MINE WATER MANAGEMENT OF FLOODED COAL MINES IN THE SYDNEY COAL FIELD, NOVA SCOTIA, CANADA

JOE SHEA

Cape Breton Development Corporation

ABSTRACT

Coal was first mined in Cape Breton, Nova Scotia, Canada in 1685, by the French military authorities, from the exposed coal seam outcrops. By 2001 the last remaining underground coal mine in the Sydney Coalfield had ceased operation and so began the legacy of mine water in Cape Breton. More than fifty underground coal mines have worked the three major coal seams in the Sydney Coalfield, producing an estimated 500 million tons of coal and waste rock, thus leaving enough void space for more than 50 billion gallons of ARD producing mine water. At present there are several large groups of interconnected and abandoned coal mines or “hydraulic systems” within the Sydney Coalfield that are flooded to equilibrium, and there are several other hydraulic systems that are in the process of flooding. One such group of ten interconnected mines that is partially flooded is referred to locally as the 1B Hydraulic System. This paper addresses the mine water management techniques that were developed to prevent a discharge of deleterious mine water to the environment from the 1B Hydraulic System and outlines the plans for the future.

1. THE 1B HYDRAULIC SYSTEM

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). The regional setting for this paper is found in the southern and eastern portion of the Sydney Coalfield.

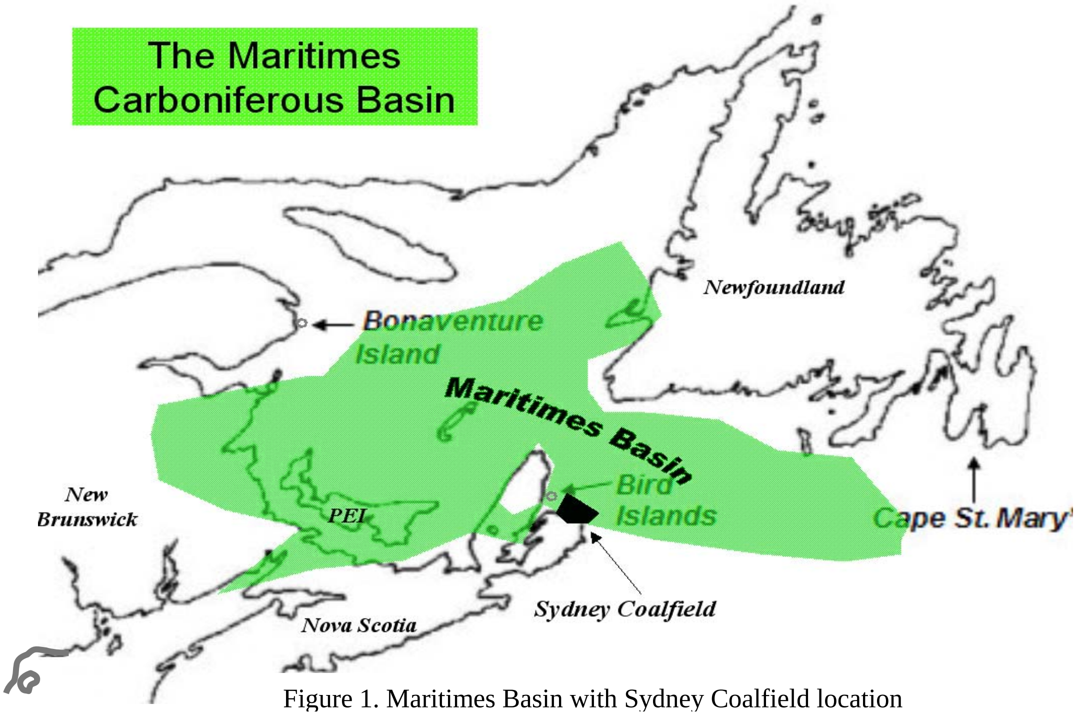


Figure 1. Maritimes Basin with Sydney Coalfield location

The 1B Hydraulic System, (one of 26 Hydraulic Systems within the Sydney Coalfield), is comprised of ten interconnected and abandoned underground coal mines spanning three coal seams (Figure 2). The coal mines located within the 1B System typically began their workings on land at the coal seam outcrop and extended seaward beneath the Atlantic Ocean. The mining history of the coal mines in the 1B System spans 127 years, beginning with the opening of No.5 Colliery in 1872 and ending with the closure of Phalen Colliery in 1999. The majority of the mines that make up the 1B System were owned and operated by the Dominion Coal Company, a British owned company that was facing closure in 1967. The Government of Canada took control and assumed full ownership of all Dominion Coal Company properties and assets in Cape Breton in 1967, and formed the Cape Breton Development Corporation (CBDC), a Federal Crown Corporation, to manage the coal mines on it’s behalf. The CBDC operated only the No.20, No.26, Lingan and Phalen mines in the 1B System. A summary of the pertinent data for the individual mines in the 1B System is listed in Table 1.

Proceedings ISBN Number: 978-0-9802623-5-3
Pretoria, South Africa
Produced by: Document Transformation Technologies cc
Conference organised by: Cilla Taylor Conferences

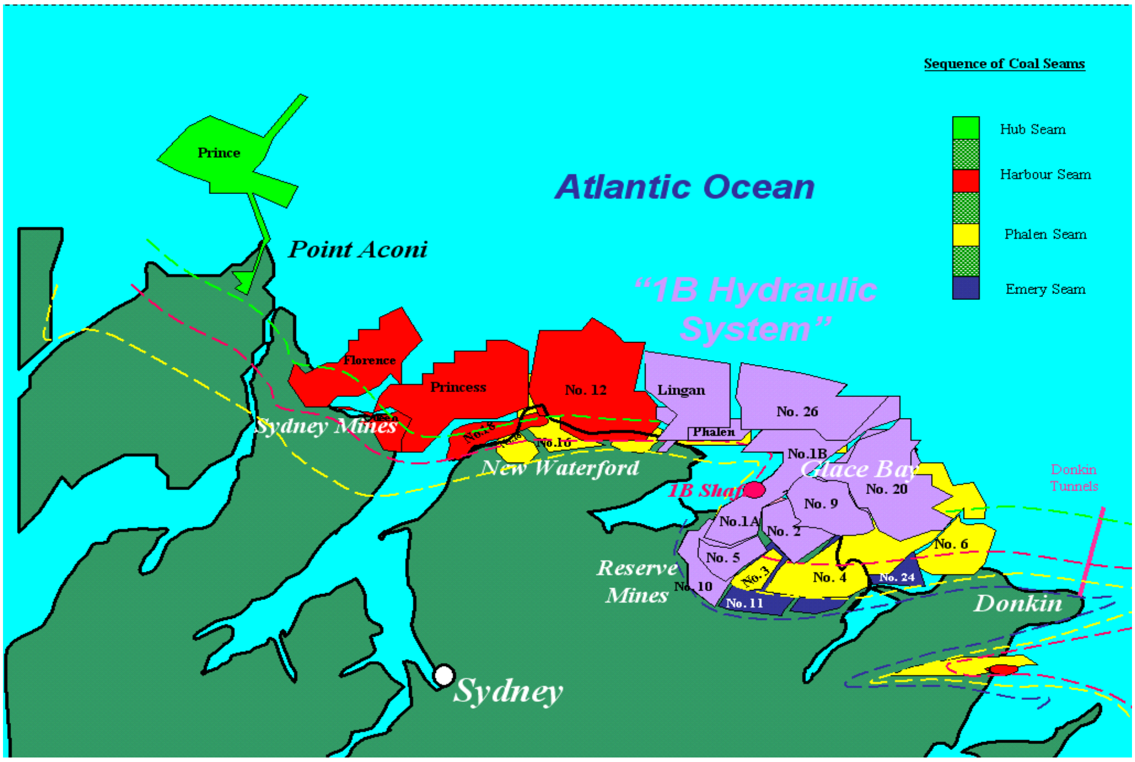


Figure 2. Plan view location of the 1B Hydraulic System within the Sydney Coalfield

2. GEOLOGICAL SETTING AND GEOGRAPHIC LOCATION

The mines in the 1B Hydraulic System operated within a gently folded structure known as the Glace Bay Syncline and along the northward flanks of the Bridgeport Anticline. Three major coal seams (in order from the deepest to shallowest: the Emery, Phalen, Harbour) were mined.

The coal seams outcrop on land and dip northward at 3 to 14 degrees and are known to extend seaward under the Atlantic Ocean for at least 25 miles. The coal measures strata are of Carboniferous age, with the seams separated by sequences of sedimentary rock ranging from 130 ft (Emery to Phalen), to 425 ft (Phalen to Harbour). The inter seam strata generally consists of mudstone, shale, siltstone, sandstone, and minor carbonaceous limestone, which are indicative of deposition in fluvial and lacustrine environments (Figure 3). Faulting did not impact the operations of these mines.The working areas of No.1A, No.5, and No.10 originated at the seam outcrops and were entirely under land. The working areas of No.1B, No.20, No.26, Lingan and Phalen were entirely submarine but all were connected directly or indirectly to land through slopes or interconnected tunnels from other 1B System mines. The workings of No.2 and No.9 straddle both land and the submarine environment. The working depths of the mines ranged from 125 ft above sea level at the southern outcrop of No.10 Colliery in Reserve Mines, to 2700 ft below sea level at the northern most extent of No.26 Colliery. There has never been a recorded or reported inflow of seawater into the mines of the Sydney Coalfield.

Stratigraphic Section Through Coal Seams Mined in the 1B Hydraulic System

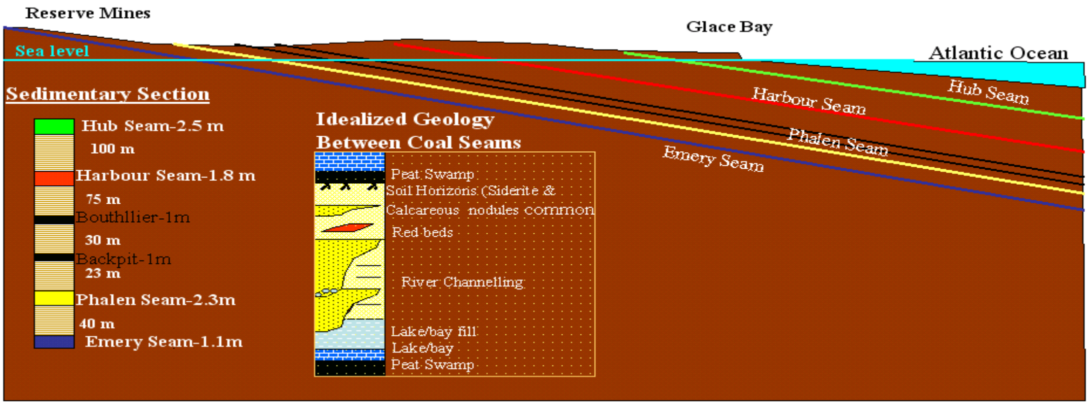


Figure 3. Typical cross section through the 1B System

Table 1. Mines within the 1B Hydraulic System

Mine Name	Year Opened	Year Closed	Seam Mined	Seam Thickness (ft.)	Location	Mining Method	Estimated volume in Mine (US gal)
No.5 Colliery	1872	1938	Phalen	7.5	Under land	R&P & R&P with with pillar extract	803,000,000
No.1A Colliery	1893	1927	Phalen	6.9	Under land	R&P & R&P with with pillar extract	863,000,000
No.2 Colliery	1899	1949	Phalen	7.2	Under land & Submarine	R&P & R&P with with pillar extract	4,559,000,000
No.9 Colliery	1899	1924	Harbour	6.2	Under land & Submarine	R&P & R&P with with pillar extract	1,315,800,000
No.10 Colliery	1905	1942	Emery	3.6	Under land	R&P & longwall	748,770,000
No.1B Colliery	1924	1952	Phalen	6.9	Submarine	R&P & longwall	4,348,500,000
N0.20 Colliery	1939	1971	Harbour	5.3	Submarine	R&P & longwall	2,634,000,000
No.26 Colliery	1943	1984	Harbour	5.9	Submarine	R&P & longwall	1,872,000,000
Lingan Colliery	1978	1993	Harbour	6.6	Submarine	R&P & longwall	1,562,000,000
Phalen Colliery	1985	1999	Phalen	6.9	Submarine	longwall	1,573,500,000
						Total Volume of the 1B System	20,279,570,000

3. MINING METHODS AND MINE CONNECTIONS

The earliest and shallowest mines in the 1B System were located under land and used the room and pillar method of extraction. This resulted in the extraction of 40 to 50% of the coal with the remainder left as pillars to support the mine roof. However in many cases, the remnant pillars were removed by over zealous mine managers which led to widespread collapse of roof strata and ground subsidence at surface. In No.5 Colliery, extensive areas of de-pillaring took place, with almost 100% of the coal removed over large portions of the mine with some areas having less than 100 ft of vertical cover. In No.1A Colliery, room and pillar mining with very little pillar extraction was practiced, probably because this mine was located directly below the more heavily populated community of Dominion. As the mines proceeded under the sea, regimented room and pillar mining was employed, with pillar sizes always erring on the side of safety. Full extraction longwall mining was practiced when vertical, solid rock cover to the seabed exceeded 900 ft.

The mines within the 1B System are connected to one another by one or more openings consisting of shafts, tunnels, drifts, boreholes, or by mining induced fractures through longwall gobs or de-pillared zones. For example, direct connectivity exists between many mines that worked in the same coal seam, such as No.1A, No.5, and No.1B by virtue of dozens of mutually used roadways. Likewise, other mines that operated in different seams such as No.1B and No.26 were directly connected by cross measure stone tunnels and/or inter seam boreholes. The picture is further complicated by the fact that available records leave considerable doubt as to the extent and adequacy of many of the mine seals, especially in the older mines, and it is practically impossible to obtain confirmatory information regarding their current condition.

4. FLOODING OF THE 1B HYDRAULIC SYSTEM

The flooding process for many of the mines in the 1B System began when individual mines ceased operation due to poor economics and the mine pumps were simply shut down. This was the case for No.9 and No.10. However, a key group of other mines in the 1B System including No.1A, No.1B and No.5 (all in the Phalen Seam), were intentionally kept dry, as they were directly connected, via several inter seam cross measures tunnels, to No.26 Colliery which was extracting coal further offshore in the Harbour seam. A large mine water collection lodgment and pumping station had been constructed near the 1B Shaft during the development of No.1B. It was designed to intercept and collect all mine water that was draining down dip from the land based shallower mine workings in No.1A and No.5. The pumping operation from this lodgment kept No.1A, No.1B, No.2, No.5 and eventually the No.26 workings dry. Mine water was pumped to the surface from this lodgment for more than 50 years at a rate of 1750 US gpm, and discharged to an ocean outfall without any noticeable discoloration to the ocean.

The No.26 Colliery was lost to a mine fire in 1984 and a decision was made in 1985 to shut off the 1B Shaft pumps. This decision set in motion an accelerated rate of flooding for the entire 1B Hydraulic System. The ensuing flooding history of the 1B System has been recorded by water level measurements taken in the 1B Shaft beginning in March 1986. These measurements were used to construct a representative mine flooding hydrograph (Figure 4). The hydrograph does not portray the typical mine water rebound curve for an abandoned coal mine.

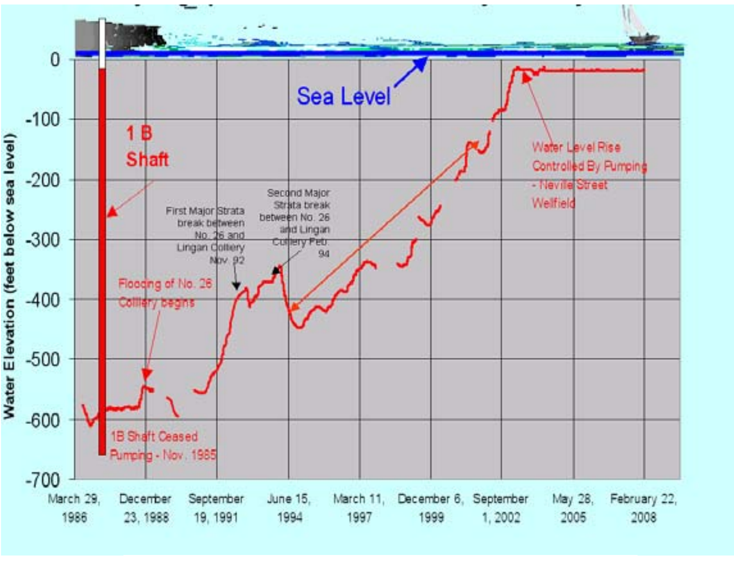


Figure 4 – Hydrograph of the rising mine water in the 1B System

The flooding of the 1B System was rather unique in the fact that there were still two operating mines within the group of ten that were operating during the flooding process. The hydrograph identifies several occasions where the rising mine water reverses direction due to underground dam failures and inrushes in the two remaining operating mines. One such incident occurred in 1992 when 5 East longwall at Phalen Colliery, located in the Phalen seam, retreated below the flooded No.26 workings in the Harbour seam, continued below an 1100 ft wide barrier pillar of coal, and then retreated below the operating Lingan Colliery, also located in the Harbour seam. The result was a sustained, major inrush of water (up to 7000 US gpm) through the now compromised barrier pillar that had been designed to separate the workings of Lingan and No.26 Colliery. Pumping was immediately re-established to lower the level of water in the 1B Shaft. The objective was to reduce the pressure head acting on No.26 Colliery (300 psi) and to stop the inrush of mine water from No.26 into Lingan, so that Lingan Colliery could continue to operate. The mine water in the 1B Shaft had been sampled and was found to be of very good quality.

Figure 5 – Iron rich plume from the 1B System at the 1B Shaft

However, after several hours of 4000 US gpm of pumping, the quality of the mine water from the 1B Shaft changed dramatically and proved to be unacceptable (very high iron and TDS) and the pumping operation was stopped (Figure 5). The compromised barrier pillar and the inability to pump from the 1B Shaft led to the closure of Lingan Colliery. It was determined that it was no longer safe to work the mine with the high risk of catastrophic mine water inrushes. Phalen Colliery now had the distinction of being the last operating mine in the 1B System. It continued to mine directly below (425 ft vertical separation) the flooded workings of Lingan and No.26 Colliery until 1999. During that seven-year mining period, there were several large flushes of mine water into the longwall gobs at Phalen Colliery from the overlying workings of Lingan and No.26 Colliery.

However, the Phalen pumping system was upgraded to handle the increased water makes. The Phalen Colliery closed in 1999 due to severe longwall weighting problems associated with massive overlying sandstone beds. At closure the Phalen Colliery was making approximately 1200 US gpm of mine water from the indirect connections to the overlying, flooded workings. Surprisingly, the mine water being pumped from Phalen was of sufficient quality that it did not require treatment. The highly acidic mine water located in the Lingan and No.26 Harbour Seam workings was being filtered and buffered as it percolated down through 425 ft of gob induced subsidence fractures to the underlying Phalen workings.

5. WHERE DO WE GO FROM HERE?

With the closure of the Phalen Colliery in 1999, the company focus had shifted to the operation of it's remaining coal mine, (Prince Colliery at Point Aconi) and the shutdown of the remaining infrastructure associated with the coal industry. Prince Colliery closed due to economic reasons in late 2001.

Meanwhile, monitoring of the rising mine water level in the 1B Hydraulic System continued at the 1B Shaft and other locations. In the summer of 2001, the Corporation drilled a series of boreholes near the shoreline into the No 1A workings and found that they were dry. By mid year 2002, the mine water had reached the boreholes that were drilled in 2001, and the chemistry of the mine water samples collected from these boreholes indicated that it was of poor quality and very similar to the mine water that had been pumped from the 1B Shaft in 1992. The realization set in that detailed plans were required to deal with an impending discharge of deleterious mine water. The following engineering stepped approach was taken to address the rising mine water problem.

Step 1 – Calculation of Overflow Date and Rate

Mine plans were scrutinized to calculate the remaining void spaces left to fill. Data loggers were installed at various mine shafts and boreholes and were checked for rates of fill. It was determined that the point of mine water overflow from the 1B Hydraulic System, would be at the No.1A Colliery water level tunnel which exits the mine just above sea level at the shore in the Town of Dominion. It was projected that overflow would begin in April 2003. It was estimated that the mine water outfall would average 1800 US gpm with peak flows of 6000 US gpm expected during high precipitation events.

Step 2 - Identify and block surface water entrance points into the mines

Mine plans for No.1A and No.5 were overlaid with topographic plans to identify areas where shallow workings from these mines and illegal "bootleg workings" were in the shadow of any wetlands or watercourses. An area known as MacKays Corner, which lies directly above the shallow and de-pillared workings of No.5 Colliery, was identified as being a major surface water infiltration point. The MacKay's Corner area is a lowland drainage feature and natural wetland that forms the headwaters for Cadegan Brook.

In addition, several areas to the west of MacKay's corner, above both No.1A and No.5, along the Phalen seam outcrop were also identified as probable inflow areas. All surface water infiltration points that could be identified were backfilled and sealed with clay. However, the MacKays Corner wetland is still considered the main infiltration point to the 1B System.

Step 3 – Establish expert groups to give advice in mine water treatment and mine water management
A Technical Advisory Committee (TAC) was set up with individuals who had a high level of expertise and a strong historical understanding of the issue of rising mine water in abandoned coal mines. Subcommittees for Hydrogeology and Water Treatment were established, and various consultants studied the mine water issues and recommended both short term and long term solutions.

Step 4 – Sample rising mine water chemistry

TAC recommended that additional land based boreholes be drilled near the shoreline into the No.1A workings to intercept the rising front of mine water, and to sample and assess the mine water quality. The chemistry of the mine water in these boreholes was found to be similar to those drilled in 2001.

Step 5 – Construct an emergency water treatment plant at the 1B Shaft
TAC recommended to the Corporation that an emergency water treatment plant would have to be constructed and operating by March 2003 to avoid an overflow of deleterious mine water to the marine environment. A conventional, hydrated lime injection, 1500 US gpm emergency water treatment plant and settling pond was hastily constructed and operating at the 1B Shaft location by the end of February 2003. Plans were made to increase the capacity to 4000 US gpm if required.

Step 6 – Establish sampling boreholes in the upper areas of No.5 Colliery
TAC recommended that additional land based boreholes be drilled, into the shallower up dip workings of No.1A and No.5 Colliery, to sample the chemistry of the poor quality rising mine waters and try to identify if there was a distinct mixing zone forming. The mine water chemistry in the adjacent and flooded workings of No.3 Colliery (not connected to the 1B System), had been sampled on previous occasions and was known to be net alkaline. The new boreholes drilled into No.1A and No.5 were carefully logged to identify the presence of any buffering material (limestone beds) in the roof strata. The boreholes were successful in proving the presence of limestone beds in the strata above both mines. However, the strata above No.1A, was found to be mostly intact with very few pathways for surface water percolation and limestone buffering. The strata above the shallow workings in No.5 were found to be highly fractured, due to widespread pillar extraction being the preferred mining practice for this mine, thus providing substantial buffering capacity. In conjunction with the borehole campaign, the mine plans of No.5 and No.1A were studied to identify the underground pathways that surface infiltration waters had been following for the previous 75 years. It was believed that the flushing action along these pathways should have helped to remove many of the products of pyritic oxidation. In the fall of 2002, the rising mine water reached the boreholes that had been drilled into the upper workings of No. 5 Colliery. It was sampled and the results indicated that a much better quality of mine water was present. In fact, the mine water chemistry was extremely similar in quality to the surface water in the MacKay's Corner wetland area.

Step 7 – Establish an untreated discharge
TAC recommended that a pilot pumping test program be implemented to determine if a high volume pumping operation could be sustained with an acceptable discharge to the environment. In February 2003, a site at Neville Street in Reserve Mines owned by the Corporation, which was located 175 ft above the No.5 Colliery flooded workings, was selected for the test. Mine water was pumped from two wells at a rate of 200 US gpm for a period of one week, into Cadegan Brook. The water chemistry was monitored, fish mortality tests were performed, and the mine water discharge quality remained constant. In March 2003, these results were presented to the Federal and Provincial regulators who accepted the findings. Subsequently, additional wells and pumps were installed at the Neville Street wellfield location to increase the pumping capacity to 3500 US gpm. The chemistry of the mine water discharge remained stable and it was further determined that the removal of mine water from the No.5 Colliery workings resulted in the ability to control the mine water elevation in the 1B Hydraulic System. The flooding of the 1B System had been halted, albeit, with less than 5% of the workings in the 1B System remaining to be flooded. The ability to be able to control the mine water level in the 1B Hydraulic System from Neville Street eliminated the need to operate the emergency water treatment plant at the 1B Shaft site. The WTP was mothballed in June 2003 and has been maintained in a state of emergency preparedness ever since.

6. PUMPING STRATEGY AND MINE WATER QUALITY TRENDS

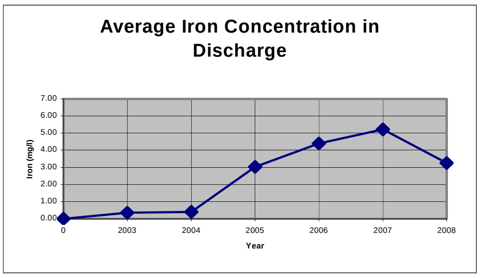
From 2003 to 2009, the pumping strategy has been prioritized to pump from the best quality wells, and to pump from the lesser quality wells only during increased demand from large and extended precipitation events. In 2003, the Neville Street Wellfield was a fairly crude setup with individual wells, supplied with a 7.5 or 20 HP submersible pump, powered by a portable diesel generator. In late 2003, the individual generators were replaced by a more reliable, 350 KVA diesel generator. In 2004, the site infrastructure was upgraded by adding a 12.4KV electrical service, telephone lines, and electrical switch rooms. In January 2005, the pumping infrastructure was upgraded with an 18" common pipeline installed to collect individual well flows and direct the mine water by gravity flow to an equalization pond. As well, below ground pump chambers were installed and the well pumps were standardized to 20 and 30HP Berkeley submersibles.

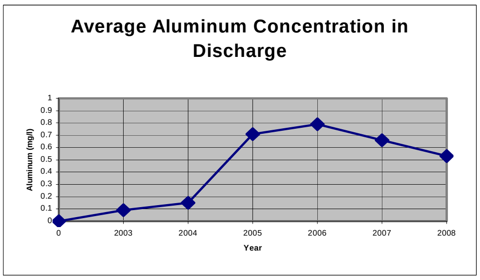
Since 2005, the Neville Street Wellfield has been further upgraded to a fully automated, 5700 US gpm capacity facility, consisting of twelve x 30 HP and two x 60 HP submersible pumps and related infrastructure. The mine water chemistry for each individual pumping well is sampled and analyzed twice yearly. A SLC 500 plc is programmed to start/stop the pumps in order of mine water quality and mine water elevation. The current operating strategy is to minimize the "beach" in the mine workings and the risk of subsidence due to fluctuating mine water levels, by maintaining the top of the mine water pool in the remaining unflooded workings within a stable maintenance zone of between –17 and –19 ft below sea level. The extra pumping capacity and full reliability was required to deal with major rain/snow melts that occur in the late Fall and early Spring. Inflows into the 1B System from large precipitation events are time dependent, normally showing up 24 hours after the event has started. Large event, peak inflows into the 1B System have been calculated at up to 8000 US gpm.

During the 2003 to 2008 time period, the mine water quality trends have been slowly deteriorating. The reason for this has not been fully determined, but it is suspected that more frequent large rain events, which create extended periods of full pumping capacity at the Neville Street wellfield, is drawing poorer quality mine water southward from the deeper mine workings (Table 2)

Table 2. Iron and Aluminum Concentration (mg/l) in the Neville Street Discharge

		2003	2004	2005	2006	2007	2008
Fe	Min	0.10	0.14	0.43	0.87	0.20	1.10
	Max	0.50	16.00	12.00	12.00	9.60	6.70
	Mean	0.36	0.40	3.03	4.40	5.22	3.25
Al	Min	0.02	0.01	0.05	0.13	0.05	0.05
	Max	0.40	0.83	2.10	2.50	1.80	1.80
	Mean	0.09	0.15	0.71	0.79	0.66	0.53





The pumping data for 2005 to 2008 shows a very strong correlation between pumping rates and total annual precipitation (Table 3). This is good news for the CBDC, as it indicates that no new inflows are entering the 1B System through surface sinkholes, mining induced fractures, or from adjacent coal mines.

Table 3. Pumping at Neville Street vs. total annual precipitation

Pumping Periods	Average Pumping Rate (US gpm)	Total Precipitation (mm)	Ratio Pumping/Precip
Calendar year 2005	2325	1434	1.62
Calendar year 2006	2228	1320	1.69
Calendar year 2007	1909	1241	1.54
Calendar year 2008	2690	1677	1.60
Averages	2288	1418	1.61

7. THE FUTURE – NEAR TERM AND LONG TERM

During 2008/09 the Corporation commissioned several initiatives to address and "stay ahead" of the mine water issues. In early 2008 a risk study was initiated to ensure that the installed pumping capacity and the remaining volume of unflooded workings in the 1B System were sufficient to prevent an uncontrolled discharge due to a complete collapse of the underground workings (Forgeron 2008). During the summer of 2008 an aerial survey using LIDAR technology to identify possible sinkholes from legal and illegal workings was flown across the outcrops and shallow workings of the major coal seams. In 2009 an extensive drilling campaign designed to gather additional information on the mine water in the mines that make up the 1B System, and to better study the lithology and potential buffering capacity of the rock strata in the saturated and unsaturated zones was implemented.

The deteriorating mine water quality at the Neville Street Wellfield was addressed in a substantial manner in February 2008 when the Corporation engaged Atkins International Limited/CBCL Limited to review the historical chemistry and pumping data and to recommend a mine water treatment scheme. The review by Atkins determined that the trend of the mine water being pumped at the Neville Street Wellfield should remain in a net alkaline position for a further 6 to 8 years. A passive treatment system consisting of aeration cascades, a settling pond and constructed wetland with future provision for an alkalinity-dosing chamber was recommended. In March 2008, the CBDC Board approved an expenditure of $ 2.5 million Cdn to construct a passive treatment system at Neville Street. The construction of a 6000 US gpm scheme began in earnest in August 2008 with major civil works completed by end of December 2008. The settling pond was actually commissioned in late November 2008 and the positive effects on the 2008 water discharge quality are noticeable in the graph in Table 2. Initial wetland species planting was conducted in June/July 2009 with anticipation of full flow of mine water through the wetland planned for the late fall/early winter 2009.

For the long term, the solution is not totally clear. We realize that the 1B System is probably a unique situation in the fact that an extensive drilling and sampling program was able to identify the main surface water infiltration zone into the mines in the MacKays Corner lowland area. The receiving stream for the Neville Street passive treatment scheme is Cadegan Brook. It flows through this lowland feature in a northerly direction to the Atlantic Ocean and covers a drainage area of 8.64 km^2 (McRoberts 2003). The upper area of this lowland drainage feature is underlain by very shallow mine workings which are providing a pathway for surface water to enter the 1B System. The Neville Street Wellfield lies adjacent to this lowland area and is accessing mine water in the mixing zone that can currently be treated passively once degassed of excessive levels of CO_2 (Bamforth 2008). However, on occasions when large precipitation events cause increased pumping demand at the Neville Street wellfield in excess of 2500 US gpm, it appears that the pumping demand exceeds the infiltration supply in this area and the pumps begin to draw in deeper and more contaminated mine water. It is suspected that some form of active treatment will eventually be required to fully flush the deeper and metal rich acidic mine water located down dip of the mixing zone beneath the landward portion of the 1B Hydraulic System. The volume of highly contaminated mine water in this portion of the 1B System is estimated at 4 billion US gallons.

To lead us to the final solution, the CBDC is co-sponsoring the establishment of an Industrial Research Chair at Cape Breton University (CBU) in the area of Mine Water Management for a period of no less than 5 years. In January 2009 the University announced that Dr Christian Wolkersdorfer had accepted the Chair position with the goal of elevating the University to the status of a world-renowned center of excellence in the area of mine water management within a 5-year timeframe. CBU's Mine Water Research Programme has been given the name MinWaReP. The CBDC and the CBU have developed an agreement whereby the MinWaReP will use the Sydney Coalfield as a showcase for mine water remediation and management technologies. The University is well into the process of procuring state of the art equipment and software to outfit the center as well as attracting undergraduate and graduate assistants to study and perform mine water related research under Christian's direction. The CBDC and the CBU have developed a detailed 5-year schedule and work package for MinWaReP to deal with all of the CBDC mine water issues that will arise during that timeframe across the Sydney Coalfield.

In June 2009 the CBU MinWaReP began the task of undertaking the research and testing necessary to develop the science to create a compliant, passive discharge of mine water from the 1B System to the marine environment in as short a timeframe as possible and to minimize any environmental impacts. Several mine water tracer tests designed to give understanding of the underground flow paths in the 1B System as well as hydrogeological, hydrochemical studies and 3-D numerical modeling using FEFLOW software are planned for late 2009.

In conclusion, in the near term the control point for the release of mine water from the 1B System will be through the passive treatment system recently constructed at the Neville Street site. The mine water discharge continues to be sampled twice monthly and there has never been a fish mortality recorded since the wellfield was put in operation. The newly constructed settling pond has already had a positive effect on reducing the level of metal contamination in the discharge from the wellfield. It is anticipated that the metal concentration in the discharge water from the completed passive treatment system will decrease to receiving stream background levels of 1.5mg/l by late 2010 when the constructed wetland has two full seasons of growth. A recent travel of the Cadegan Brook waterway by an independent consultant noted that iron precipitates have decreased along the streambed in comparison to previous years and that speckled trout are beginning to occupy habitat just downstream of the new settling pond discharge. However, for the long term it is fully understood that there is still a significant risk to an upset of the mine water quality that we are currently pumping. One of the key questions to be answered by MinWaReP is whether the mine water from the 1B System is following the "first flush" theory (Younger 1997), and can it be accelerated. The CBDC is fully committed to supporting the CBU MinWaReP to lead us in developing a fully passive and environmentally compliant discharge from the 1B System to the marine environment within 5 to 15 years.

8. REFERENCES

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

Forgeron, S. (2008): Coal Pillar Failure Risk Analysis, 1B Hydraulic System, Glace Bay, Reserve and Dominion, Nova Scotia, - For: Cape Breton Development Corporation.

McRoberts, B. (2003): Receptor Stream Hydraulic Analysis – Cadegan Brook – Glace Bay, Nova Scotia, - For: Public Works Government Services Canada.

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