Innovative Management Techniques to deal with Mine Water Issues in the Sydney Coal Field, Nova Scotia, Canada

Joe Shea

Enterprise Cape Breton Corporation, Director of Mine Water Management, 70 Crescent Street, Sydney, Nova Scotia, Canada, B1P 6T7, joe.shea@ecbc-secb.gc.ca

Abstract More than fifty underground coal mines have worked the three major coal seams in the Sydney Coalfield during the past 150 years of organized mining. This mining legacy has left behind enough void space for more than 190 million m^3 of ARD producing mine water. There are twenty-three flooded or flooding mine pools that have been identified in the Sydney Coalfield. A mine pool is defined as a single mine or a group of mines that are hydrologically connected to form a large, high volume mine pool that can interact according to the degree of their interconnection. Three mine pools that have not yet flooded to equilibrium that could seriously impact the environment if allowed to discharge without treatment lay beneath the communities of Glace Bay, New Waterford and Sydney Mines respectively. The largest of the three mine pools known locally as the 1B Mine Pool, began to flood in 1985 and rebounded to the point of imminent overflow by 2003. The two remaining mine pools that are still rebounding, are projected to flood to surface outfall locations by late 2012.

Key Words mine pools, rebound, Sydney Coalfield

Background

The Sydney Coalfield is located in the Maritimes Carboniferous Basin on the east coast of Cape Breton Island, in the Province of Nova Scotia, Canada (figure 1). Within the Sydney Coalfield, twenty of the mine pools have flooded to an equilibrium point and are currently discharging, one mine pool is being held at an artificial equilibrium point, and two mine pools are in the final stages of rebound with surface discharge projected to occur in 2012 if left unchecked. This paper discusses the latter three mine pools (figure 2) and the innovative mine water management techniques that were developed to deal with the impending mine water issues

The 1B Mine Pool

The 1B Mine Pool is comprised of ten interconnected and abandoned underground coal mines spanning three coal seams. The coal mines of the 1B System typically began their workings on land at the coal seam outcrop and extended seaward beneath the Atlantic Ocean. Their mining history spans 127 years, beginning with the opening of No.5 Colliery in 1872 and ending with the closure of Phalen Colliery in 1999. In 1985, mine pumps were shut down and flooding was allowed to begin. In 2001, several boreholes were drilled along the Atlantic shoreline to detect the arrival of the rising mine water. By mid-year 2002 the mine water was intercepted and analysis indicated low pH with high metals and acidity content. Realization set in that a discharge of deleterious mine water to the local marine coastline which is home to a lucrative inshore fishery, was imminent.

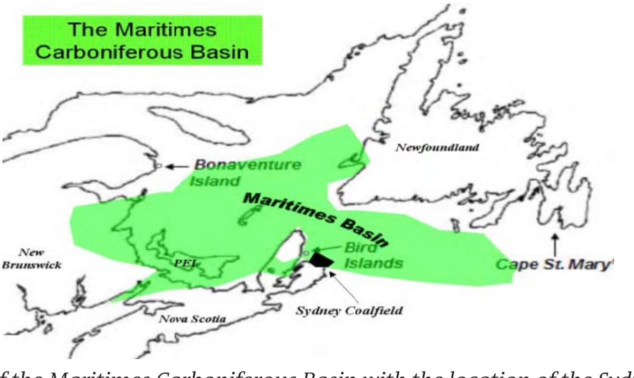

Figure 1 *View of the Maritimes Carboniferous Basin with the location of the Sydney Coalfield*

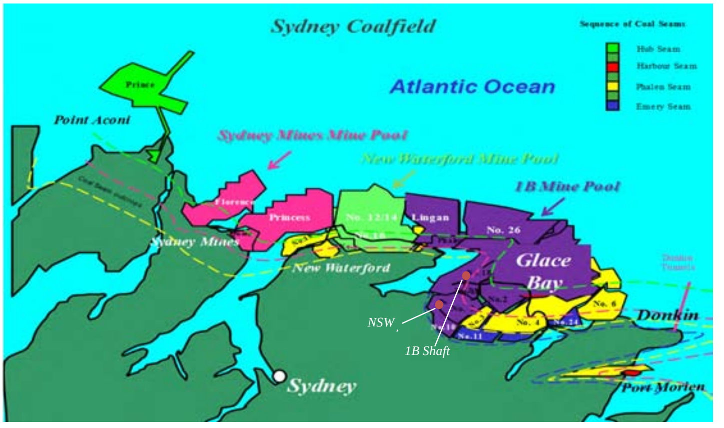

Figure 2 *Plan view location of the three major Mine Pools within the Sydney Coalfield*

A scientific committee (TAC) comprised of members with a strong historical understanding and expertise in dealing with rising mine water from abandoned coal mines was formed. The TAC committee recommended that an emergency active treatment plant be constructed at the 1B Shaft to prevent an uncontrolled discharge. In addition, TAC ordered a drilling program in the up dip, unflooded zones of the mine workings to test the quality of the rising mine water. Better quality mine water was identified from the drilling program in the Neville Street area of Reserve Mines. Multiple pump tests were conducted and regulatory approval was received to permit the better quality mine water to discharge directly to a receiving stream without treatment. This allowed the Corporation to shut down and "mothball" the active treatment plant at the 1B Shaft location and to control the mine water elevation in the 1B Mine Pool from the Neville Street location.

From April 2003 to December 2007, the Corporation operated a manually controlled 250 L/s pumping well field at the Neville Street location (NSW). During the same period, the mine water discharge quality from the NSW had steadily deteriorated, with Fe discharge levels rising to an average of 5.22 mg/L. In November 2007 the Corporation re-organized staff responsibilities to develop a mine water management program. The first priority identified in the new program was to automate the NSW operation to free up more time to actually address mine water issues. By the end of January 2008, utilizing in-house skills, surplus equipment, and a very innovative thought process, the Corporation was able to convert the manually operated NSW operation to a fully automated and remotely controlled system. Upon completion of the NSW automation upgrade, the focus turned to the mine water quality that was being pumped from the well field. A review of the 2003—2007 mine water data indicated that Fe levels had increased from <1 to >5mg/L and were trending towards a net acidic discharge that would require treatment. In March 2008, the Corporation awarded a contract to Atkins International/CBCL Limited to confirm these findings. On site testing of the mine water from the individual wells indicated that approximately 70 percent of the lab measured acidity from the pumping wells was in fact CO_2 (Bamforth 2008) and recommended that with good aeration, the mine water could be treated with passive treatment technology. The construction of a 315 L/s passive treatment system consisting of aeration cascades (figure 3), a 1.2 hectare settling pond (23,000 m^3 capacity) and a 1.1 hectare reed bed wetland began in August 2008 and were completed in January 2009. The first planting of the wetland began in June 2009 and by September 2009 growth was sufficient to introduce up to 40% of the outflow from the settling pond through the wetland.

The mine water flow through the settling pond was designed on simple piston flow theory to provide a 50 hour retention time for the mine water based on an average flow of 126 L/s. In May 2009, the Cape Breton University (CBU) mine water research program (MinWaReP) was contacted to verify the actual retention time. The CBU Chair in mine water remediation, Prof. Christian Wolkersdorfer, a world expert in the use of mine water tracers, conducted two tracer tests in the NSW settling pond. The testing concluded that the retention time measured in the settling pond averaged between 10 and 18 hours (Wolkersdorfer 2009). A configuration of five floating pond curtains

Figure 3 *Neville Street Passive Treatment System aeration cascades*

was installed to increase retention time by guiding the mine water leaving the cascades in a slow meandering pathway to the discharge. In September 2009, a bi-monthly mine water sampling program was set up to evaluate the effectiveness of the passive treatment system. Sampling points were established at the settling pond cascade inlet (CPI), the settling pond outlet (OSP), and the wetland outlet (OWL). Results to date have been encouraging with Fe at the settling pond CPI sampling location averaging 8.39 mg/L Fe, and the wetland discharge OWL sampling location averaging 0.67 mg/L Fe,

The 1B Mine Pool chemistry continues to evolve over time. Based on research put forth by Younger and others, the first flush theory (Younger 1997) suggests that the chemistry of the discharge from the 1B Mine Pool should be significantly improved in approximately 72 years, or 4 times the length of time it took to completely rebound. The goal of the Corporation is to continue to support CBU's MinWaReP to develop a solution that will significantly reduce the timeframe that it will take to achieve an environmentally acceptable discharge from the 1B Mine Pool to the marine environment.

The New Waterford Mine Pool

The New Waterford Mine Pool is comprised of three coal mines located beneath the Town of New Waterford that worked two coal seams during the period 1910—1972. The workings for each of the three mines began on land at the surface outcrop and extended seaward beneath the Atlantic Ocean. Mine flooding in the Phalen Seam began in 1962 with the closure of No.16 Colliery and mine flooding began in the Harbour seam in 1972 with the closure of the combined workings of No.12/14 Colliery. During the Spring of 2008, the Corporation drilled two deep boreholes and installed outstations as close to the ocean shoreline as possible in an attempt to intercept the rising mine waters from each mine (figure 4). Surprisingly, mine water was immediately intercepted by each borehole, and data collection began. By July of 2008, enough data had been collected to predict that No.16 Colliery would flood to a surface outfall location in New Waterford within 1 year, at a flooding rate of 4 L/s. The data collected by the No.12/14 outstation indicated that these workings had more void space remaining than No.16 workings, but would also flood to an outfall location in New Waterford by the end of 2011, at a rate of 14 L/s. Analysis indicated that an acidic mine water with high metals content was present in both systems that would need to be actively treated at each location.

The Corporation had previously flown high resolution LIDAR aerial surveys over the coal seam outcrops across the Sydney Coalfield. The LIDAR survey flown over the New Waterford area revealed a 600 meter stretch of "bootleg" workings along the outcrop of the Harbour Seam that was consequently backfilled and sealed during the Summer of 2008. The No.12/14 outstation verified that the backfilling operation had the immediate effect of reducing the flooding rate of the No.12/14 system and delayed the requirement for the construction of the first treatment plant by over one year.

Figure 4 *No.12/14 borehole outstation at the Atlantic Coast*

With additional time before treatment was required, the Corporation decided to directly connect No.16 Colliery and No.12/14 Colliery with an inter-seam borehole. By April 2009 the borehole was completed and the New Waterford Mine Pool was created. This solution allowed for the combined mine waters from the two systems to mix and to be treated at only one location. In January 2010, a contract was signed with CBCL Limited to design/build a mine water treatment plant for the New Waterford Mine Pool to be commissioned by July 2011.

The Sydney Mines Mine Pool

The Sydney Mines Mine Pool is comprised of three abandoned coal mines located beneath the communities of Sydney Mines and Florence that worked one coal seam during the period 1854—1976. The workings generally began on land and extended seaward beneath the Atlantic Ocean. Flooding began in 1976 with the closure of Princess Colliery. During the Spring of 2008, the Corporation drilled a deep borehole and installed a monitoring outstation close to the coast in Sydney Mines. Immediately, a poor quality acidic mine water was intercepted by the borehole and data logging began. The flooding rate was determined to be 12 L/s with a projected outfall date of late 2012.

The Corporation has commissioned an engineering study to determine if it is possible to directly connect the Sydney Mines Mine Pool to the New Waterford Mine Pool via several strategically placed boreholes and pipelines. If this idea can reach fruition, it will mean that the Corporation will be in a position to treat the mine water from one combined Sydney Mines/New Waterford Mine Pool treatment plant which will reflect substantial savings in capital and operating costs.

Conclusion

The Sydney Coalfield has a history of over 150 years of organized mining. During the past 10 years, the Corporation has learned that one of the keys to success in being able to solve many of the mine water related issues was to retain a knowledgeable, core group of employees who had the historical knowledge and understanding of the mine plans and the degree of interconnection between the mines. In addition it has also learned that it is very important to have access to competent mine water research scientists who can confirm ideas and hypotheses using the latest state of the art research equipment and techniques to solve mine water problems. The Corporation was instrumental in lobbying and supporting the creation of a mine water research program at Cape Breton University. It is anticipated that over the next 5 years, the Corporation and Cape Breton University's MinWaRep, will be able to solve the mine water related problems in the Sydney Coalfield.

References

Bamforth, S. (2008): 1B Hydraulic System Assessment – Neville Street Mine Water Outline Design Report, For: Cape Breton Development Corporation

Wolkersdorfer, C. (2009): Tracer Test in a Settling Pond – The Passive Mine water Treatment Plant of the 1B Mine Pool, Nova Scotia, Canada

Younger, P.L. (1997): The Longevity of Mine Water Pollution – A Basis for Decision Making – Science Total Environment