The 1B Hydraulic System
Winnipeg, MB
Sydney, NS

11 Coal Seams
2500 sq kms
2.4 billion tonnes
More than 50 u/g mine produced over 500 million tons

Left behind voids for more than 50 billion gal of AMD And so began the ……
1B System Geologic Structure

Sequence of Coal Seams
- Hub Seam
- Harbour Seam
- Phalen Seam
- Emery Seam

Point Aconi
- Sydney Mines
- New Waterford
- Glace Bay

"1B Hydraulic System"

1B Shafts
- Port Morien
- Donkin
- Bridgeport Anticline
- Glace Bay Syncline
- Donkin Tunnels

Glace Bay Syncline
- Bridgeport Anticline
- Phalen Seam
- Emery Seam
- Harbour Seam
- Hub Seam
Stratigraphic Section Through Coal Seams Mined in the 1B Hydraulic System
(Section A - B through the Glace Bay Syncline)

Sea level

Reserve Mines

Glace Bay Reserve Mines

Atlantic Ocean

A

B

Hub Seam-2.5 m
100 m
Harbour Seam-1.8 m
75 m
Bouthllier-1m
30 m
Backpit-1m
23 m
Phalen Seam-2.3m
40 m
Emery Seam-1.1m

Phalen Seam
Emery Seam
Harbour Seam
Hub Seam

Idealized Geology Between Coal Seams

Peat Swamp
Soil Horizons (Siderite & Calcareous nodules common
Red beds
River Channelling
Lake/bay fill
Lake/bay
Peat Swamp

+128’ asl

-2760’ bsl

Canada

CAPE BRETON DEVELOPMENT CORPORATION
Mining Methods within the 1B System

- Room and pillar
- Room and pillar with pillar extraction
- Longwall
Flooding of the 1B System

- Flooding begins for the 8 directly connected mines.
- 1B Shaft pumps – 1750 USgpm are shut down in Nov. 1985.
- No. 26 lost to a fire in 1984.
- Flooding soon follows for the 2 operating mines with all captured on a hydrograph in the 1B Shaft.

[Map of Sydney Mines and surrounding areas with labels for points of interest such as Point Aconi, Glace Bay, Sydney, and New Waterford.]
Hydrograph of Water Level Rise - 1B Hydraulic System

Water Level Rise Controlled By Pumping - Neville Street Wellfield

1B Shaft

Sea Level

Parameter | 1B Shaft
---|---
pH | 7.4
Iron | 4.1
Alkalinity | 236
Sulphate | 951
Conductivity | 8760

1B Shaft Ceased Pumping - Nov. 1985

1B Shaft

No. 26 floods

Lingan inrushes

Pumps prepared in 1B shaft

Chemistry 1B Shaft 1991

Time

Atlantic Ocean

Lingan Colliery

Coal Barrier – 1100’

Flooded No. 26 Colliery

Phalen Seam

Phalen Colliery Retreat Direction

Emery Seam

Flooding of Lingan Colliery starts – Nov./92

Start the pumps in the 1B Shaft!
1B Discharge Nov. 1992 – 10 days of pumping
Hydrograph of Water Level Rise - 1B Hydraulic System

Sea Level

1B Shaft

Upgrade Phalen pumping capacity
And build WTP

Phalen longwall effects
No treatment!

Equalized

Lingan inrushes

Phalen closes

Pumps prepared in 1B shaft

No.26 floods

Water Level Rise Controlled By
Pumping - Neville Street Wellfield

Flooding rate increases

Parameter | 1B Shaft
--- | ---
pH | 3.9
Iron | 1600
Alkalinity | 4.7
Sulphate | 4823
Conductivity | 13,800

1B Shaft Ceased Pumping - Nov. 1985

1B Shaft Shaft

1B Shaft Shaft Ceased


Time

Water Elevation (feet below sea level)
Atlantic Ocean

Harbour Seam

Pillars >200'

Flooded Lingan Colliery

Flooded No. 26 Colliery

Phalen Colliery Retreat Direction ~300 USgpm/panel

Emery Seam

Phalen Longwalls receive mine water
Mine water is Getting Close!

- In mid 2002, monitoring boreholes along the shoreline intercept bad quality mine water
- Less than 100 ft to overflow

WHERE DO WE GO FROM HERE!
CBDC Developed a Stepped Approach to Deal With Rising Mine Water

(1) Late 2002, all focus is now on mine water
(2) The location, quantity and mine water overflow date was calculated
(3) All surface water entrance points sealed
(4) Established expert groups to give advice
(5) Additional boreholes drilled to sample mine water chemistry and geology in upper areas
(6) Began immediate construction of an emergency WTP at the 1B Shaft site
1A Outfall projected to discharge by April 2003 at elev. +6’ asl

No. 1A Outfall at shoreline
MacKay’s Corner “bootleg” workings and AMD formation
1B Shaft WTP
1500 US gpm capacity

1B Treatment Plant and Settling Pond
January 2003 – Less than 100’ to overflow

Reserve Mines
Outline of Mine Workings
Suspected infiltration zone hatched
Approx 4500 acres

Dominion
No. 1A
(1893-1927)
No. 5
(1872-1938)
No. 1B
Shaft
No. 1A Outfall
Boreholes 2001
Boreholes 2002
Atlantic Ocean

No. 1B Shaft
(Glace Bay)

(Emergency WTP)

PARAMETERS

<table>
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<tr>
<th>PARAMETERS</th>
<th>No. 1B Shaft</th>
<th>No. 1A</th>
<th>B-171</th>
<th>B-172</th>
<th>B-175</th>
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<td>pH units</td>
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<td>3.3</td>
<td>7.4</td>
<td>7.7</td>
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<td>0.56</td>
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<td>Alkalinity (mg/L)</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>286</td>
<td>319</td>
<td>308</td>
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<td>Sulphate (mg/L)</td>
<td>5,905</td>
<td>7,060</td>
<td>1,128</td>
<td>1,290</td>
<td>1,580</td>
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<td>Cond (u/cm)</td>
<td>14,400</td>
<td>7,760</td>
<td>2,560</td>
<td>2,820</td>
<td>3,350</td>
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</table>
(7) In January 2003, borehole sampling in upper area of No.5 showed good mine water chemistry. Needed to understand the reasons why.

(8) Intensive study of mine water flow paths, local geology, mining methods and infiltration areas carried out.

(9) Recommended that an untreated discharge should be established in area of good mine water chemistry.
Probable infiltration zone and flow path prior to flooding of 1B System

Outline of Mine Workings

Suspected Infiltration zones hatched
Approx 4500 acres

Reserve Mines

No. 5
(1872-1938)

No. 3
(1900-1915)

No. 2
(1899-1947)

No. 1A
(1893-1927)

No. 1B Shaft

Pumps @ 1750 USgpm
Until 1984

Dominion

Atlantic Ocean

Phalen Seam Outcrop

Glace Bay

No. 1A Outfall

Probable infiltration zone and flow path prior to flooding of 1B System

Coal Pillars

80+ years of flushing
No.1A Room and Pillar workings

“LESS access to acid neutralizing roof strata”

ROOF STRATA

Limestone

borehole

COAL

AMD

PILLAR

AMD

Mining Method – 92% Room and pillar
Only 45% of coal removed
No.5 Pillar Extraction

Mining Method – 75% Room and Pillar with pillar extraction

Almost 85% of coal removed

“MORE access to acid neutralizing strata”

Limestone

borehole

AMD
Establish an Untreated Discharge

- In Feb 2003 a pilot pumping program was implemented in upper area of No.5 near Neville Street. Very positive mine water chemistry – zero fish mortality – results accepted by regulators.
- In March 2003, Neville Street upgraded to 3500 gpm capacity, discharge quality remained stable.
- The flooding of the 1B System was now under control. (mine water level had reached 12’ bsl)
- The operation of the WTP at 1B Shaft was halted and the plant was put in a state of readiness.
Flooding status halted in March 2003

Sequence of Coal Seams
- Hub Seam
- Harbour Seam
- Phalen Seam
- Emery Seam

Only 5% left dry

"1B Hydraulic System"
Current Pumping Strategy

• Since 2003 the Neville Street Well field has undergone several infrastructure upgrades.
• It is now fully automated with 12 x 30 hp submersible pumps providing 5700 gpm at full capacity.
• Pump startup priority is based on quality at individual wells. Maintain mine water level at –17’ to –19’ bsl.
• Normally see increase in mine water volumes 24 hours after precipitation events.
### Mine Water Fe/Al Quality Trends 2003-2007

#### Iron and Aluminum Concentration in the Neville Street Discharge

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<th>2003</th>
<th>2004</th>
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<td><strong>Fe</strong></td>
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<td></td>
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<tr>
<td>Minimum</td>
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<td>0.14</td>
<td>0.43</td>
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<tr>
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<td>0.40</td>
<td>3.03</td>
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<td><strong>Al</strong></td>
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<tr>
<td>Minimum</td>
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<td>0.01</td>
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<td>0.13</td>
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<td>0.83</td>
<td>2.10</td>
<td>2.50</td>
<td>1.80</td>
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<tr>
<td>Mean</td>
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<td>0.15</td>
<td>0.71</td>
<td>0.79</td>
<td>0.61</td>
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#### Average Iron Concentration in Discharge

![Graph showing average iron concentration in discharge from 2003 to 2007](image)

#### Average Aluminum Content in Discharge

![Graph showing average aluminum content in discharge from 2003 to 2007](image)
Figure 21

Sketch Showing General Mine Pool Chemistry and Location of Local Features.

- Colored Contours Represent Approximate Total Iron Concentration in Mine Pool (mg/L)
- Maintenance zone -17 to -19 ft bsl
- Monitoring Well
- 1 kilometer

2007 Contour Map - Mine water iron concentrations in mg/l

Net alkalinity vs Net acidity

R² = 0.1759
R² = 0.4435
R² = 0.3836

mg/l (as CaCO₃)

Linear (Net alkalinity/acidity (mg/l as CaCO₃))
Linear (Net alkalinity/hot acidity (mg/l as CaCO₃))
Linear (Net alkalinity/mineral acidity (as mg/l CaCO₃))
Neville Street Well Field - Key Statistics

- Annual precipitation of 60”, average pumping rate of 2200 US gpm
- Infiltration rate is estimated to be 2.9 gallons per acre. The total infiltration varies from 450 gpm (summer) to 7000 gpm (rain/snow melt)
- Currently pumping 1.2 billion US gallons annually without treatment
- Annual cost to operate the Neville Street Well Field is $ 250k
The Future – Near Term

- Recognize mine water quality is slowly deteriorating
- Assessing adjacent mines for leakage/pillar failure
- Drilling additional boreholes for strata information and looking for better quality mine water. Plan to use tracers to better identify u/g flowpaths
- Planning for an aerial survey using LIDAR technology to identify surface sinkholes
- Construct passive treatment wetland at Neville St.
- Establish/support research in Mine Water Management at Cape Breton University
The Future – Long Term

• Our ultimate goal is to establish a compliant, passive discharge from the 1B Hydraulic System to the marine environment
• Work closely with CBU Mine Water Chair to help develop the plan to accomplish this goal
• Probable use of active treatment to flush the 2 billion gallons of AMD under the land portion of the 1B System before release – how many times will the 1B System have to be flushed is the question that needs to be answered
Thank you