SNIP MINE: SEVEN YEARS AFTER CLOSURE

S.J. Sibbick, P.Geo. AMEC Earth & Environmental
R. MacGillivray, P.Geo, Barrick Gold Inc.

AMEC Earth & Environmental Ltd., 110 – 160 Traders Blvd. E., Mississauga, Ontario
Barrick Gold Inc., Eskay Creek Mine, PO Box 3908, Smithers BC

ABSTRACT

Closure of the Snip Mine was successfully completed in 1999. Portals into the lower underground workings were sealed with water tight plugs while the upper mine openings were sealed with plugs designed to minimize airflow into the mine. The lower third of the mine was allowed to flood naturally. Discharge from the mine flows through a short channel into the upstream end of the adjacent tailings impoundment. Tailings in the impoundment were regraded and covered with a layer of inert waste rock. A spillway was constructed that allows for limited ponding within the impoundment and maintains a saturated condition within the tailings.

Regular inspections of the mine facilities and ongoing field monitoring have occurred since closure. Monitoring of 13 humidity cells representing tailings, backfill and waste rock materials has continued since 1998. Discharges from the tailings impoundment into the receiving environment have maintained concentrations below the acceptable water quality criteria for the site. Discharges from the underground workings are slightly elevated for a few metals in comparison to the receiving environment criteria. However, these concentrations are mitigated by the tailings impoundment, which acts to reduce the metals load. Monitoring results over the last 7 years indicate that discharge water quality from the site to the receiving environment will continue in its current state.

INTRODUCTION

The Snip Mine is located in the Iskut River basin approximately 100 kilometers northwest of Stewart, British Columbia. The mine site is drained by the Bronson Creek, Monsoon Creek and Sky Creek drainages. Both Bronson Creek and Monsoon Creek flow directly into the Iskut River, whereas Sky Creek flows into the Craig River and then to the Iskut River.

The Snip Mine operated between January 1991 and June 1999, first by Cominco Ltd. and then, beginning in 1996, by Homestake Canada Inc. The mine was successfully closed in October 1999. In 2001 the property was acquired by Barrick Gold Inc. (Barrick) as part of its acquisition of Homestake Canada Inc.

Based on the potential for non-compliance of the underground mine drainage to occur in the long-term, Barrick has continued to focus on assessing the potential of the unflooded workings to produce metal leaching and/or ARD in the future. This has been accomplished by maintaining comprehensive site monitoring and laboratory kinetic testing programs for the last seven years.

GEOLOGIC SETTING

The Snip Mine area is underlain by volcanics, volcaniclastic and clastic sedimentary rocks of Mesozoic age. These rocks are intruded by intermediate to felsic stocks and plutons related to the Coast Plutonic

Complex. Extensive faulting is found throughout the region. The property geology consists of feldspathic greywacke, siltstone and mafic tuffs that have been intruded by feldspar porphyries. The most notable intrusive in the area is the Red Bluff porphyry, which forms a prominent feature along the south side of Bronson Creek.

Ore occurs in two shear veins, known as the Twin zone and the 150 (Twin West) vein. The veins consist of interlayered, laminated calcite and chlorite-biotite-pyrite veins and quartz and pyrite-pyrrhotite veins. The main zone of mineralization is the Twin Zone, which consists of a 0.5 to 15 meter wide sheared vein that cuts through a sequence of massively bedded greywackes and siltstones. Approximately 90% of the ore is composed of only five minerals. In decreasing order of abundance, the ore consists of calcite, quartz, pyrite, chlorite and biotite.

Sulphides consist of pyrite, pyrrhotite, chalcopyrite, sphalerite, galena, molybdenite and arsenopyrite. Minor to trace amounts of bismuth and lead tellurides have been observed. Gold mineralization occurs in 1 centimetre to 1 metre alternating bands of massive (streaky) calcite, heavily disseminated to massive pyrite, biotite-calcite as thin bands or streaks, or in quartz with sulphides in a crackle breccia or pyritic to non-pyritic fault gouge.

MINE OPERATIONS

The Snip Mine consisted of an underground mining operation, mill, tailings impoundment and ancillary facilities. The mine was a fly-in / fly-out operation which was serviced by air flights from Bob Quinn Lake and Smithers to the Bronson airstrip located adjacent to Snip.

Access to the underground workings was provided by a series of portals that accessed the Twin Zone (130, 180, 300, 340, 400, 420, 440, and 520 portals) and Twin West zone (150 and 225 portals). Access and haulage from the Twin zone workings was provided by the 130 and 180 portals respectively. The mill and ancillary facilities were located north of the mine between Monsoon and Bronson Creeks. The tailings impoundment was constructed in the saddle of a narrow valley forming the headwaters to both Monsoon Creek and Sky Creek. Dams were constructed at each end to form a tailings impoundment approximately 150 meters wide and 800 meters long. Discharge from the impoundment was directed towards Sky Creek.

Ore was mined using a variety of underground mining methods and hauled to the mill for processing. Free gold was recovered from the ore using shaker tables and processed on site into dore bars. Concentrate was also produced to recover gold associated with the sulphides. Gold and concentrates were shipped from the mine for additional processing.

Mine wastes generated during operations included waste rock and tailings. During operation, limited waste rock (180,000 mt) was stockpiled in dumps adjacent to five portals (130, 180, 300, 440 and 150). The majority of the waste rock was ground down and used as hydraulic backfill (280,000 mt), or placed directly as rockfill underground (344,648 mt). Tailings were discharged to the tailings pond.

MINE CLOSURE

Closure of the mine was initiated following the completion of mining and the suspension of production in June 1999. Site closure operations were completed in October 1999. The isolated location of the mine and its restricted access posed several challenges for closure. Therefore a comprehensive program was developed to ensure that the site closure could be sustained long-term with minimal post-closure maintenance. Key activities for closure were the:

- Sealing of the underground workings;
- Decommissioning of the waste dumps;
- Reclamation of the tailings impoundment; and,
- Demolition of the site buildings and structures.

Reclamation activities were successfully completed by the end of 1999.

The underground workings contained backfill and rock surfaces considered to be potentially acid generating. Therefore, to minimize the potential for acid generation, the mine was flooded to the 300 level, the highest elevation possible. Concrete bulkheads were installed in the 130 and 180 portals to prevent discharge of mine water. The 340, 400, 420, 440, and 520 portals were sealed with a mixture of waste rock and concrete to limit airflow and prevent public access into the mine.

Waste rock dumps that were identified as being potentially acid generating were dismantled and either placed in the subsequently flooded portion of the underground or encapsulated within the tailings pond. The two dumps that were determined to be non-acid generating, the 150 and 180, were used as cover material for the tailings pond. The 300 dump, also non acid generating, was left in place to provide access to the 300 portal, the location of the underground mine drainage.

Tailings were identified as potentially acid generating, requiring an oxygen-limiting cover to ensure that ARD/ML conditions could not occur. Construction of a suitable dry cover was ruled out as it would have required a volume of material greater than the volume of the entire mine. The final design resulted in the construction of a saturated cover that would maintain water-saturated conditions within the tailings. To achieve this, the tailings were regraded to promote drainage towards Sky Creek, and then capped with a layer of non-acid generating waste rock from the 150 dump and 180 dump. A spillway was built at the south end of the impoundment to allow discharge into Sky Creek. The spillway elevation was constructed to maintain the water level within the waste rock layer capping the tailings. A coarse rock blanket was placed in the spillway to prevent potential damming as a result of beaver dam construction Subsequent settlement of the tailings has resulted in the formation of shallow ponding behind the embankment which ensures saturation during drier periods. Consolidation of the tailings and the migration of vegetation onto the cap have resulted in the development of a naturally formed wetland as shown in Photo 1.

The mill and all ancillary buildings were dismantled and salvaged, or buried on site. Small volumes of hydrocarbon contaminated soils were excavated and continue to be land farmed on a lined facility at the old mill site. Recontouring and seeding was carried out on the building areas and roads; revegetation to date has been highly successful.

CLOSURE MANAGEMENT PLAN MONITORING PROGRAM

Barrick has maintained a rigorous monitoring program as part of its Closure Management Manual for the site that includes water quality sampling, geotechnical inspections of the tailings dam and underground portal plugs, aquatic resource monitoring, and land use inspections. The compliance for the site is judged at the tailings pond discharge (TPD). Water samples are collected five times per year from the outfalls of the TPD, the 300 Level portal (300), the 180 Level portal (180) and the 130 Level portal (130). A bulk water sample is also collected annually from the TPD and evaluated for toxicity. The following table summarizes the location, frequency and parameters of each sampling point:

Table 1 –Water Quality Sampling Requirements for the Snip Mine

Location	Frequency	Parameters
Tails Pond Discharge	May-June-August-October-December	Flow, pH, TSS, hardness, conductivity, sulphate, dissolved and total metals, annual toxicity.
300 Portal	May-June-August-October-December	Flow, pH, TSS, hardness, conductivity, sulphate, dissolved and total metals,
180 Portal	May-June-August-October-December	Flow, pH, TSS, hardness, conductivity, sulphate, dissolved and total metals,
130 Portal	May-June-August-October-December	Flow, pH, TSS, hardness, conductivity, sulphate, dissolved and total metals,

Geotechnical monitoring of the piezometers installed within the tailings embankment is conducted at the site on a semi-annual basis and visual inspections of the embankment and the outlet spillway are completed during each water quality monitoring round as listed in the table above and once every 3 years by a professionally certified geotechnical engineering specialist. The most recent inspection found the impoundment to be in good condition, with no signs of deformation, significant erosion, cracking, bulging, or differential settlement (Knight Piésold, 2005).

In addition to the field monitoring program, Barrick operates a kinetic testing program to predict the long term geochemical behavior of the Snip mine wastes. Thirteen humidity cells containing samples of tailings, backfill and waste rock have been monitored continuously for a period of approximately eight years. Data from the cells is periodically assessed to estimate the potential for the onset of acidic conditions.

The Closure Management Manual, which has been distributed to key management and regulatory personnel, lists the required monitoring and inspection programs, includes sampling protocol, and documents the contact information for site management and regulatory officials for transferring information in the event that significant environmental issues are identified at the site.

WATER QUALITY MONITORING RESULTS

Regular monitoring of the Snip Mine has been carried out since closure. In addition, monitoring of the discharges from the mine and tailings pond were monitored during operations on a regular basis.

Tailings Pond and 300 Portal Discharges

The compliance monitoring point for the Snip Mine site is the tailings pond discharge (TPD) into Sky Creek. This site has been sampled 54 times since closure. Table 2 below lists the summary statistics for the tailings pond discharge. Water quality of the discharge has been well below the permitted levels.

Table 2 - Tailings Pond Discharge Data January 2000 to October 2005

Parameter	Mean	Median	Maximum	Permit Level
pH	8.1	8.1	8.4	6.5-9.5
TSS	5	3	37	≤50
Dissolved Cadmium	0.0002	0.0002	0.0004	<0.0008
Dissolved Iron	0.07	0.03	0.73	≤1.0
Dissolved Lead	0.002	0.001	0.038	≤0.05
Dissolved Zinc	0.007	0.005	0.027	≤0.2

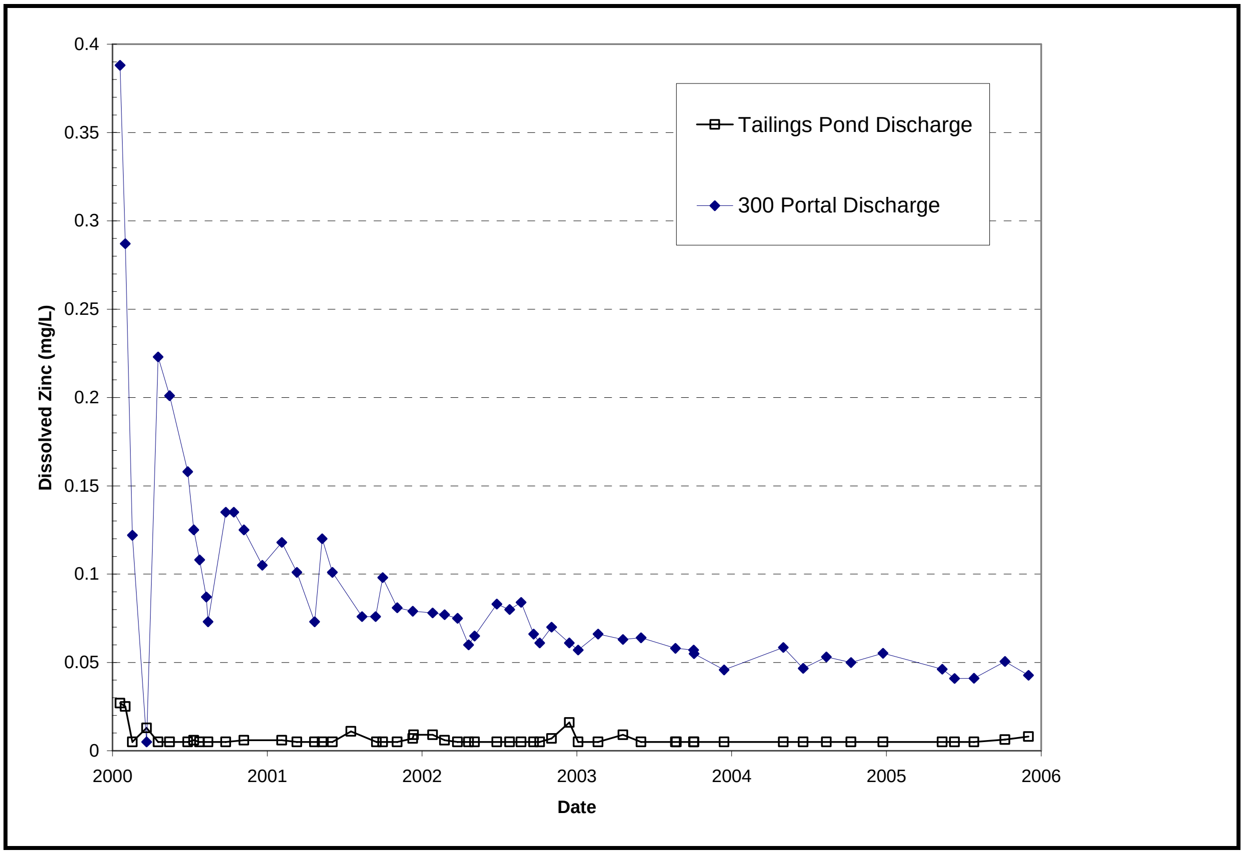
Notes: T - total metals, D – dissolved metals. Concentrations in mg/L.

Flooding of the mine began in October 1999; the mine water reached the elevation of the 300 Portal by January 2000 and began to discharge. Flow from the 300 Portal travels downslope via a small creek where it enters at the tailings impoundment approximately halfway along its length. The tailings are partially covered by a seasonal pond which forms in the southern half of the impoundment. Flow in the impoundment is southwards towards the spillway and Sky Creek.

Initial discharges from the 300 Portal reported elevated levels of metals, most notably zinc (Figure 1). A peak concentration of 0.388 mg/L was measured in January 2000 from the 300 Portal discharge. Since that time, zinc concentrations have shown a pattern of near-continuous decrease. Concentrations measured in 2005 were approximately 0.05 mg/L or less, representing an almost ten-fold decrease since mine water began to discharge from the mine. Conversely, zinc concentrations measured at the TPD have remained very low, generally at or below the detection limit of 0.005 mg/L.

Sulphate concentrations in mine drainage are an indicator of sulphide oxidation and/or the dissolution of secondary sulphate minerals produced from the oxidation of sulphides. Sulphate tends to be a conservative parameter; unless saturated, sulphate concentrations will be unaffected by interactions with other metals or compounds. Therefore, sulphate concentrations in mine water discharges can be used to gauge the ongoing oxidation of sulphides and the release of oxidation products that have accumulated within the mine. Initial sulphate concentrations discharging from the mine had elevated concentrations (~425 mg/L) in the 300 Portal drainage (Figure 2). Sulphate concentrations have gradually decreased in the portal flow since mine flooding. Flows from the TPD have reported lower sulphate concentrations than the portal discharge (Figure 2) that show a pattern of variable, but gradually decreasing concentrations over time. In general, the TPD flows have sulphate concentrations that range from equivalent to approximately one-half of the 300 Portal concentrations.

Figure 1 - Dissolved zinc concentrations, 300 Portal and Tailings Pond discharges, 2000 to 2005

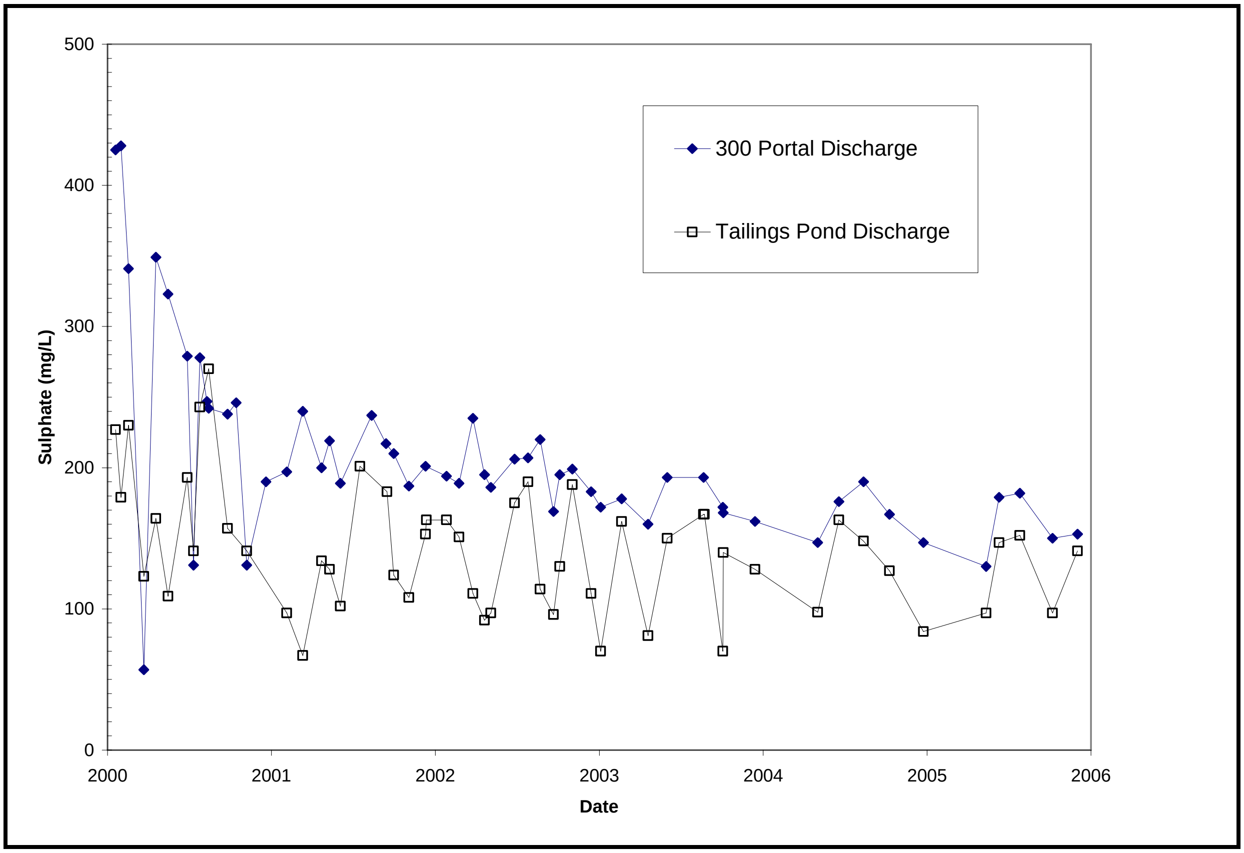


A notable distinction between zinc and sulphate are the differences in the concentrations found between the 300 Portal and the tailings pond discharge (TPD). As noted, sulphate concentrations at the TPD are as little as one-half the 300 Portal discharge concentration. However, zinc concentrations in the TPD have remained near or below detection limit (0.005 mg/L) since closure. Zinc concentrations of the 300 Portal water have been reduced by at least an order of magnitude during flow through the tailings impoundment. Based on the available flow monitoring data, the estimated monthly flows from the TPD are twice that of the 300 Portal (Table 3), suggesting that dilution can account for approximately a 50% reduction in concentrations at the TPD. Therefore the zinc concentration reduction appears to be the result of both dilution and the attenuation of zinc within the impoundment, possibly by the absorption onto organic materials.

Table 3 – Estimated Mean Flows from the TPD and 300 Portal (based on flow data 2001 to 2005)

	L/s	m^3/month
TPD	21	54221
300 Portal	9	23525

Figure 2 – Sulphate concentrations, 300 Portal and Tailings Pond discharges, 2000 to 2005



Mine Flooding

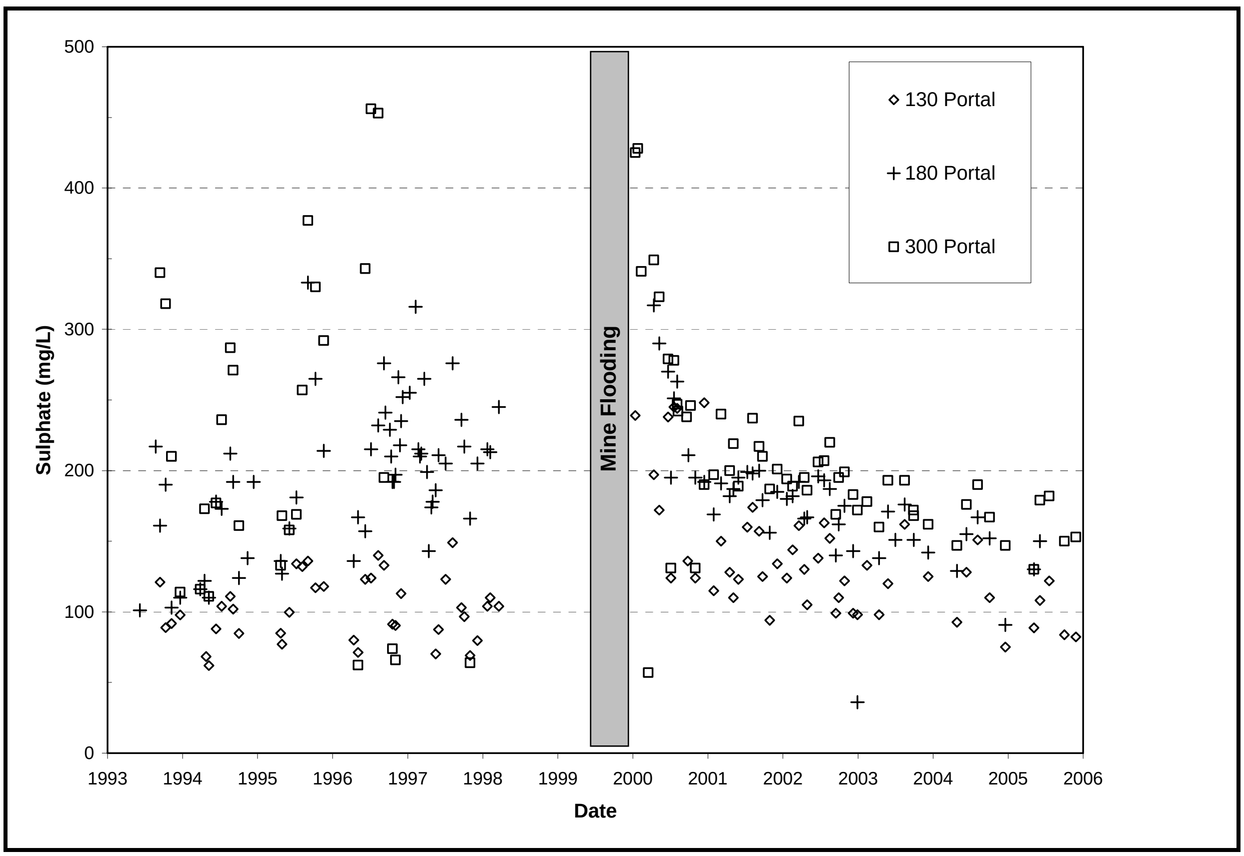
Figure 3 presents concentration data for sulphate collected from mine water discharge at the 130, 180 and 300 portals before and after closure of the mine. Mine water discharge at these portals was regularly collected between 1993 and 1998 and from 2000 to 2005. Mine water quality during operations showed an overall wide range of concentrations but similar concentration ranges for each of the three portals. The mine water represented a combination of groundwater, surface infiltration from areas such as the Crown Pillar, and mine process water. Process water primarily constituted water used in the placement of hydraulic backfill in stopes; other lesser sources included water used in the operation of machinery such as drills.

The 130 Portal discharges generally had the lowest concentrations, followed by the 180 Portal and finally the 300 Portal with the highest overall concentrations. This likely reflects the use of the 180 and 300 portals for active discharge of mine water to the tailings pond. Lower concentrations in the 130 Portal discharges may also represent dilution by groundwater seepage along the longer flowpath from the mine workings to the portal entrance.

During the operation of the mine prior to flooding, mine water from all three portals showed a similar overall pattern of increasing concentration with time. Concentrations of the discharges were commonly in the range of 50 to 300 mg/L sulphate, with some values in the 300 to 450 mg/L range. These concentration increases over time likely reflect both the increasing volume of backfill placed in the mine during operations, and oxidation of sulphides within the backfill and possibly on mine surfaces.

Following flooding of the mine the to 300 Portal level, discharge concentrations showed initial maximum concentrations (up to 425 mg/L) which decreased rapidly over a few months. By early 2003, sulphate concentrations in the mine water discharges were below 200 mg/L. Like the water quality data during mine operations, sulphate levels in the 130 Portal discharges had lower concentrations than the 180 and 300 Portal flows. Discharges from the 180 and 130 portals have been relatively insignificant since closure; these flows consist of minor seepage flows that emanate from bedrock downgradient of the plugs. Inspections during 2005 observed no flows from these two locations. It is not clear what the source of the post-closure flows from the 130 and 180 portals; however, the similarity in the concentrations and patterns of decrease suggest that these waters are at least partially derived from mine water.

Figure 3 – Mine water sulphate concentrations, Pre and Post flooding



Dissolved zinc concentrations for pre- and post-closure water quality are shown in Figure 4. Concentrations during mine operations generally ranged from at or below detection limit (0.005 mg/L) to

0.01 mg/L, with infrequent concentrations between 0.01 and 0.1 mg/L. No relationship appears to exist between dissolved zinc concentrations and discharge location in the mine.

Following flooding, zinc discharge concentrations from all three portals increased significantly over their pre-closure concentrations; values greater than 0.1 mg/L were measured in flows from the 300 and 180 portals. Concentrations in the 130 portal discharges reached 0.05 mg/L. Since mine flooding, dissolved zinc levels in flows from the 300 Portal have decreased steadily to concentrations below 0.05 mg/L. Concentrations from the 130 and 180 portals have also decreased steadily, reaching concentrations of approximately 0.01 mg/L. Dissolved zinc concentrations in the 300 Portal flows have been significantly higher that those measured for the 130 and 180 portals. The patterns of decrease followed a very similar pattern to that observed for the 300 Portal concentrations. As well, these patterns of decrease are also very similar to that observed for sulphate (Figure 3). However, like sulphate, the dissolved zinc concentrations decreased rapidly from their peak concentrations immediately following onset of discharge from the 300 Portal. The pattern of mine water concentrations suggest that steady-state concentrations may be reached in the near future.

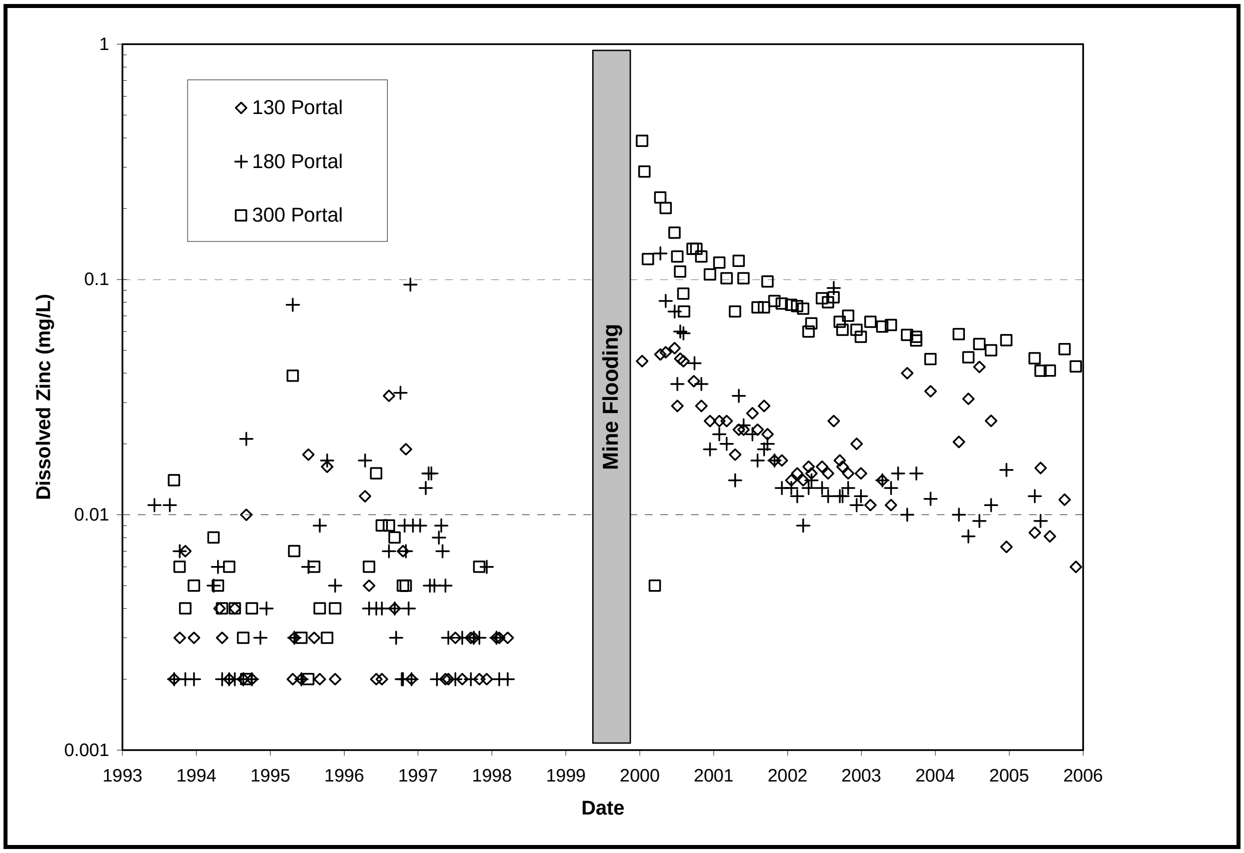
The observed increases in the sulphate and dissolved zinc concentrations in mine water immediately following closure of the mine indicate that a mass of soluble metals were released into the mine water during flooding. These metals accumulated on the mine surfaces during the operational phase of the mine due to the oxidation of sulphides on surfaces such as mine walls and backfill. During the mine operation these soluble metals remained in place as there was no mechanism to remove them in significant quantities from the mine surfaces. However, as the mine flooded these accumulated oxidation products were released into the mine water.

The similarities in the discharge data suggest that the three portal waters are sourced from the mine water pool in the flooded workings. However, differences between the concentrations suggest three potential factors may have produced the observed discharge water qualities:

- Dilution from groundwater and/or surface water;
- Chemical precipitation along bedrock flowpaths; and/or
- Mine water stratification.

Similar sulphate concentrations in 300 and 180 portal water and lower concentrations in the 130 Portal discharges suggest that dilution has occurred along the longer flowpath between the mine workings and the 130 Portal. The lower overall zinc concentrations in the 180 and 130 portal flows suggests that dilution and/or chemical precipitation may have effected these concentrations as the mine water seeped out along bedrock fractures. Dilution of these seepage waters by shallow groundwater may also have resulted in lower concentrations. Thirdly, stratification of the mine water may have resulted in concentration variations within the mine water pool. The stratification could have occurred as the rising mine water leached levels of the mine with differing quantities of soluble metals.

Figure 4 – Mine water zinc concentrations, Pre and Post flooding



CONCLUSIONS

Based on the results of this study, it would appear that the reconstruction of the tailings impoundment during closure as a wetland has been successful in attenuating metal concentrations. The release of metals from the underground workings has been steadily decreasing following mine flooding in 1999. Near steady-state metal concentrations in the mine water discharge may be reached in the near future.

Barrick Gold Inc. is committed to maintaining a responsible post-closure monitoring program that is capable of detecting variations and establishing trends for analytical water quality results. Based on the current success of the closure works, and continued success throughout 2006, a reduction in frequency and parameters analyzed for, will be pursued, if prudent. Geotechnical monitoring will also be conducted for the long-term; however, continued consolidation of the tailings over time is further mitigation against future potential stability issues with the tailings facility.

Photo 1 - Snip tailings pond, looking north, May 2005

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