by looking at each of the major "accounts"—technical feasibility, environmental protection, cost, closure design—and then ranking these systematically from the perspective of the participants. Results from each account were combined, and then further examined by assigning different weightings to various components.

The clear winner in this exercise, regardless of the weightings used, was the third option—delay *tailings* from going into cell D for as long as possible. This option has the advantage that use of cell D may be avoided altogether if Beartooth Pit becomes available soon enough for backfilling. In addition, maintaining cell D as a water clarification pond (in addition to cell E) would provide extra insurance for safeguarding downstream water quality after closure.

Agency's Assessment

The Agency was impressed with BHPB's serious effort to review the issues posed by the current *tailings* management in Long Lake, and to identify a way to improve this operation. In particular, the collaborative approach adopted by the company in conducting this review appeared to be beneficial for all parties—it produced an apparently workable solution for the company, and all participants gained a much-improved understanding of the issues involved in managing the *tailings* facility.

The exercise also highlighted a number of concerns that need to be addressed by the company.

First, the remaining uncertainties about *tailings* behaviour are substantial, and have very real implications for closure. This is a concern since the company intends to submit its revised *tailings* management plan for approval in the fall of 2005, apparently without having all of the key closure information in place. Information needs that were identified in the workshop are:

- the quality of *tailings* porewater;
- *mineralogy* and *geochemistry* of *tailings* solids;
- the degree of uptake of heavy metals by plants;
- the *toxicity* characteristics of *tailings* and vegetation;
- knowing how much of the ultra-fine *processed kimberlite* will be produced (Fox pipe could produce 3-5 times as much as Panda and Koala pipes did);
- knowing what plant species can re-establish on the *tailings* and which are not attractants for wildlife; and
- knowing how to permanently stabilize and reclaim the clay slurries forming in the cells.

The clay slurries present serious, and as yet, unresolved closure challenges for the company. Despite questioning by the Agency at the workshop, it is apparently not yet known by the company how these, and the transition zones with beached *tailings* which are prone to liquefaction, can be effectively stabilized and reclaimed. For example, it is not known how to place a waste rock cover (as outlined in the currently approved *tailings* closure plan), or how to construct internal erosion control measures within the *tailings* facility.

The Agency expects that when BHPB submits its updated management plan for Long Lake, the closure measures for each component of the facility will be described at a reasonable level of detail. In particular, this should include a description of how the clay slurries and transition zones will be reclaimed, and what measures will be used to cover the exposed *tailings*. Reviewers of the plan should have sufficient information available to demonstrate that the proposed *reclamation* and closure measures are workable.

Discussing options for managing the Long Lake Containment Facility

Waste Rock and Seepage

Activities in 2004

Mining in 2004 focused on developing access to the underground mine for Panda and Koala North pipes. Open pit mining at these pipes is essentially completed, and the Panda-Koala waste rock pile is being readied for closure. A small portion of the pile will likely remain open to accept waste rock from the underground mines.

Stripping waste rock from Fox Pit continued in 2004, this being the major source of waste rock during the year. Misery Pit ceased operation, and will be put into temporary closure in 2005.

As a condition of the water licence, BHPB is required to monitor the waste rock piles during the open water season to detect any seeps from the piles, and to sample these for potential contaminants such as heavy metals. Past surveys reveal a general pattern of few seeps, low volume flows where seeps do occur, and low concentrations of contaminants in the seeps.

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Caribou at Ekati

Seepage surveys carried out by BHPB's consultant in 2004 revealed similar results to previous years. Continued rock sampling and testing at Beartooth, Misery, Fox and Koala revealed similar rock *geochemistry* as previous years—low acid-neutralizing potential and elevated sulphur in schists, low sulphur in granites.

Drainage from the coarse *kimberlite* waste rock, now mostly stored within the granite waste rock piles, has been shown to be acidic down-gradient from the pile. *Sulphide* oxidation within the *kimberlite* pile has been shown to occur. It is believed by BHPB that acid generation from the *sulphide* oxidation is neutralized within the pile, and that the *acidic drainage* down slope is a product of oxidizing iron-rich waters that emerge from the waste rock. Whatever the cause, *acidic drainage* resulting from the waste rock pile seepage, if it continues into the future, is a potential concern for closure.

One sampling station at Misery had elevated concentrations of sulphate, nickel, cobalt and molybdenum, although these have decreased since 2003. Concentrations of sulphate and major ions down-gradient from the Misery temporary ore storage pad have also decreased since 2003.

Seeps from Fox waste rock piles had elevated total suspended solids (TSS) and aluminum concentrations intermittently along one edge of the pile. Pumps and silt fences were installed to effectively mitigate this.

Agency's Assessment

Seepage from waste rock dumps is currently a low environmental concern. The volumes of drainage are low, and most contaminants of potential concern are well within acceptable limits. However, there are issues which may be of concern for closure planning, and BHPB needs to pay attention to these.

Our last annual report described an independent expert review we commissioned of the BHPB's 2003 seepage survey. That review made the following observations:

- there was no discussion of the management implications in the seepage report of the survey results;
- there is significant uncertainty regarding future performance of some rock wastes and the ability of present mitigation measures to achieve the post-closure environmental protection and *reclamation* objectives;
- drainage from the coarse *kimberlite* rejects may present an environmental concern after mine closure;
- the cause of the acidity observed at some seeps is uncertain;
- the leaching of nickel from *kimberlite* and black clay may be a potential problem in the long-term; and
- heat produced from *sulphide* oxidation in some of the rock dumps may interfere with the adopted strategy of relying on freezing of the waste rock material to prevent acid rock drainage (ARD).

As an outcome of our 2004 review we made a number of recommendations designed to address the above issues and to improve the usefulness of the work for the next year.

We are disappointed to discover that BHPB's 2004 seepage report, just distributed as we go to press, is silent on the issues we raised. The Agency believes that BHPB needs to take these issues more seriously, since a number of them have very real implications for closure success. We are conducting an independent assessment of the seepage report once again, and will report back next year on the results of this.

The Panda-Koala waste rock pile

Air Quality Monitoring

Transport truck on the Misery haul road

Two years ago we drew attention to the need for BHPB to upgrade its air quality monitoring program, since that program was not producing reliable data. A key component of this program is the computer model that is used to predict how airborne contaminants from the mining activity disperse outwards from the sources, and how far they travel before settling out. Such models are constructed using available wind data from the site. The emerging pattern of dispersion away from the source is then used to properly locate monitoring stations at appropriate directions and distances from the mine. As we recommended in our 2002 annual report, a new dispersion model was required.

Progress has been slow. In our annual report last year we indicated that BHPB had distributed terms of reference for the modeling work to various reviewers for comment. At that time we stressed the need for the company to work collaboratively with both Environment Canada and the GNWT in developing the model design, and to ensure that model could handle the following issues:

- the deposition of dust as it moves away from the source;
- the variability of dust *emissions* over time to correspond with different types of mining activity; and
- the deposition of other airborne contaminants such as sulphates, *nitrates* and *ammonia*.

As we go to press this year, BHPB has told us that the air quality model has been finalized, with input from Environment Canada and GNWT, and is now being run. We look forward to the results of the snow sampling survey conducted in the spring of 2005.

Government of the Northwest Territories Study

We are pleased to note that GNWT's Environment and Natural Resources (ENR) department published a study last year which analyzed fecal pellets from barren ground caribou at several sites in the NWT for evidence of exposure to dust and soil sources. Sites sampled included locations at Colomac, Ekati and Diavik Mines, along with off-site control areas and seasonal ranges. The study explicitly acknowledges the concerns expressed by Aboriginal elders about the possible effects of caribou exposure to dust from the mines, something we have also been emphasizing with the company in its site monitoring activities.

The results showed that caribou diets around the mine sites consisted of higher quantities of soil or dust ingested than those away from the mines. The signal was most dramatic at Colomac where the average ash content of all the samples collected from the *tailings* area was significantly higher than the off-site control samples. In one case, ash content was so high as to suggest that 50% of the diet comprised soil uptake.

The results also suggested that metal levels in the ingested soils differ markedly between the sites, and that this is reflected in the varying levels of ash in the caribou diet.

The study notes that there are two key questions remaining to be answered:

- what is the cumulative risk to caribou across their annual range from other mines?
- to what degree are metals in the dust taken into the gastrointestinal tract by caribou, and how do they interact?

Some hints concerning the potential exposure at other mines are provided in the GNWT study, since it notes that lichens sampled at both Ekati and Diavik have increased levels of some metals such as aluminum, titanium and iron. *Kimberlite tailings* are relatively high in sodium and calcium which could attract caribou, thereby exposing them to other metals in the *tailings* directly through soil ingestion, or indirectly through revegetation if that is adopted as a *reclamation* strategy at Ekati. Either way, additional assessment of the toxicological risks of exposure to *tailings* by caribou is required at Ekati before a final closure option is selected as recommended in our 2003 annual report.

Reclamation and Closure

Closure Planning for Ekati

While the Ekati Mine is not quite half way through its planned life, the Agency is of the view that effective planning for mine closure is the single most important matter today for effective environmental management at the mine. Moreover, in order to reduce the chances of problems at closure, it is urgent that closure planning be given the highest priority.

The currently approved *reclamation* and closure plan (Interim Abandonment and *Reclamation* Plan) is now five years old, and is significantly out of date with what is happening at the site. Efforts by BHPB to update it have not been successful, as we noted in last year's annual report. It is most important that BHPB take the time to significantly improve this closure plan. As the end of mine life approaches (currently expected to be 2016), the closure plan should mature from a preliminary plan, to an increasingly detailed plan, to a final plan. The Agency believes the status of the closure plan is substantially behind what it ought to be at this time in the life of the mine. There is a need for much more progress on closure planning at Ekati.

It is essential that BHPB, and regulators, have approved a closure plan that accurately reflects the ongoing mining operation and is detailed enough to provide a reasonable degree of certainty that the closure measures proposed will be successful. We recognize that as the mine life progresses, closure details will evolve.

Agency Hosted Reclamation and Closure Workshop

Shared Terminology to Aid in Closure Planning at Ekati

Goals – 'The end toward which effort is directed' or a general 'umbrella statement that defines the end-point.' Goals can be mine-specific or mine component specific.

Objectives – Actions or steps taken to get to the goal that are preceeded by adjectives that define the level or scale at which one is speaking. Objectives can be mine-specific or mine component specific.

Criteria – Measurable and specific performance targets or actions to meet objectives.

The most important next steps involve specifying clear closure goals, objectives, criteria and, ultimately, the means of closing the mine in an environmentally sound manner. These need to be carried out for each of the mine components (e.g. pits, *tailings* pond, rock piles, roads, buildings, airport).

Because it is not known exactly how best to close some mine components, the evolution from a preliminary closure plan to a final closure plan requires carrying out studies

Colomac Mine Story

From 2000 to the present, the Tlicho and DIAND participated in a partnership venture to prepare a closure plan for the Colomac Mine. The partnership meant the Tlicho, the Aboriginal people most affected by the mine, participated from the beginning in the planning for site reclamation. This partnership involved the Tlicho in the following activities: collecting supplementary environmental baseline information at the site; the conduct of contamination studies around the site; the investigation of water quality and water balance studies to identify key issues and potential solutions; the use of Traditional Knowledge (TK) in designing ecological risk assessments, site visits for Tlicho land users and community visits by the DIAND planning team; the use of Tlicho company for site management; and, most importantly, the selection of closure options for the various mine components. This fully integrated approach to closure planning over the four years meant that the closure plan submitted to the Mackenzie Valley Land and Water Board was approved without difficulty, an environmental assessment of the plan was not called for, and the board could dispense with public hearings since there were no issues to address. The closure plan is now being implemented, with full collaboration of the Tlicho.

Shoreline erosion protection at Ekati

Principles for Progressive Reclamation and Closure Planning (Agency 2003 Annual Report)

1. Mines should be 'designed for closure'.
2. *Reclamation* objectives must be identified for each *reclamation* unit (i.e. roads, pits, etc.).
3. Criteria for determining when objectives are attained are essential.
4. Credit for *reclamation* work undertaken should be based on the basis of achievement of criteria rather than expenditures.
5. The outstanding *reclamation* liability should be adjusted annually to reflect work completed to ensure the security deposit matches the liability.
6. 'Conceptual' yet 'viable' closure plans are acceptable prior to mine development, as the mine progresses the plan should be detailed enough to be implemented in the event of premature closure.

to gain the information necessary for proper closure planning. For example, BHPB is carrying out studies on the Panda Diversion Channel and is about to conduct studies on mine pits. Both of these studies (and others) will provide information to allow BHPB to determine what specific objectives should be developed for these mine components. The information is also very important to allow a determination of how best to meet these objectives. This is why there is a requirement for a *reclamation* research plan in the water licence. BHPB has indicated to the Agency that it will include a *reclamation* research plan with its next closure (Interim Abandonment and *Reclamation*) plan.

The Agency has met with BHPB to discuss these matters and the company has clearly stated it agrees on the importance of closure planning. We have offered to work closely with the company and with our other Society members to develop the closure plan. BHPB has indicated it plans to use a process much like it used this year to review the operation of the Long Lake Containment Facility (see chapter on *Tailings* and Wastewater Management). We encourage the company to commence such a process sooner rather than later. The Mackenzie Valley Land and Water Board (responsible for approving the closure plan) also offered to lead such a process (an action we encouraged), but it has not followed through to date.

In last year's annual report, we suggested that the regulators need to provide guidance to BHPB (and to other mine operators) regarding how better to develop closure

plans and we recommended that BHPB, the government and other affected parties should meet to finalize closure criteria for Ekati. To this end, we were pleased to have been funded by DIAND to offer a workshop on mine *reclamation* in February 2005. Proceedings of this workshop were distributed to participants and are available on the Agency's website. The purpose of the workshop was to initiate discussion and identify issues surrounding mine *reclamation* and closure. The workshop brought together representatives of the diamond mine monitoring agencies along with Aboriginal organizations, mining industry staff and government officials. Highlights of the workshop were:

- examination of other northern mines and their closure planning;
- Colomac Mine successes in involving Aboriginal Peoples (opposite page);
- observations about likely (almost certain) need for post closure follow-up;
- DIAND commitment to get the next draft of mine *reclamation* guidelines document out quickly to assist mines generally (and, for us, Ekati specifically); and
- other DIAND commitment to host further workshops involving use of TK in mine closure and closure criteria, and financial assurance.

One of the potentially important documents intended to provide guidance to mine operators regarding closure planning is the DIAND Mine *Reclamation* Guidelines for the NWT and Nunavut. It is now in draft form and, as noted above, DIAND committed at the workshop to improve the draft and plans to complete it in late 2005. The provision of regulatory guidance regarding what is expected or required at closure is a serious constraint on the mine specific closure plan. However, it is only a constraint and the specifics must be applied to the Ekati Mine.

In last year's annual report, we presented some principles of *progressive reclamation* (see opposite page). The Agency presented these at the hearings held by the Mackenzie Valley Land and Water Board in July 2004 for the renewal of the Ekati water licence. We believe they are sound and should be incorporated into the new licence and closure plans.

BHPB carried out a number of *reclamation* projects and studies during 2004 including:

- an evaluation of the Long Lake Containment Facility (see other sections of this annual report);
- a five-year review and summary of revegetation studies;
- revegetation at South Airstrip esker, Culvert Camp and Fred's Camp;
- developed a Standard Operating Procedure for seed collection and processing;
- Old Camp *progressive reclamation* project;
- studies of *reclamation* stockpiles; and
- preparation of terms of reference for a study on pit lakes.

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Aerial view of the Long Lake Containment Facility

Recommendations

1. **BHPB should develop a workable closure plan, within one year, with closure objectives and preferred options for the mine components leading to specific closure criteria.**
2. **Decisions should be made about closure of mine components based on information from the corresponding studies in the forthcoming Abandonment and *Reclamation* research plan.**
3. **BHPB should use a collaborative consultation process to assist in developing its next closure plan, similar to the process used for improving the operation of the Long Lake Containment Facility.**