Case Study Assessment – Rehabilitation of the Dona Lake Tailings Area Pickle Lake, Ontario

MEND Report 9.2a

This work was done on behalf of MEND and sponsored by Environment Canada

November 2006

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FINAL Report

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This work was done on behalf of MEND and sponsored by Environment Canada

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The case study for Dona Lake was completed in 2004; with the report finalized in 2006. It was part of a series of case studies that were to be compiled and released on CD-ROM. Approval for publication was not obtained for some of the case studies, and in 2010 the MEND Steering Committee recommended posting the completed studies on the redesigned MEND web site.

As such, the data for this case study was collected up to 2003 from Placer Dome Canada. Monitoring, data collection, and reclamation works have continued at the Dona Lake site since 2003 up to the present. The site changed owners in 2006 to Goldcorp Canada Ltd. Even though this case study is somewhat dated, it provides relevant and useful information on high permeability covers for saturating tailings.

ABSTRACT

The Dona Lake Mine, an underground gold mine that ceased operation in 1994, is located near Pickle Lake, in northern Ontario. The nominal production rate during operation was approximately 500 tonnes per day.

The tailings impoundment is situated in a low lying area and is surrounded by natural topographic highs to the east and west. A dyke, Dyke 3, was constructed at the south end during operation of the tailings impoundment, and a dam was constructed to the north after production ceased. The physical characteristics of the tailings impoundment are not conducive to underwater tailings disposal.

Acidic drainage prediction tests were conducted by Placer Dome Inc. As the prediction tests indicated that the tailings were potentially acid generating, site rehabilitation focused on maintaining the highest possible degree of saturation in the tailings material. The elevated water table, maintained by the site topography, minimizes the ingress of oxygen in the saturated tailings and ultimately reduces their oxidation. The Dona Lake Mine provides an example of a current application of the elevated water table concept to the decommissioning of a tailings management facility.

Field monitoring involving piezometers, neutron probe measurements of moisture within the tailings, and matrix suction profile measurements were conducted by the University of Saskatchewan. Predictive modeling was conducted to couple the depth to phreatic surface with the climatic conditions.

To improve the infiltration rate into the tailings beach, where tailings were exposed and oxidized to a 1 to 2 m depth, a series of soil cover models were analyzed for different cover options. A rockfill cover appeared to be the most effective option among the cases analyzed. The rockfill material promotes infiltration due to its high permeability at lower suction and lower permeability at moderate suction range. It allows the water to infiltrate easily through the cover during rainfall events when suction decreases to zero.

The tailings impoundment area was partly flooded and a rockfill cover was installed over the exposed tailings to reduce the area of tailings potentially exposed to oxidation to <1% during normal years and approximately 5% under drought conditions.

Key words: Elevated water table, Dona Lake, acid mine drainage, neutron probes and rockfill cover.

SOMMAIRE

La mine Dona Lake, une mine d’or souterraine qui a cessé ses activités en 1994, est située près du lac Pickle, dans le Nord de l’Ontario. Le taux de production nominal pendant son exploitation était d’environ 500 tonnes par jour.

Les résidus miniers se trouve dans une dépression de terrain et est entouré de hauteurs topographiques à l’est et à l’ouest. Une digue, Digue 3, a été construite à l’extrémité sud pendant l’exploitation du parc à résidus, et un barrage a été construit au nord après l’arrêt de la production. Les caractéristiques physiques du parc à résidus ne sont pas propices à la disposition subaquatique des résidus miniers.

Des tests visant à prévoir le drainage acide ont été effectués par Placer Dome Inc. Comme les tests ont indiqué que les résidus produisaient potentiellement de l’acide, la réhabilitation du site était axée sur le maintien du plus haut degré de saturation possible dans les résidus. La nappe phréatique surélevée, maintenue par la topographie du site, minimise l’entrée d’oxygène dans les résidus saturés et, finalement, réduit leur oxydation. La mine Dona Lake constitue un exemple de l’application actuelle du concept de la nappe phréatique surélevée pour la fermeture d’une installation de gestion des résidus miniers.

Le suivi comprenant l’utilisation de piézomètres, la mesure du taux d’humidité des résidus à l’aide d’une sonde à neutrons et la mesure du profil de succion de la matrice, a été effectué par l’Université de la Saskatchewan. Une modélisation a été réalisée pour associer la profondeur du niveau phréatique avec les conditions climatiques.

Afin d’améliorer le taux d’infiltration dans la plage de résidus, où les résidus étaient exposés et oxydés à une profondeur d’un à deux mètres, une série de modèles de couvertures du sol a été analysée pour différentes options de couvertures. Une couverture d’enrochements s’est avérée être l’option la plus efficace parmi les cas analysés. Les enrochements favorisent l’infiltration en raison de leur grande perméabilité lorsque la succion est faible et de leur faible perméabilité lorsque la succion est modérée. Elles permettent à l’eau de s’infiltrer facilement à travers la couverture pendant les précipitations, soit lorsque la succion diminue jusqu’à devenir complètement nulle.

Le parc à résidus a été partiellement inondée et une couverture d’enrochements a été installée sur les résidus exposés afin de réduire la zone de résidus potentiellement exposés à l’oxydation à moins de 1 % pendant les années normales, et à environ 5 % en périodes de sécheresse.

Mots clés : Nappe phréatique surélevée, Dona Lake, drainage acide, sonde à neutrons, et couverture d’enrochements

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1. INTRODUCTION

Natural Resources Canada (NRCan) has commissioned GEOCON, a wholly-owned subsidiary of SNC-LAVALIN ENVIRONMENT INC., to perform a series of case studies on 5 different reclaimed mine sites specially selected because of the reclamation technologies that were applied.

This study explores an application of the elevated water table concept, which involves raising the water level within the tailings to increase their saturation so that reactive tailings are maintained in a sufficiently saturated condition to minimize sulphide oxidation (MEND, 2001, MEND, 1996). This concept was applied at the Dona Lake tailings impoundment, where the closure plan relies in part on the elevation of the water table within the tailings beach area. The topographic conditions of the site are such that a near saturation condition can be maintained in the tailings with a combination of water cover and rockfill cover over the exposed tailings.

2. SITE CHARACTERISTICS

2.1 Location

The Dona Lake Mine is located near Pickle Lake, 370 km north of Thunder Bay, in northern Ontario. Figure 2-1 shows the site location. The mine is located in a flat regional topography with elevations ranging from 330 m to 410 m.

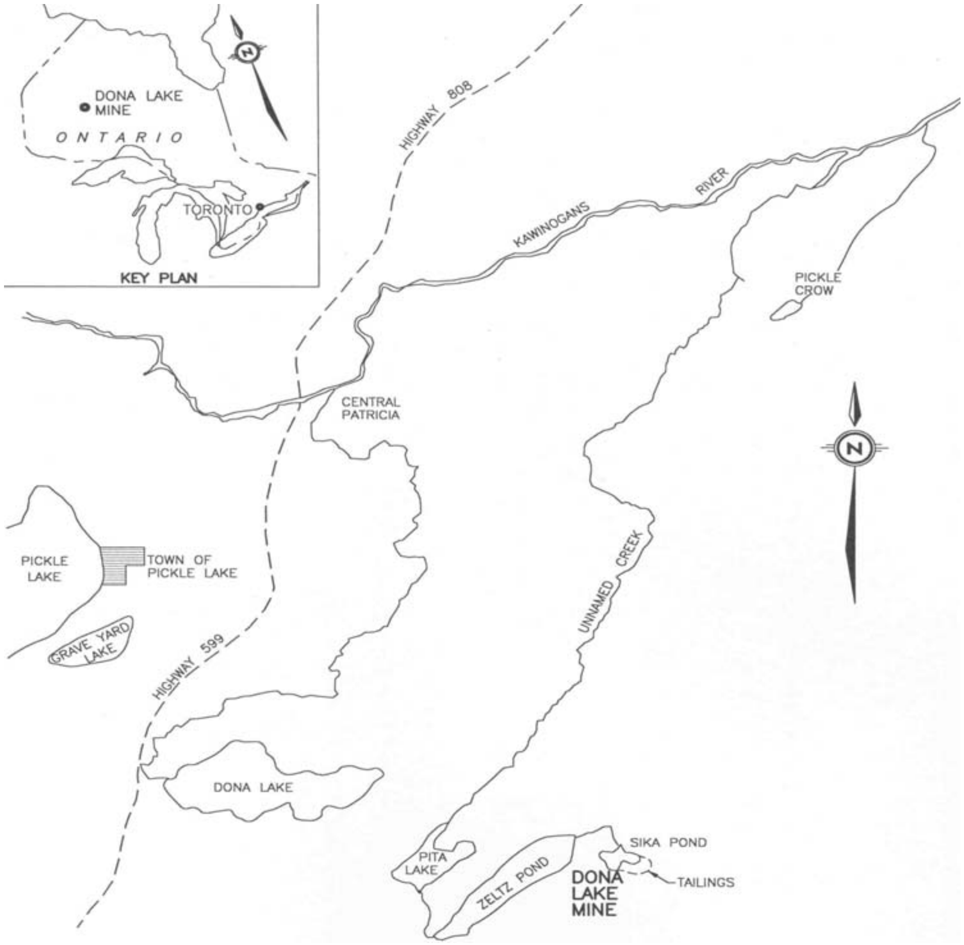

Figure 2.1 – Site location (from Klohn Crippen, 2002)

2.2 Site history

The Dona Lake Mine, an underground gold mine, was in operation from 1989 to 1994. Placer Dome Canada (PDC) owned the property and operated it until 1993. Then Ross-Finlay Limited, a contractor in mine development, operated the mine and the tailings facility until August 1994, when production ceased at the mine. Production rate was approximately 450 tonnes/day. After closure, Placer Dome was responsible for the reclamation of the tailings related areas (tailings pond and polishing ponds downstream) while Ross-Finlay was responsible for the plant site and underground. Placer Dome has been working on the closure of the Dona Lake tailings impoundment since 1994, which is now entering the final phase of the closure plan.

2.3 Climate

The continental type climate found at the site can be extreme, with temperatures commonly ranging from -35 degrees Celsius in the winter to +30 degrees Celsius in the summer. The temperature averages –17ºC to –20ºC in December, January and February, and 14ºC to 18ºC in June, July and August. Average annual precipitation is 733 millimetres, occurring mostly as rain (500 mm per year). 75% of the annual rainfall occurs during the period of June through September. Snow precipitation normally accounts for 233 mm water equivalent (274 cm of snow). The snow cover averages 60 to 70 cm during the months of January, February and March. The winds are predominantly from the west and southwest in the winter, spring and summer and from the north during the fall. Wind speed averages 12 km/h throughout the year.

3. DESCRIPTION OF THE TAILINGS MANAGEMENT AREA

The tailings impoundment is located in a low lying area and is surrounded by natural topographic highs to the east (a hill) and west (a drumlin, i.e. a mound consisting of compacted till moulded by glacial action). The main components of the tailings basin are shown on Figure 3-1 and include the following:

- The main tailings are impounded by Dam C in the north and Dyke 3 in the south. Both dams have a crest elevation of 394 m.
- A permanent spillway around Dam C, at elevation 392.5 m.
- A secondary spillway in the east abutment of Dyke 3.
- Sika Pond, which acted as a polishing pond during mine operation. The pond was previously bounded by Dyke 1, Dyke 2 and Dam A, which was breached to return to pre-mining water levels.

In 1994, following mine closure, the tailings were flooded to elevation 391 m. Approximately 60% of the tailings area was left exposed to oxidation.

In 1997, about 65 tonnes of crushed limestone (< ¾ inch) were spread on the tailings beach adjacent to the drumlin. Limited areas of this beach had shown pH depression.

In 1999 and 2000, rehabilitation work was undertaken in the tailings area. The objective of this work was to move the oxidized tailings apron from the east slope of the drumlin into the impoundment and to raise the spillway level to elevation 392.5 m in order to inundate the tailings beach near Dyke 3. With the tailings flooded to elevation 392.5 m, only 11% of the tailings area was exposed to oxidation. The area of exposed tailings was located along Dyke 3. The main activities consisted of the following (Klohn Cripen 2000):

- Raising the spillway at Dam C by a concrete plug with a crest elevation 392.5 m.
- Raising the impervious core of Dam C from elevation 391.95 to elevation 393.4 m.
- Raising Dyke 3 to elevation 394 m.
- Installing a secondary spillway with invert at elevation 393.2 m in the east abutment of Dyke 3. No flow is expected through this spillway unless the Dam C spillway becomes blocked.
- Moving the tailings apron from the east slope of the drumlin and relocating the tailings into the impoundment.
- Regrading the beach near Dyke 3 to elevation 393 m.

In 2000 and 2001, excess peat and till excavated from the saddle dam foundation was placed as a cover on the west end of the exposed south tailings beach, adjacent to Dyke 3. This area was at the highest elevation and usually dried out during the summer months. In total, about 1/3 of the exposed tailings beach along Dyke 3 was covered with a mix of organics and till, to a depth of approximately 10-12 cm.

Normal water level in the tailings pond is now at 392.5 m. At this elevation, the tailings impoundment is partly flooded and a tailings beach of about 45 m wide remains against Dyke 3. Maintaining the water table within the tailings at a high elevation is part of the rehabilitation strategy to prevent acid generation.

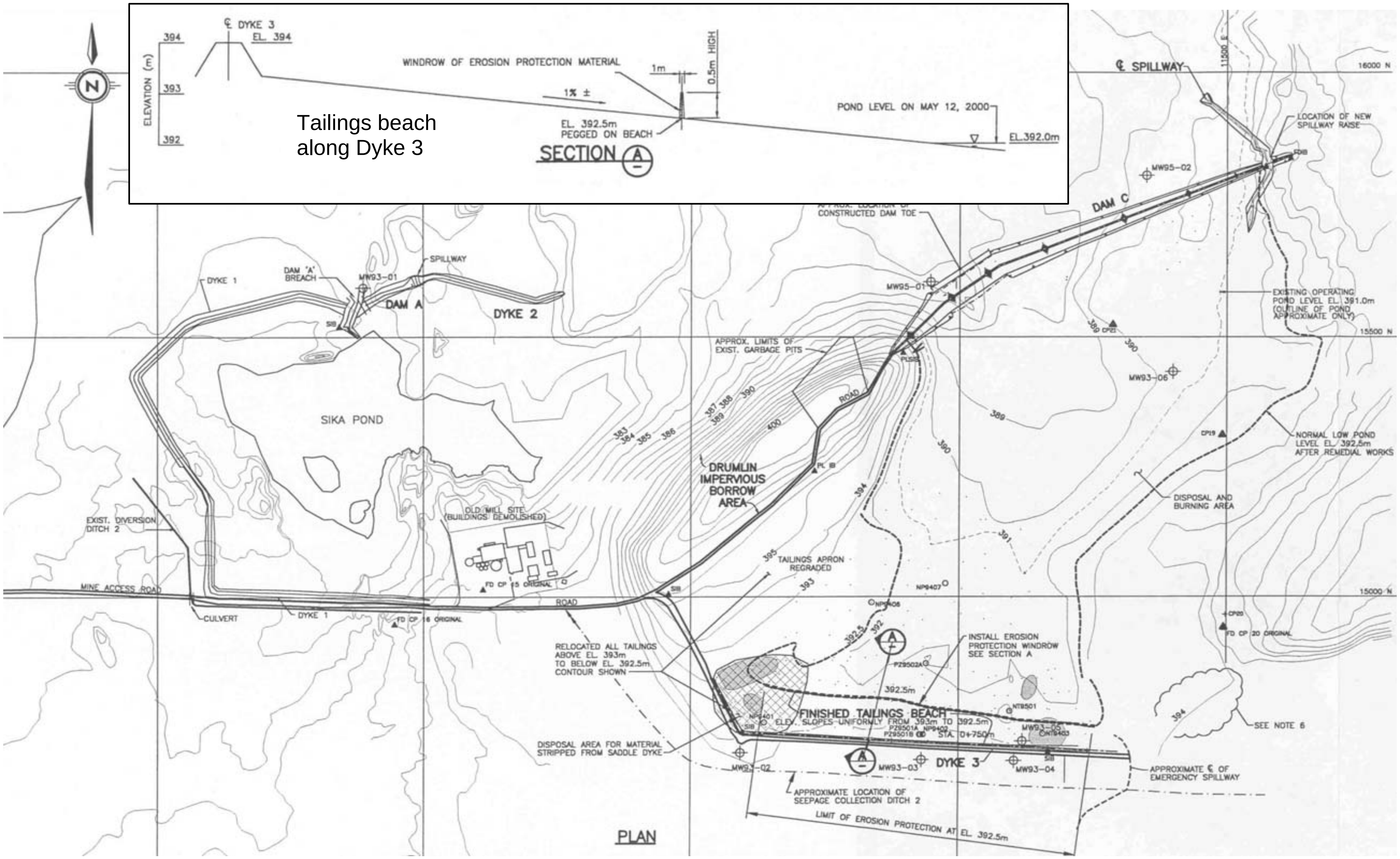

Figure 3.1 – General arrangement of the tailings impoundment (modified from Klohn Crippen, 2000)

4. CHARACTERIZATION STUDIES

4.1 Kinetic test

A kinetic test was performed on a tailings sample from Dona Lake (Placer Dome, 1999). The test was started in the Placer Dome Research Centre. The initial acid/base accounting (ABA) results of the sample are as follows: paste pH of 8.02, total sulphur of 3.44%, almost no sulphate, acid generation potential (AP) of –108 kg $CaCO_3$/t and neutralization potential (NP) of 70 kg $CaCO_3$/t. The test was run for 297 weeks and terminated in December 1997. At that time, the effluent pH was still neutral (6.88) with low alkalinity (14 mg $CaCO_3$/l) and elevated sulphate (419 mg/l). Base metal concentrations (As, Cu, Fe, Ni, Zn) in the leachate were all low (below 0.1 mg/l). Comparison of the pre- and post-ABA analysis indicated that 30-35% of the sulphur was oxidized during the test, but a greater proportion of NP had been consumed. Since there was already field evidence of acidic paste pH conditions observed in the exposed tailings along Dyke 3 (see section 7.2), it was decided to terminate the laboratory test.

4.2 Field work performed by University of Saskatchewan

In 1994 and 1995, a research program was undertaken by the University of Saskatchewan to develop field monitoring and hydrogeological modelling for the Dona Lake tailings impoundment (O'Kane et al, 1996). The objective was to couple the effect of raising the pond water level with the influence of the various climatic regimes. The most important material characterization parameters considered were the soil water characteristic curve and the saturated hydraulic conductivity. The instrumentation installed included:

- 2 piezometer nests, installed along Dyke 3, and 5 groundwater monitoring wells.
- 8 neutron probe access tubes, to monitor in-situ moisture conditions. The location of the neutron probes, labelled NP94-01 to NP-94-07 and NP-95-01, are shown on Figure 4-1.
- A series of jet-fill tensiometers, at different depths in the tailings along Dyke 3, to measure the negative pore water pressure of the tailings.
- A nest of suction lysimeters installed in the tailings material near Dyke 3.

The water content profiles measured by the neutron probe access tubes were used to validate the results obtained from the infiltration models. In 1995, the phreatic surface measured in NP94-02, located near Dyke 3, was 2.5 m below the tailings surface. Further upstream of Dyke 3, in NP94-07, the water level was 0.5 m below the tailings surface.

The soil moisture measurements taken by the University of Saskatchewan were used to calibrate the 1-D transient soil/atmosphere model, SoilCover© 2000 (MEND, 1994) and the 2-D saturated/unsaturated flow model, SEEP/W (Geoslope International Ltd, 1995), used for the study. The field monitoring and predictive modelling indicated that the tailings pond was performing well with respect to saturated/unsaturated flow and potential for acid generation. The study demonstrated that the predictive modelling approach can be used to evaluate rehabilitation options or assess long-term performance of different closure strategies.

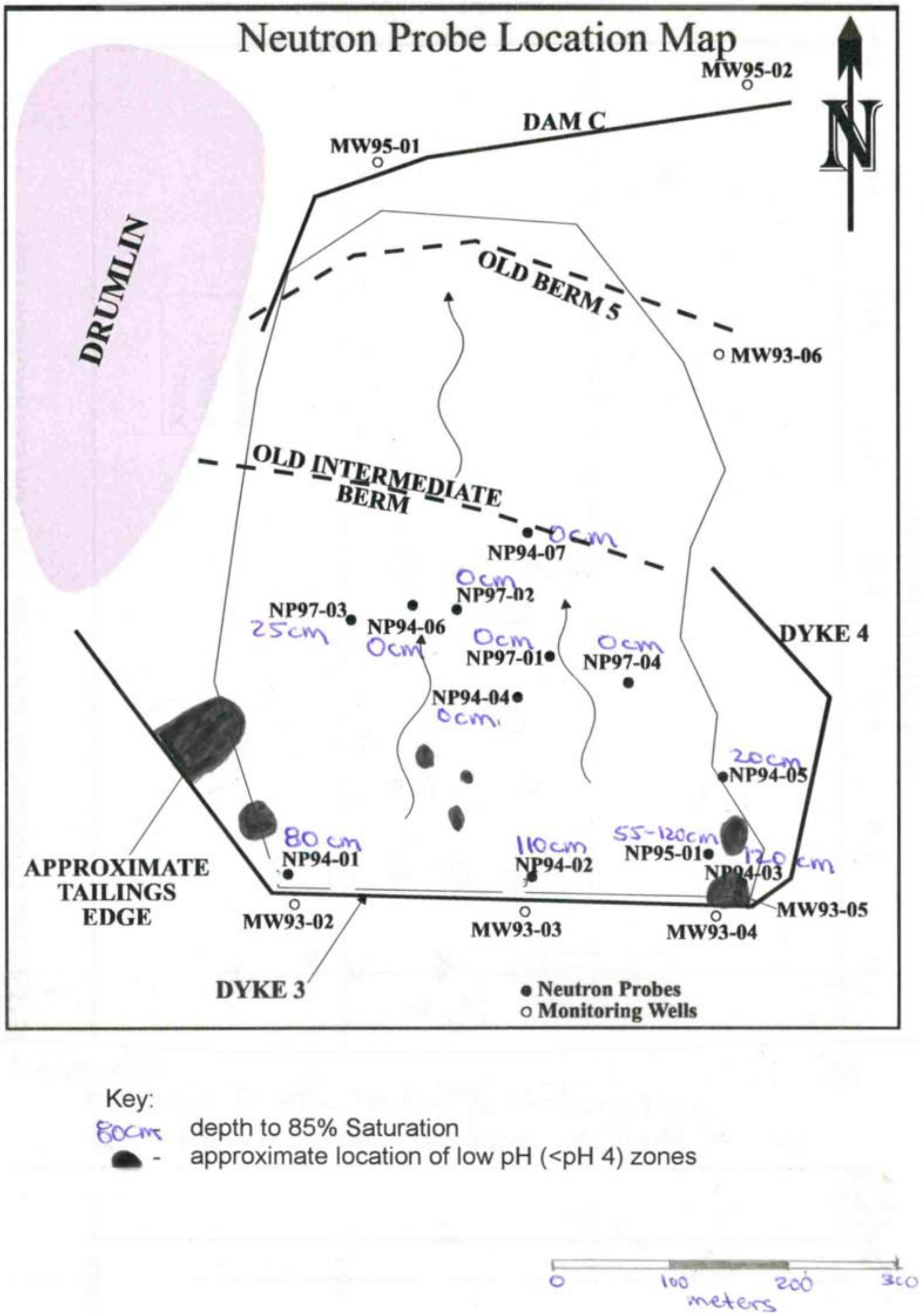

Figure 4.1 – Location of the neutron probes and areas of low pH (Placer Dome, 1999)

5. SELECTION OF THE REHABILITATION METHOD

It was expected that the increased water level in the majority of the tailings basin would result in near saturation of the remaining tailings beach. However, monitoring of the neutron probes and observations of the tailing surface indicated that some limited oxidation is occurring. The exposed tailings surface may ultimately develop a low pH but the large volume of saturated tailing below the water table is predicted to neutralize any ARD and the large pond to neutralize and dilute any surface runoff. Water quality of the tailings impoundment and seepage has remained neutral and within regulatory discharge limits. Nevertheless, revegetation of the exposed beach surface could become an issue if the pH were to become depressed. Therefore Placer Dome Canada considered additional mitigation measures to reduce the potential for oxidation (Placer Dome, 2002).

5.1 Design of the soil cover over the tailings beach along Dyke 3

In July 2001, a geotechnical investigation was undertaken (Klohn Crippen, 2002). Additional instrumentation was installed to complement the existing monitoring equipment. Piezometers were installed to investigate the depth of oxidized tailings in the Dyke 3 tailings beach and drumlin apron. Measured water levels in 2001 (July, October and November) indicated that water levels were highest (elevation 392 m) within a zone from 15 to 35 m away from Dyke 3. The water levels then fall towards the dyke, as expected. The water level also reduces slightly towards the tailings pond. However, this observation is based on a small number of readings over a 5 month period.

In order to increase saturation within the tailings beach, it was considered to design an appropriate soil cover system. A series of soil cover models were analyzed for different cover options. The soil cover analysis were conducted using SoilCover© 2000, a one dimensional finite element model developed at the University of Saskatchewan and distributed at the time by Geoslope Analysis 2000 Ltd. The software is used to predict saturated and unsaturated transient flow of water using daily weather data.

A set of weather data developed for a soil cover study for the Detour Lake Mine, located 200 km northeast of Timmins, was used for the Dona Lake Mine simulations. The precipitation data represents 45 years of daily precipitation records for the city of Timmins, about 700 km southeast of Dona Lake Mine.

Three types of covers were modelled: a till cover, a sand cover and a rockfill cover. Sensitivity studies were carried out to investigate the influence of the following parameters:

- Cover thickness (10 to 150 cm for till cover, 10 to 50 cm for sand cover).
- Depth of water table (1 to 3 m depth).
- Vegetation (surface with and without vegetation, variable depth of roots).
- Precipitations (dry, mean and wet years).
- Hydraulic conductivity of cover and tailings.

The analysis results indicated that the net annual infiltration rate in normal conditions with a till and/or sand cover is in the order of 100 to 150 mm/year without vegetation and around 0 mm with poor vegetation. The model indicated that the net infiltration with a 30 cm thick rockfill cover over the tailings is about 380 mm/yr for a normal year. Based on the results from the simulations, it is expected that in the long term, the tailings beach could not be kept saturated with a till or sand cover. The sensitivity analysis also demonstrated that infiltration is not sensitive to cover thickness but with 50 to 100 cm till covers, infiltration is sensitive to the permeability of the till. In general, net infiltration is moderately sensitive to the saturated hydraulic conductivity of the tailings. However, net infiltration is sensitive to depth of water table in the tailings, as infiltration decreases with rise of water table.

5.2 Seepage analysis

Seepage analysis was performed to estimate the ground water level and quantify the seepage rate through the tailings deposit along Dyke 3 (Klohn Crippen, 2002). The seepage analysis results indicated that the phreatic level may rise to the tailings surface along most of the tailings beach under normal precipitation conditions for an estimated infiltration rate of 380 mm/yr (infiltration rate obtained with the rockfill cover). The model predictions indicate that along Dyke 3, over a 10 m wide zone, the ground water table will remain at approximately 1 m below the tailings surface. However, based on the SoilCover© analysis, a degree of saturation of 85% will be maintained in the vadose zone, which is generally regarded as sufficient to significantly reduce oxygen transport. MEND reports 2.22.2 a, b, and c provide an extensive set of data on the relationship between the degree of saturation and oxygen diffusion coefficient. Results from laboratory work demonstrated that an effective barrier to oxygen diffusion will result when the degree of saturation can be maintained at greater than approximately 85 to 90% (MEND, 2001).

Therefore, the seepage and infiltration analysis demonstrated that a rockfill cover would promote infiltration, which would result in a rise of the water table to the tailings surface along the Dyke 3 tailings beach under normal weather conditions.

Under a dry year scenario, based on the lowest annual precipitations observed over a 45-year period, the saturation level may fall below 85% to a depth of 0.5 m or more over a width of 15 m from Dyke 3.

Studies done by Placer Dome Canada indicate that there is adequate buffering capacity to protect the environment from limited drainage passing through the unsaturated wedge of Dyke 3.

5.3 Rehabilitation options for the tailings beach

Based on the results of the different simulations and experience at similar sites, a number of options were considered to limit oxidation of the tailings beach along Dyke 3. Table 5-1 presents the options considered and the advantages/disadvantages of each option.

The rockfill cover appears to be the most effective option among the cases analyzed. The rockfill material promotes infiltration due to its high permeability at lower suction and lower permeability at moderate suction range. It allows the water to infiltrate easily through the cover during rainfall events. When rainfall stops, surface suction increases and the rock cover quickly shifts to a low permeability cover. Therefore, the cover behaves like a barrier to prevent excessive evaporation after rainfall events. It may also prevent vegetation from growing on the tailings beach, which reduces the loss of water through evaporation/transpiration.

Table 5-1
Options considered for the closure cover on Dyke 3 beach (from Klohn Crippen 2002)

Option Description	Pro	Con
1. Till cover 1 m to 0.5 m deep as oxygen barrier.	• Low oxygen flow. • Good for dam stability, low water table in beach.	• Frost action could crack the till cover and allow oxygen flow ingress. • Promotes desaturation of tailings.
2. Excavate to flood or introduce pond to low spot adjacent to dyke.	• Maximizes saturation of tailings.	• Dam stability concerns.
3. Excavate part of unsaturated material and replace with random fill (till and organic).	• Remove the 1 m of unsaturated tailings at dam. • Increases retention of precipitation water and increases saturation level.	• Infiltration through till may be insufficient to saturate tailings. • Cost.
4. Shape the beach to trap precipitation.	• Could increase water table by 1m height based on existing analyses.	• Could introduce pond at dam crest if not carefully done.
5. Include an impervious layer at the beach side face of the rock erosion windrow.	• Traps precipitation and increases infiltration. Could raise water level up to 1 m near dyke.	• Difficult to construct. • May be only a partial solution.
6. Place rockfill cover.	• Trap precipitation. • Reduces evapotranspiration. • Protects against dust and erosion.	• Cost. • Rockfill material availability.

6. CONSTRUCTION OF THE COVER ON THE TAILINGS BEACH

Different cover options were considered for the Dyke 3 beach (Klohn Crippen 2002). As discussed in section 5.3, the rockfill cover was selected to reduce erosion and promote tailings saturation along Dyke 3. In the fall of 2003, the following construction activities were completed to finalize permanent closure of the Dona Lake tailings impoundment. The remainder of the work will be completed in 2004.

A 300 mm layer of erosion protection material (rockfill cover) was placed within 20 m of the crest of Dyke 3 to enhance infiltration into the beach, reduce vegetation growth and provide protection against wind and water erosion. Beyond 20 m, a 300 mm thick layer of granular random material was placed over the exposed beach. The rockfill cover has a D_{100} of 100 mm, a D_{50} of 8 mm and a D_{10} of 0.5 mm.

- The exposed tailing on the drumlin apron was covered with 300 mm of random fill.
- The existing piezometers and neutron probe casings were extended and protected to permit future monitoring and assessment of closure works.

With the construction of the tailings beach rockfill cover, the area of tailings potentially exposed to oxidation will drop to <1% during normal years and approximately 5% under drought conditions.

The construction work at the Dyke 3 beach was carried out when the ground was frozen, to facilitate heavy equipment access to the tailings.

7. MONITORING PROGRAM AND PERFORMANCE TO DATE

7.1 Neutron probe readings

In October 1998, University of Saskatchewan monitored 9 neutron probes. Figure 4-1 shows the depth to 85% saturation measurements (Placer Dome, 1999). Results are consistent with expectations in that neutron probes adjacent to Dyke 3 (NP94-01, 02 and 03) exhibited relatively deep zones (55 to 120 cm) with less than 85% saturation. Neutron probes located approximately 100 m upstream from the exposed beach (NP94-05 to 07) showed saturation values higher than 85% at depths of 0 to 20 cm from the tailings surface. Due to construction work in 1999, most of the neutron probe tubes and piezometers installed in 1994, 1995 and 1997 had to be reinstalled. No monitoring was conducted in 2000 and Placer Dome has not confirmed whether the monitoring program was pursued after 2000.

7.2 ABA from tailings surface samples along Dyke 3

In 1995, 1996 and 1998, surface tailings samples were collected from the exposed main tailings beach, along Dyke 3. The samples were tested for paste pH. The results indicated that paste pH were lower in 1998 compared to previous years. On average, paste pH results from 1998 showed a pH of 6.0 (ranging from 2.4 to 7.4), while the average paste pH was 7.3 (ranging from 5.8 to 8.2) the previous years. Figure 4-1 shows the approximate location of low pH zones. However, it should be noted that the samples were collected closer to Dyke 3 in 1998, which historically had somewhat lower paste pH. Consequently, the results may be skewed compared to the previous years (Placer Dome, 1999).

Tailings samples were also collected from about 30 cm depth. The paste pH results of the 1998 sampling campaign showed that for 86% of the samples collected at depth have a higher paste pH compared to surface samples. Even though the area of significant oxidation is very limited and restricted to the near surface of the tailings, Placer Dome Canada implemented ARD prevention measures to prevent further oxidation of the sulphides.

In 2000, tailings oxidation was noted in some areas of the exposed tailings beach along Dyke 3.

In 2001, 35 surface samples (less than 2 cm depth) were collected on the tailings beach for ABA analysis. On average, the samples showed acidic paste pH (4.06, ranging from 2.65 to 7.17), with an average net neutralization potential (NNP) of –108 kg $CaCO_3$/t (Placer Dome, 2002).

Six surface tailings samples were selected for extraction tests. A 9:1 ratio of water to tailings was chosen to represent field conditions. The volume of the pool of water in the tailings pond, between Dyke 3 and Dam C, is approximately 9 times the volume of the oxidized zone in the tailings beach near Dyke 3.

The mass of acidity produced during the extraction tests correlated very well with the NP of the sample. This correlation was used with the estimated surface areas of NP from the contour plot to calculate the total acidity release from an assumed 1 m oxidation zone. This amounted to 6,424 tonnes of acidity. The tailings water pool contains about 46,400 tonnes of alkalinity. If all the acidity were mixed with the tailings pool it would only lower the alkalinity to about 69 mg/L. Therefore there is significant alkalinity in the tailing pools to buffer the acidity produced from the tailings beach. In fact, much of the acidity would infiltrate the beach and be neutralized by the tailings below the water table and the underlying till; both have high NP.

7.3 Surface water quality

The tailings supernatant water quality trends indicate that between 1995 and 2000, the pH remained near neutral values (7 to 8) with low iron values (less than 1 ppm) and zinc and nickel values well below predicted levels. Sulphate was generally higher in the tailings pond in 2000 compared to 1995. These results show the influence of sulphide oxidation on sulphate caused by moving the oxidized tailings into the impoundment in 1999.

The Ontario Ministry of Environment revoked the conditions of the Certificate of Approval (CofA) for the tailings impoundment, as the mine ceased operations in 1994. The surface water monitoring program is therefore governed by the terms of the approved closure plan. Water quality data at the final effluent for 2002 and 2003 is shown in Figure 7-1. The effluent was in compliance for both years, with contaminant levels well below discharge criteria.

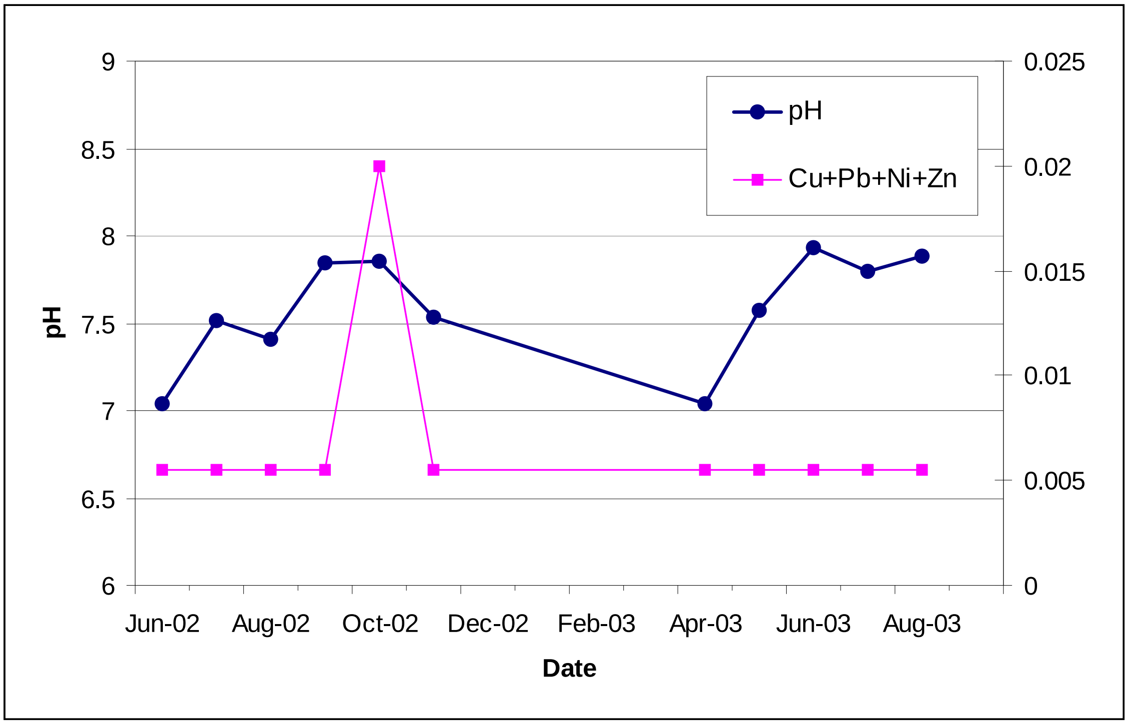

Figure 7.1 – Water quality of the final effluent

Sulphate has been increasing and was elevated significantly in 2000 compared to 1999. However, in 2001 sulphate concentrations were similar to 2000, indicating that the concentrations might have reached a plateau. The sulphate is due to sulphide oxidation and was expected. A mass balance prepared in 1998 predicted that the sulphate concentration might increase to between 292 and 773 mg/L as the pond level increased and submerged previously oxidized tailing (Placer Dome, 2001). The maximum measured sulphate concentration in 2001 was 234 mg/L, which is still below predicted values as shown on Figure 7-1. Metal concentrations at the final effluent are also well below predicted values.

7.4 Biological monitoring

In 2001, an Environmental Effects Monitoring Program was conducted at the Dona Lake Mine site (Minnow, 2002). The program revealed that biological conditions, even in areas near the rehabilitated mine site, are consistent with the surrounding natural habitat features and do not appear to be adversely impacted by historical mining activities. The study concluded that if the water quality effluent from the site does not deteriorate, there are no mine-related concerns with respect to future biological conditions.

8. CONCLUSION

8.1 Lessons learned

The fieldwork and predictive modeling performed at Dona Lake over the recent years demonstrated the applicability of the elevated water table concept. Seepage analysis indicated that a 0.3 m rockfill cover over the tailings beach promotes infiltration due to its high permeability at lower suction and lower permeability at moderate suction range. The cover behaves like a barrier in preventing excessive evaporation after rainfall events and maintains an elevated phreatic surface in the tailings. With the construction of the tailings beach rockfill cover, the tailings area potentially exposed to oxidation was reduced to <1% during normal years and approximately 5% under drought conditions.

At Dona Lake, there is significant alkalinity in the tailings water to buffer the acidity produced from the oxidation of the exposed tailings. Much of the acidity that would infiltrate would be neutralized by the tailings below the water table. At a different mine site, the buffering capacity of the tailings could be insufficient to neutralize the acidity produced by the exposed tailings. No significant impact on the tailings pool water quality were observed and none are expected in the future, given the limited area of exposed tailings.

The study conducted by the University of Saskatchewan (U of S) in 1996 demonstrated that SoilCover© (developed by MEND and U of S) and SEEP/W (developed by Geoslope International Ltd) can be used to couple the site climatic conditions with the seepage analysis and flow model. However, it should be noted that models developed to compute flux boundaries in the vadose zone and groundwater seepage have evolved significantly since 1996.

The neutral pH and low metal concentration in the tailings supernatant and the final effluent contaminant levels well below discharge criteria are indications of the success of the rehabilitation work performed at Dona Lake tailings. However, the rockfill cover efficiency has not been conclusively demonstrated in the field.

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