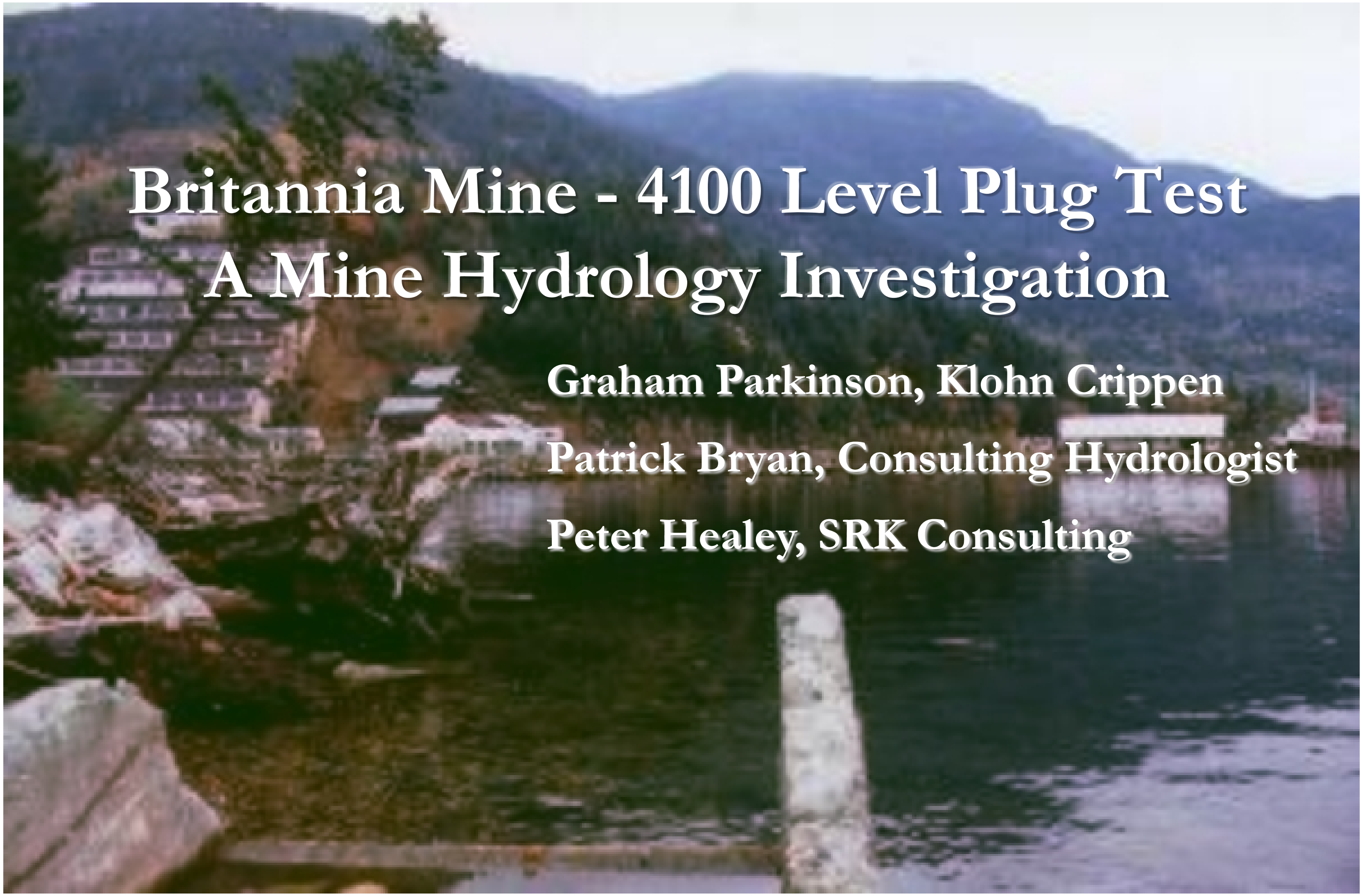

Britannia Mine - 4100 Level Plug Test
A Mine Hydrology Investigation

Graham Parkinson, Klohn Crippen

Patrick Bryan, Consulting Hydrologist

Peter Healey, SRK Consulting

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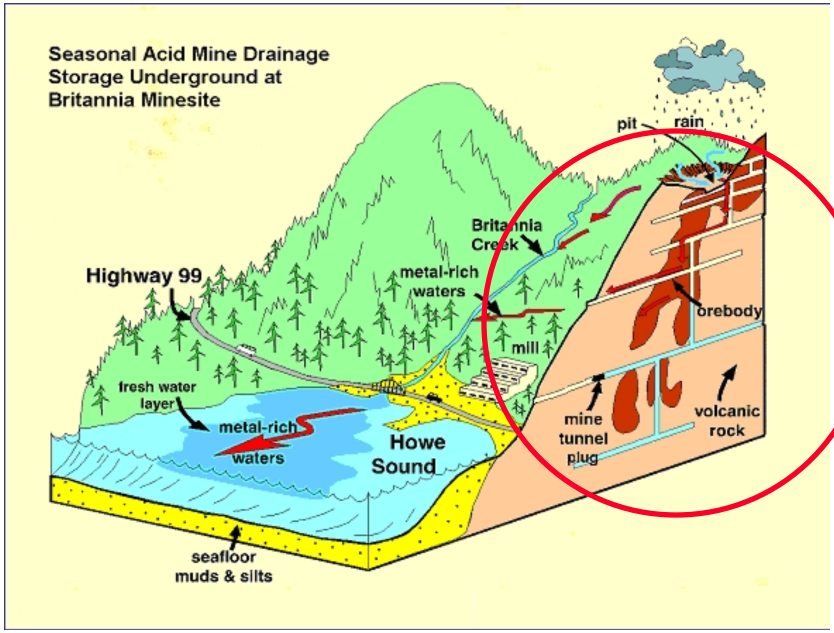
Britannia Mine 4100 Level Plug Test

- The mine remediation project focuses on reduction of AMD from an abandoned op/ug Cu mine located adjacent to a major fishery.
- The test was commissioned to provide data for the design of a suitable water treatment plan.
- KC/SRK measured AMD storage volume in the sealed underground mine using pressure and flow data obtained only at the tunnel plug.



Courtesy Natural Resources Canada / GSC

A network of open pits collects rain and snow, funneling water into the mine.

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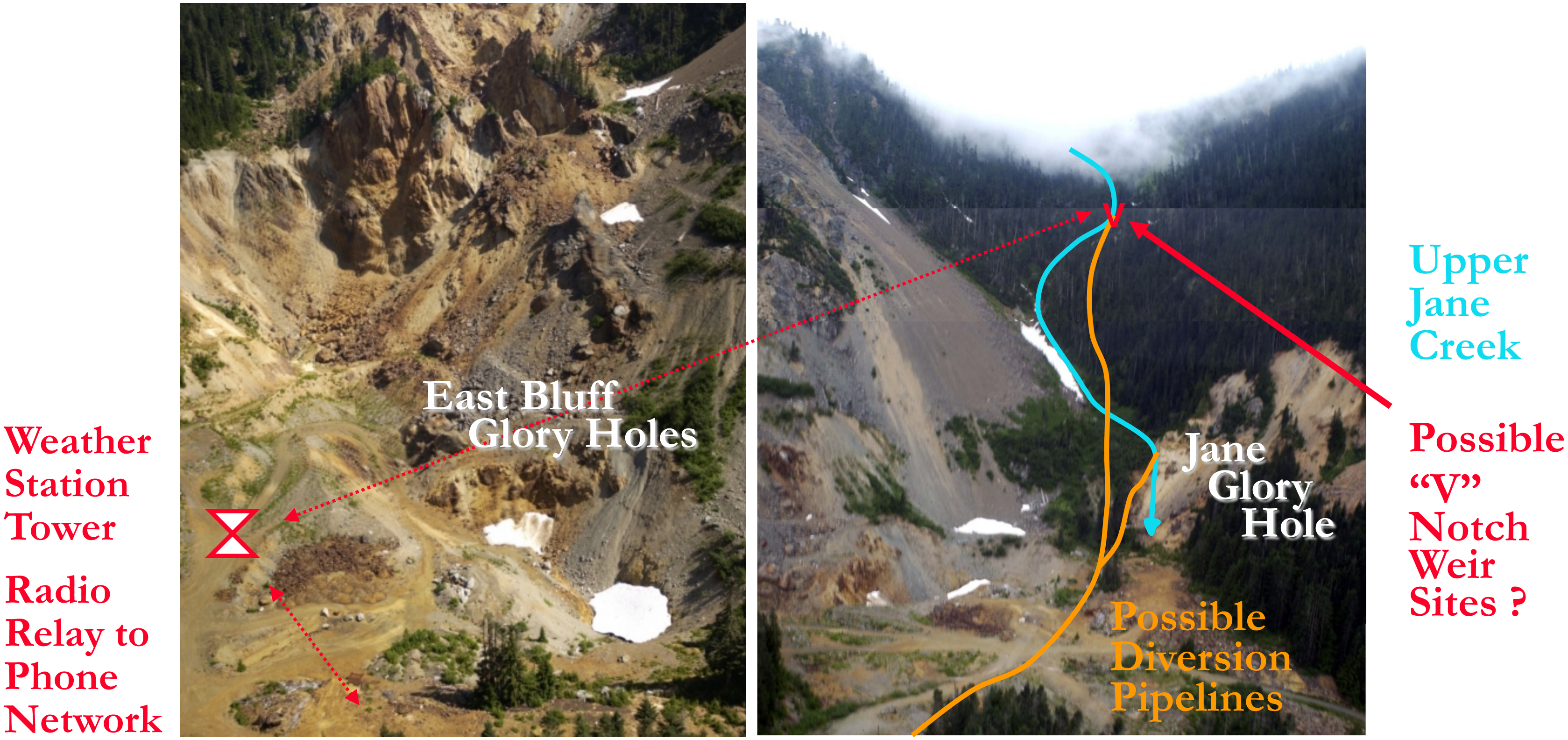
Mine Inflow - Jane Basin Glory Holes



- Diversion has been hampered by large scree slopes and mine inflows from multiple drainages. Capping would require enormous volumes of fill.
- Plugging of the caved openings from underground would be difficult due to lack of access, poor records and the large number of potential openings.
- Exposed rock and waste is acid generating.

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Upper Jane Creek
Diversion Evaluation Monitoring Weir

This "V" notch weir was built to remotely monitor flows into Jane glory hole. The weir may also be used as an intake for a future diversion.

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Upper Jane Creek
Diversion Evaluation Monitoring Weir

Radio Link to Weather Station

The weir is located on the only area of exposed intact bedrock in the creek. The flow gauging instrumentation is equipped with a solar powered radio link.

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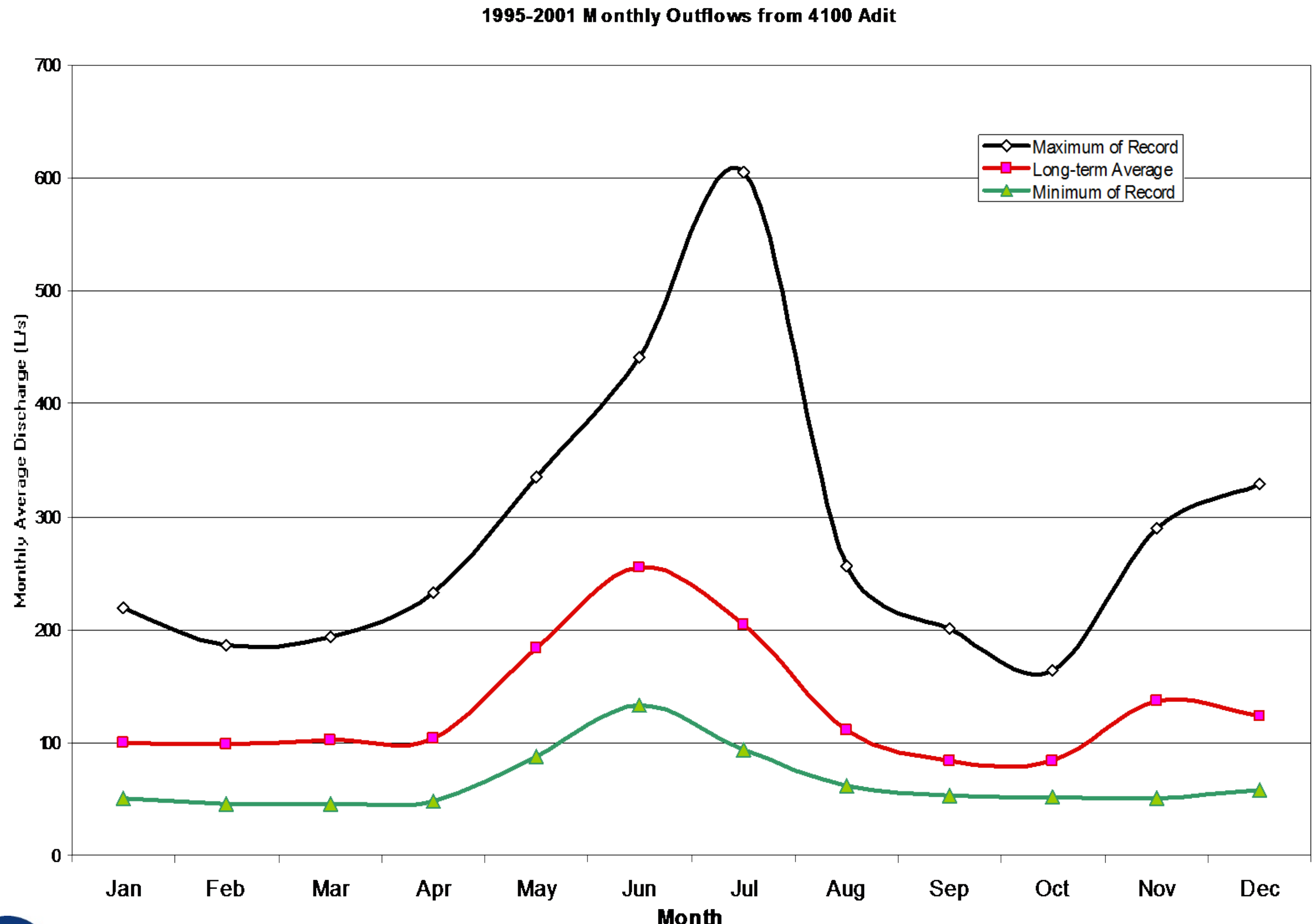
Historical Monthly Mine Flows



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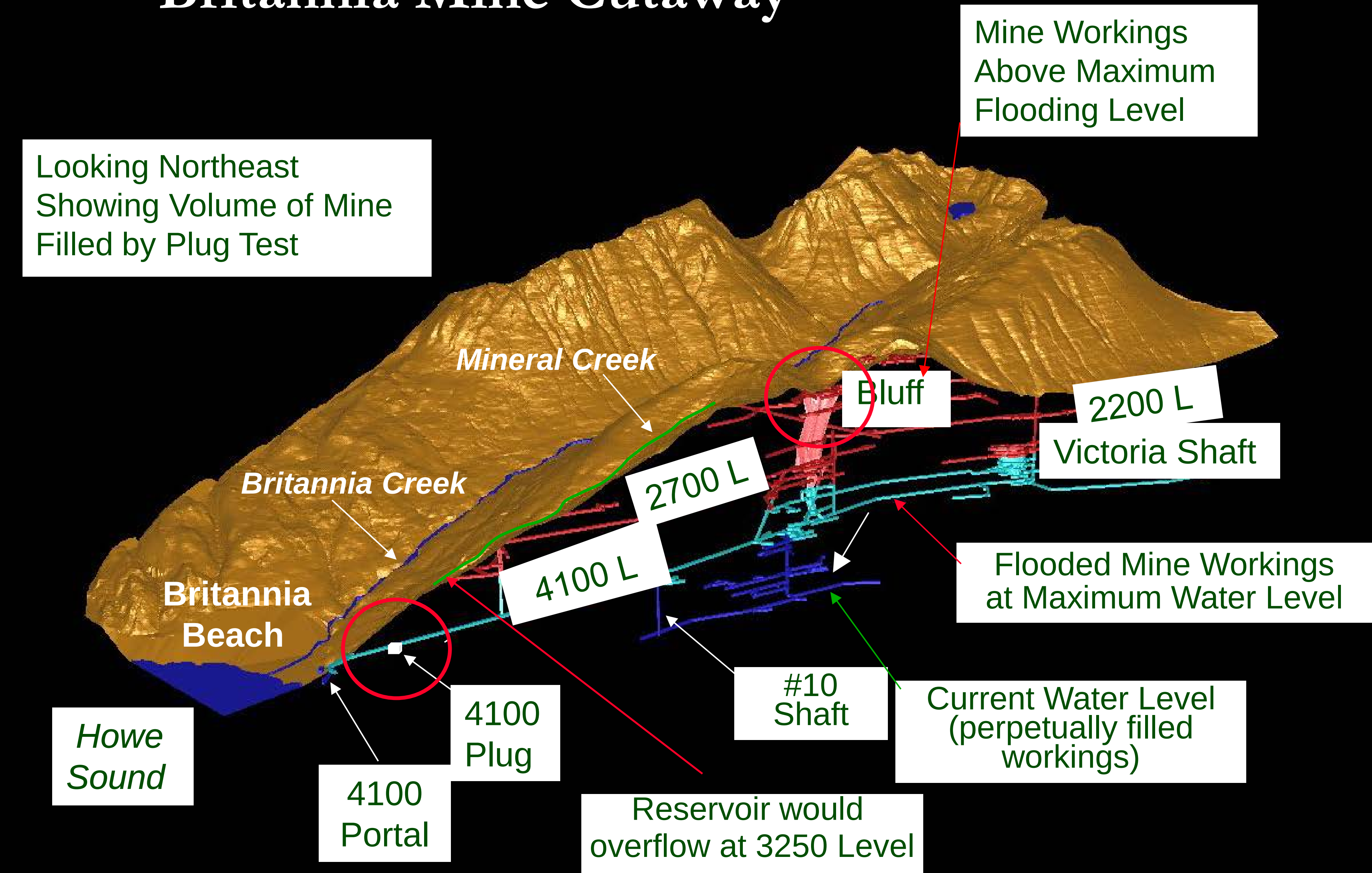
Britannia Mine Cutaway



Underground Installations - 400m into Tunnel. Energy Dissipator, Stainless Valves and Pipes.

- Piping must withstand 300 p.s.i., Flows >700 l/s and pH 3.1 mine waters with high iron content and entrained pebbles.
- Valve Opening, Flow, Pressure and Geotech Sensors are remotely monitored and controlled on line.

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4100 Plug Data Logger Station and Instrument Readouts

Instruments include: Pressure and Displacement Transducers, Magnetic Flowmeters, Drainage level sensor and Turbidity. Logger also controls valve automatically.

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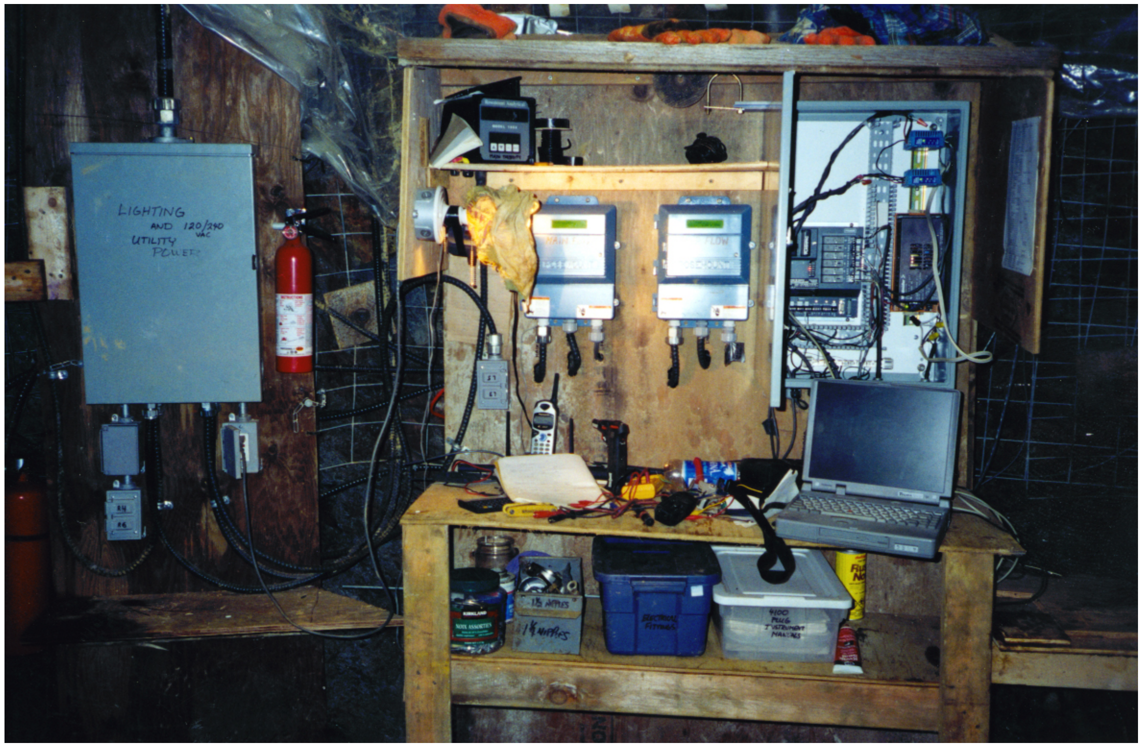
4100 Plug Data Logger Station and Instrument Readouts



Instruments include: Pressure and Displacement Transducers, Magnetic Flowmeters, Drainage level sensor and Turbidity. Logger also controls valve automatically.

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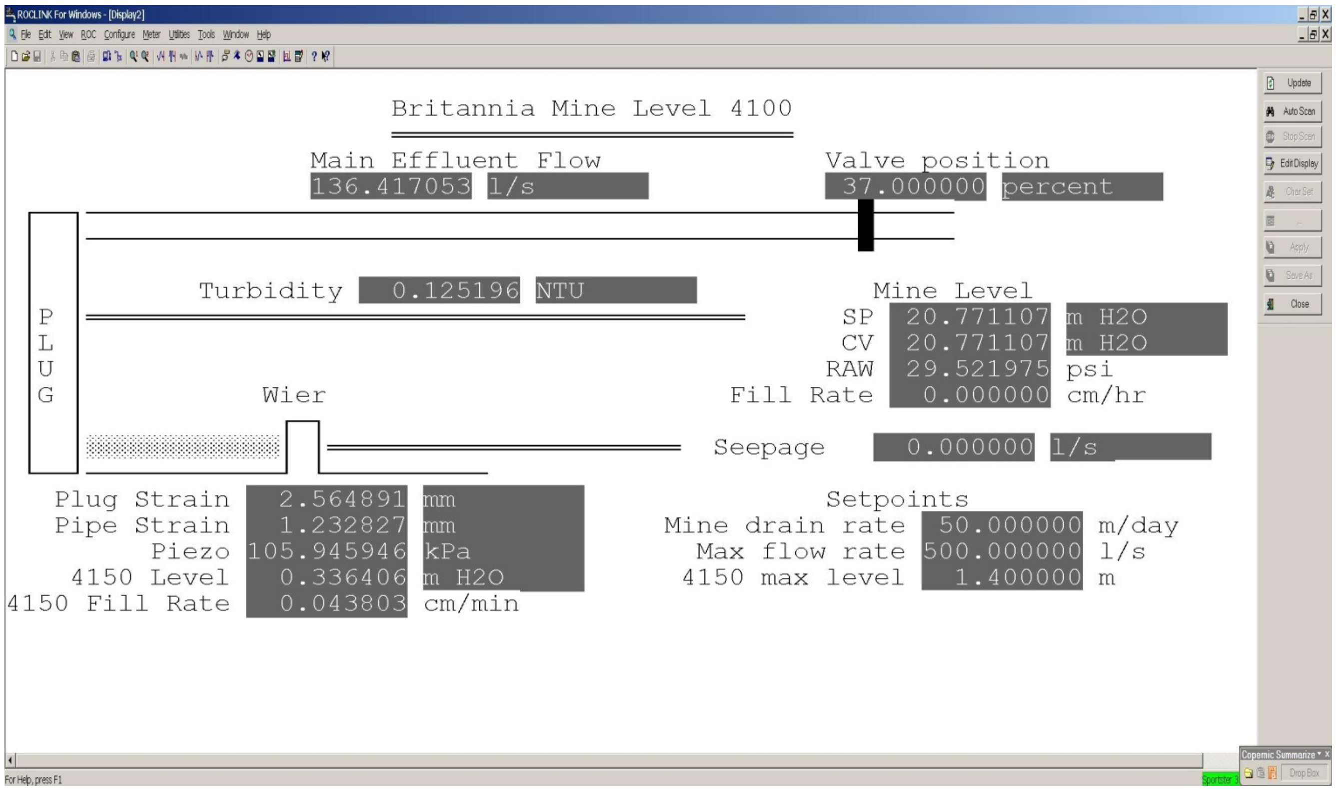
4100 Plug Data Logger Station
Remote Monitoring and Control



Instruments include: Pressure and Displacement Transducers, Magnetic Flowmeters, Drainage level sensor and Turbidity. Logger also controls valve automatically.

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Mine Water Discharging into Tunnel at Plug

- Mine Water Discharge reaches 500 litres/sec or more during freshet.
- Noise is a serious problem in the tunnel.
- Acidic copper/zinc laden mist is harmful to lung and eye tissue.
- Typical Power Dissipated during the Freshet is:

  360 hp = 0.25 Mwatt

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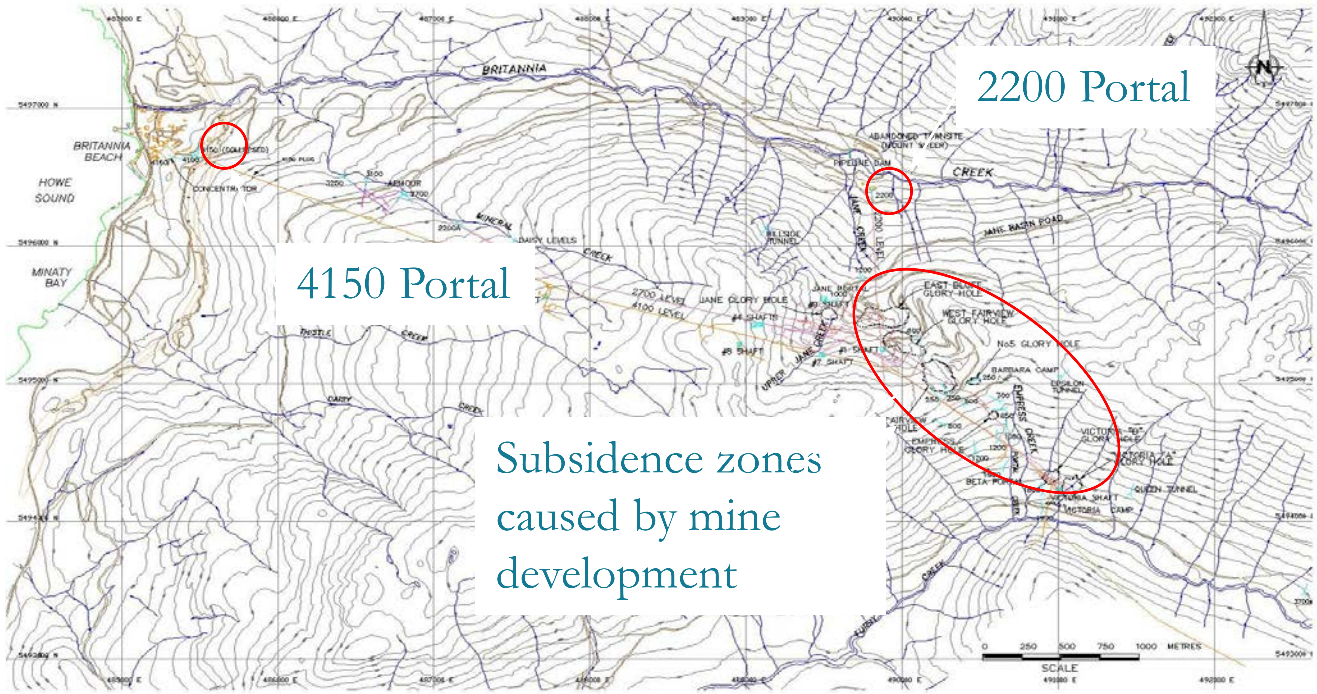
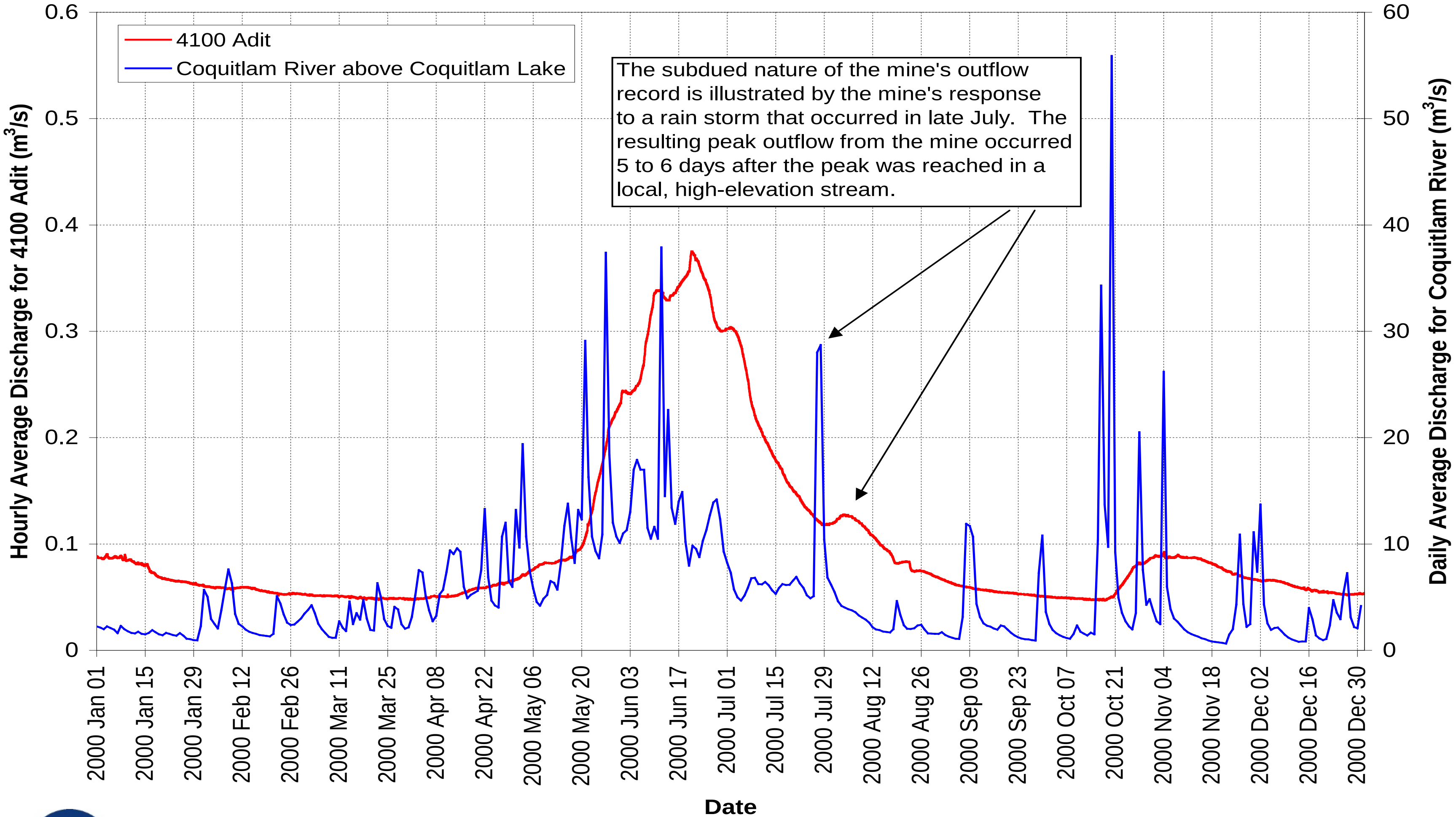
Britannia Mine Outflows



- **Long-term average outflow from mine = 5.4 million m³ per year (170 L/s or 2700 USgpm)**
- **The 2200 adit was sealed with a concrete plug in December 2001.**

4100 Adit Flows vs. Coquitlam River Flows



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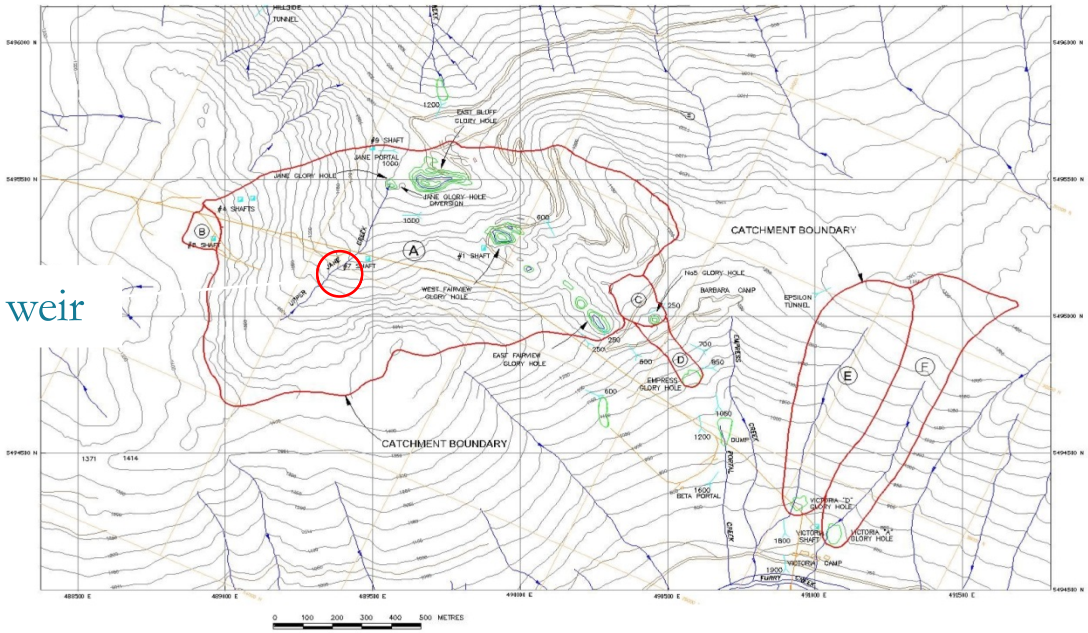
Diversion of Surface Water Into Mine Workings

New triangular weir



- Total drainage area of enclosed catchments = 1.57 km^2
- Estimated average annual yield of catchments = 2.6 m
- Estimated volume of water diverted into u/g via subsidence zones = 4 million m^3/y, or 75% of the mine's total outflows

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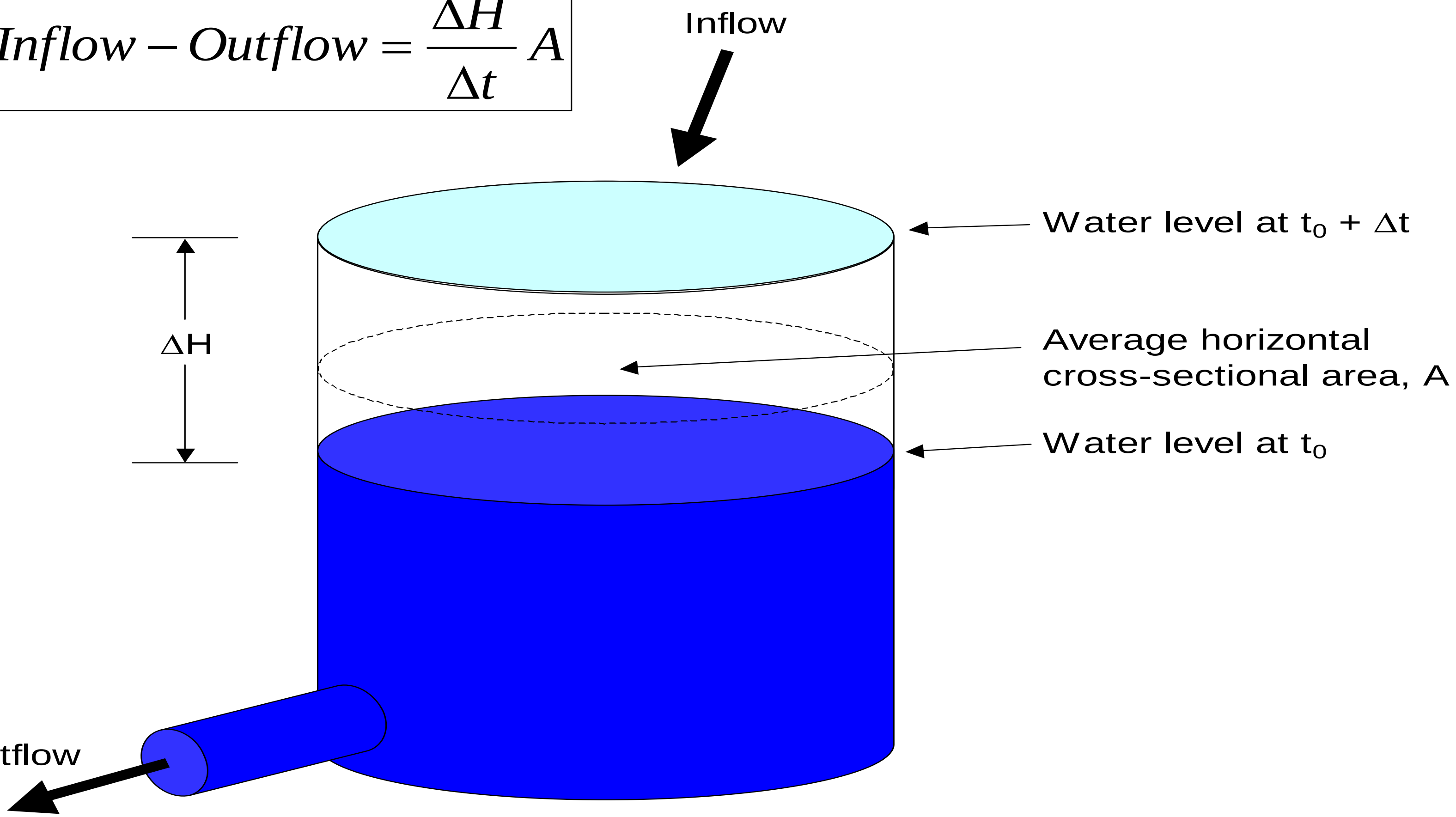
Black Box Experiment

- Challenge: estimate storage in mine workings from 0 to 250 m above 4100 concrete plug
- Method: exploit existing plug to fill mine with water
- Governing equation: $I - O = \Delta S$
- To apply equation, a method was sought to make estimates of inflow to the mine

Illustration of Continuity Equation

$$Inflow - Outflow = \frac{\Delta H}{\Delta t} A$$



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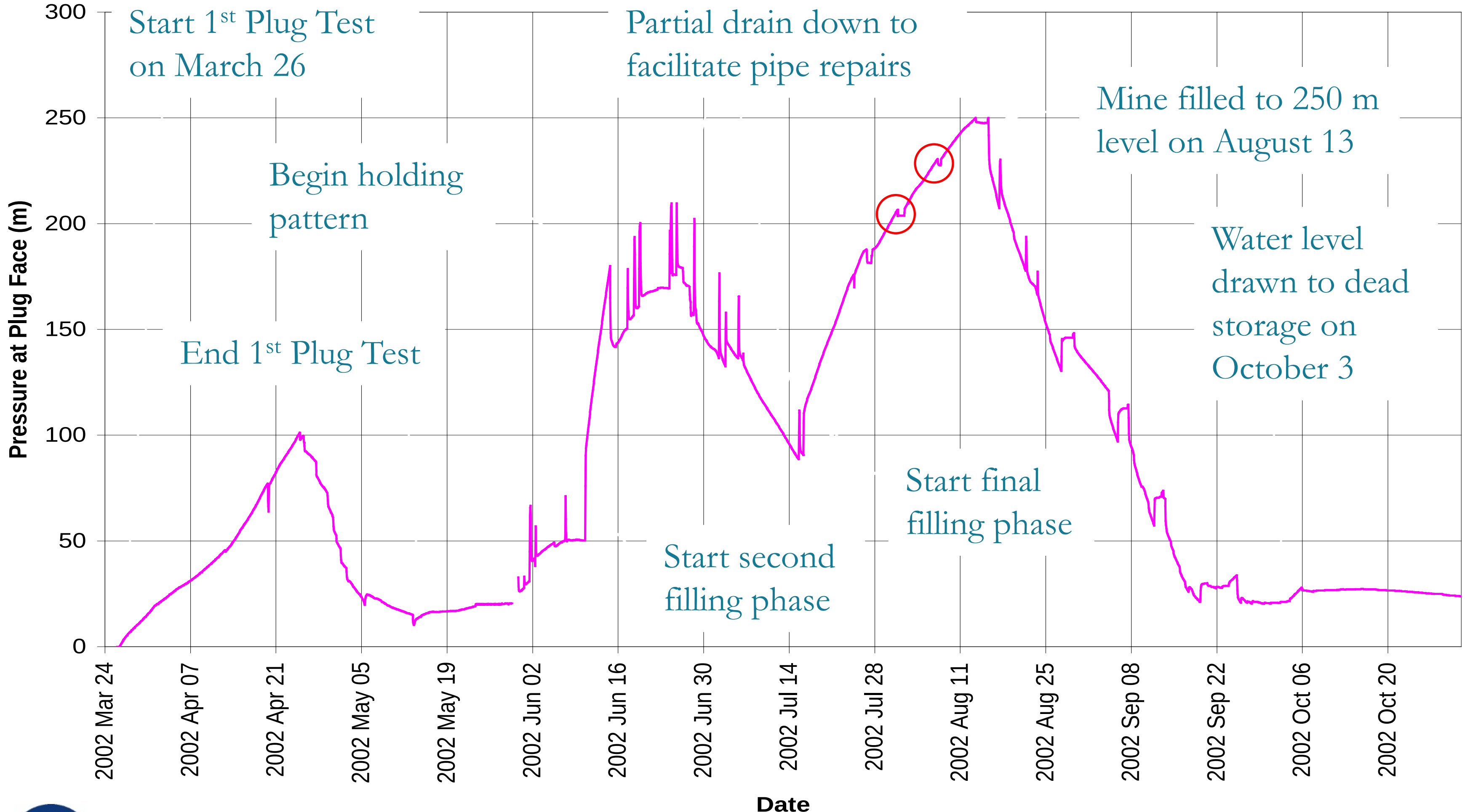
Pressure at 4100 Concrete Plug



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Inflow Test: Continuity Equation Applied Twice

First Period (Plug Outflow = 0)

dH/dt = 4.29 m/d

I = 4.29 A

Solution:

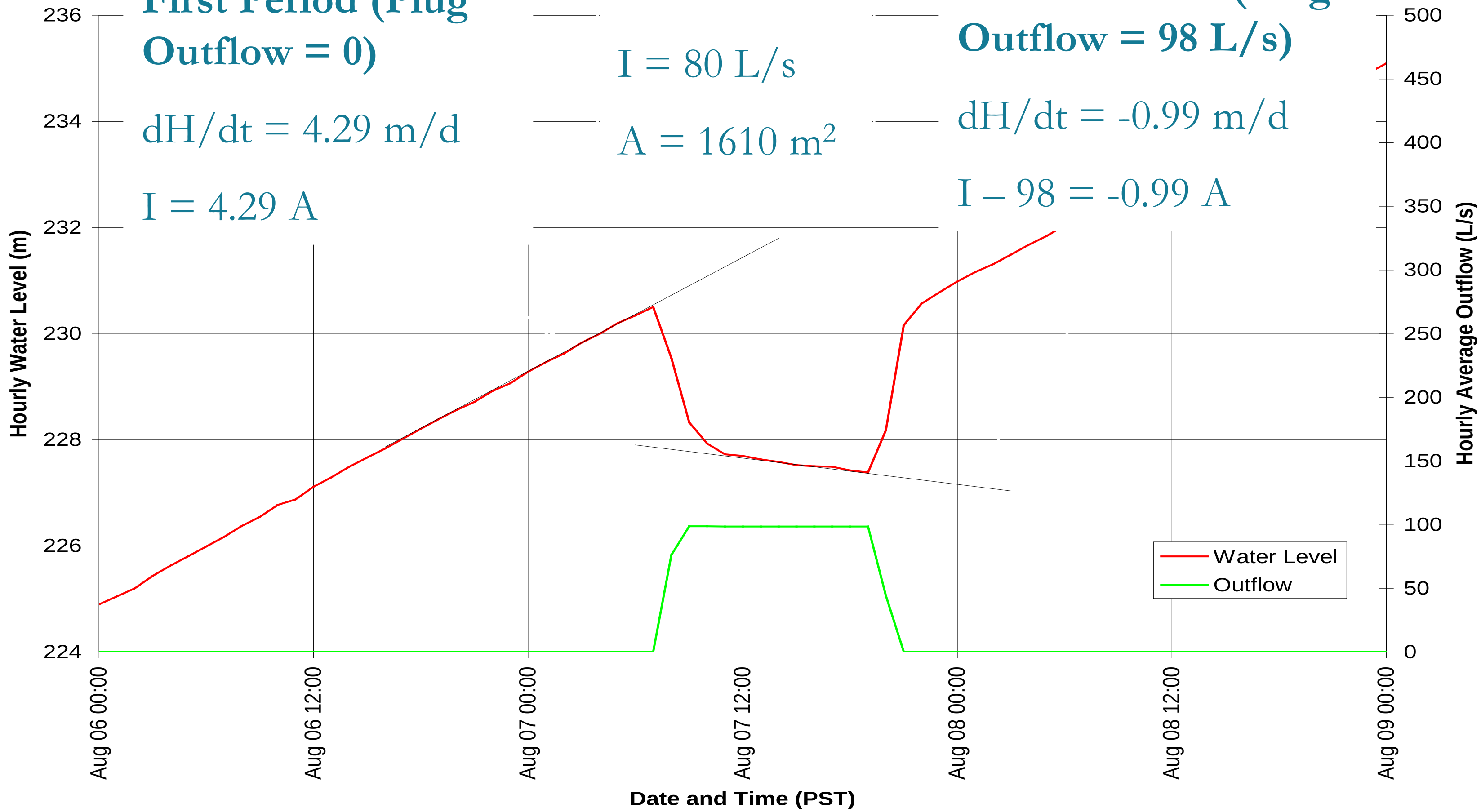
I = 80 L/s

A = 1610 m^2

Second Period (Plug Outflow = 98 L/s)

dH/dt = -0.99 m/d

I – 98 = -0.99 A



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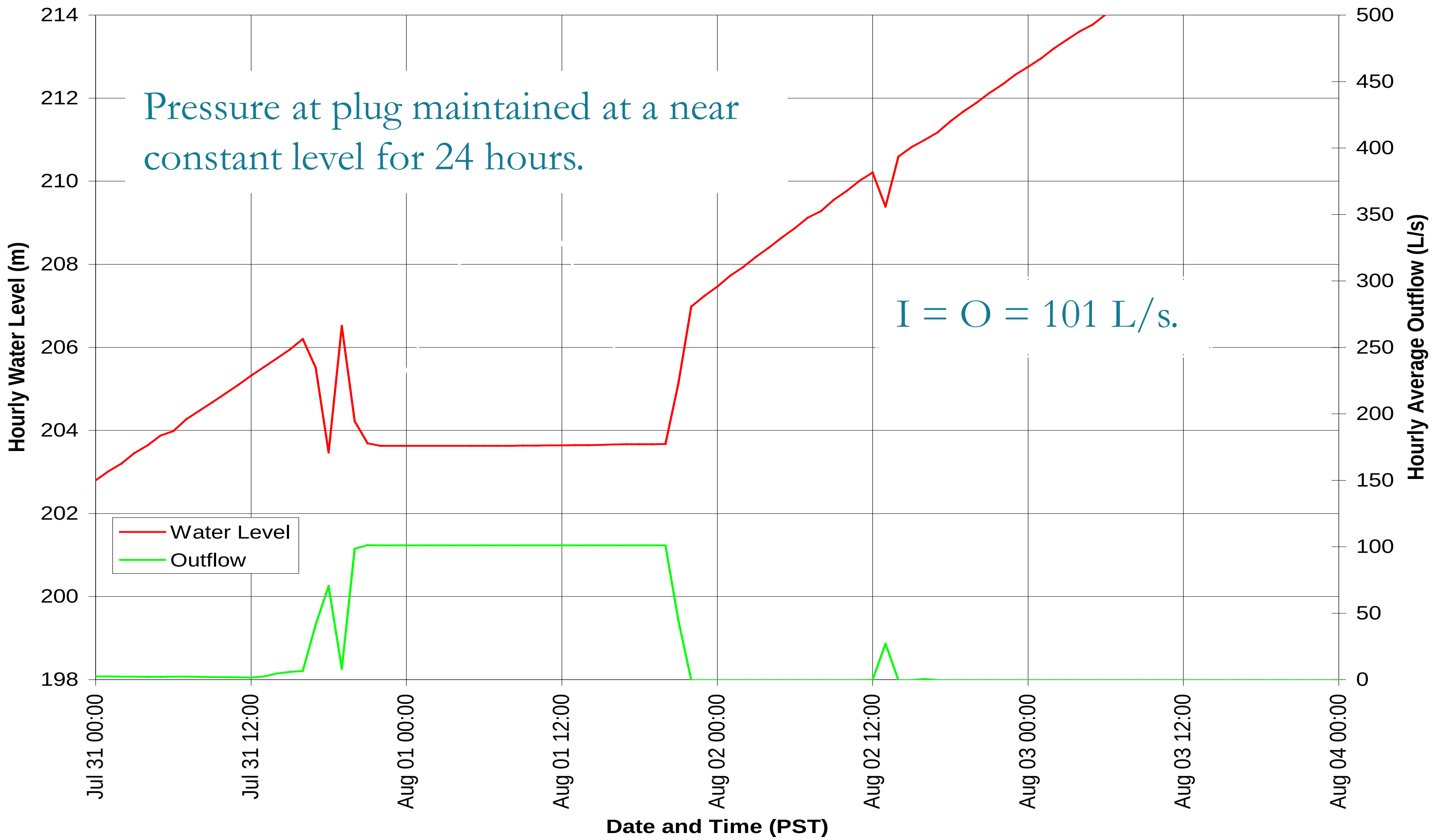
Inflow Test: Pressure Balance



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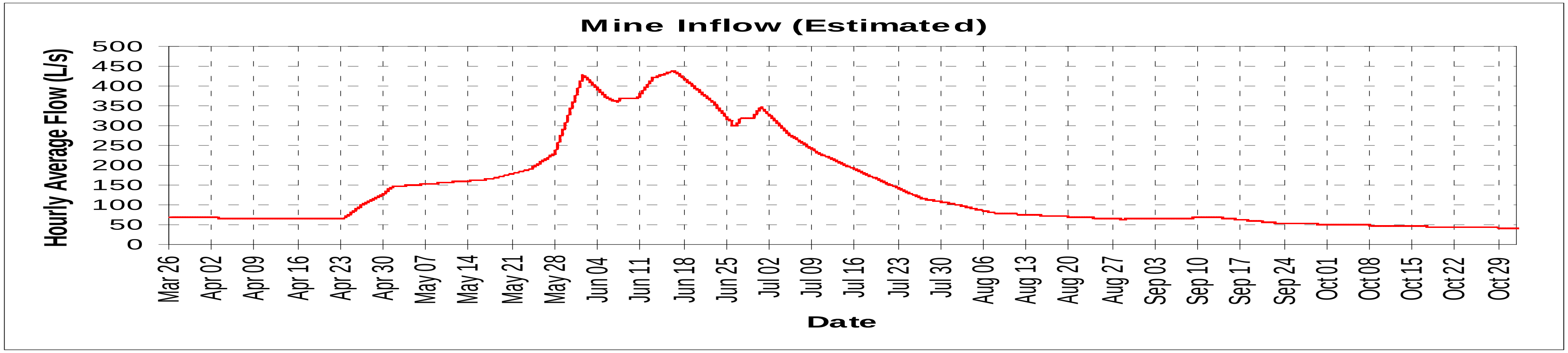

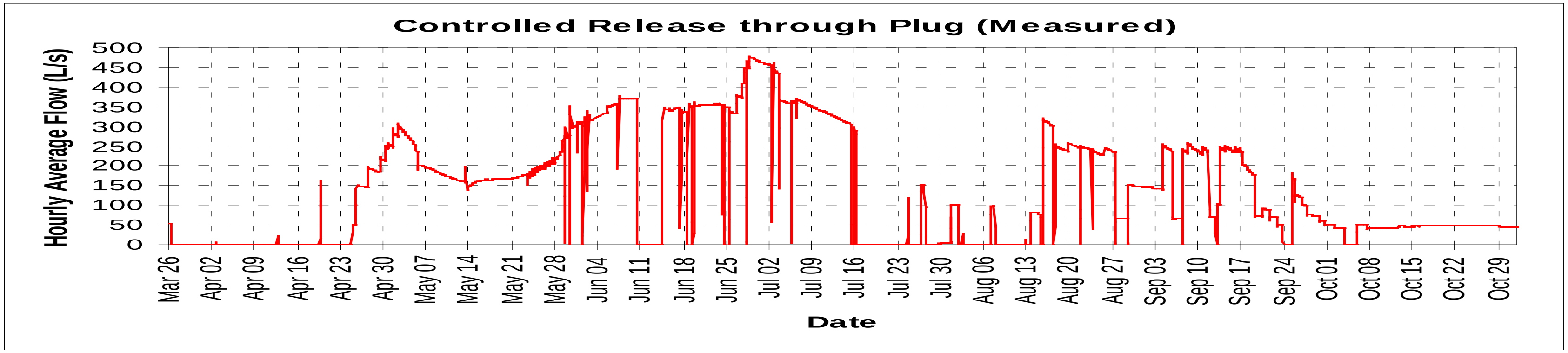

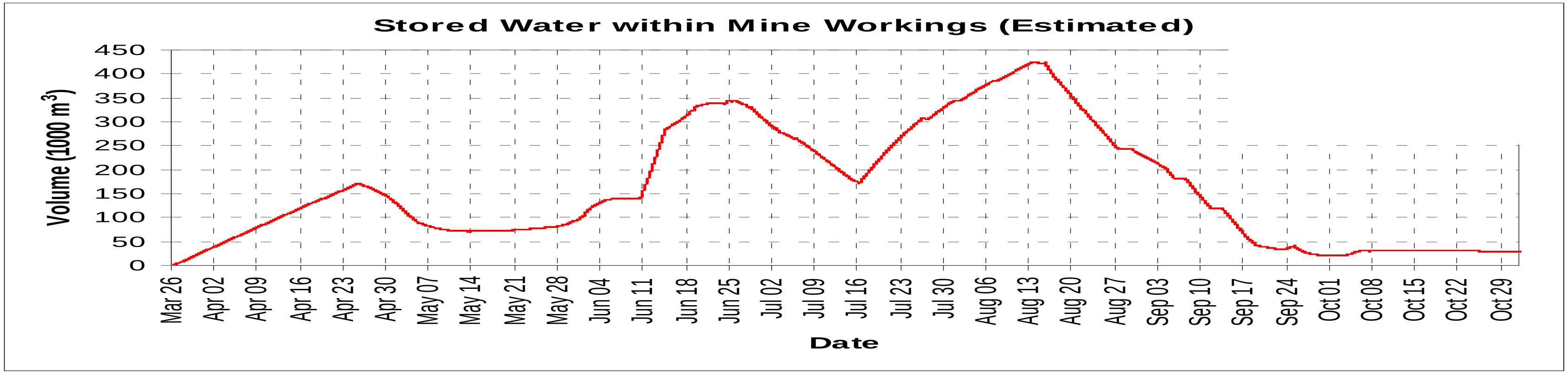

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Plug Test Water Balance

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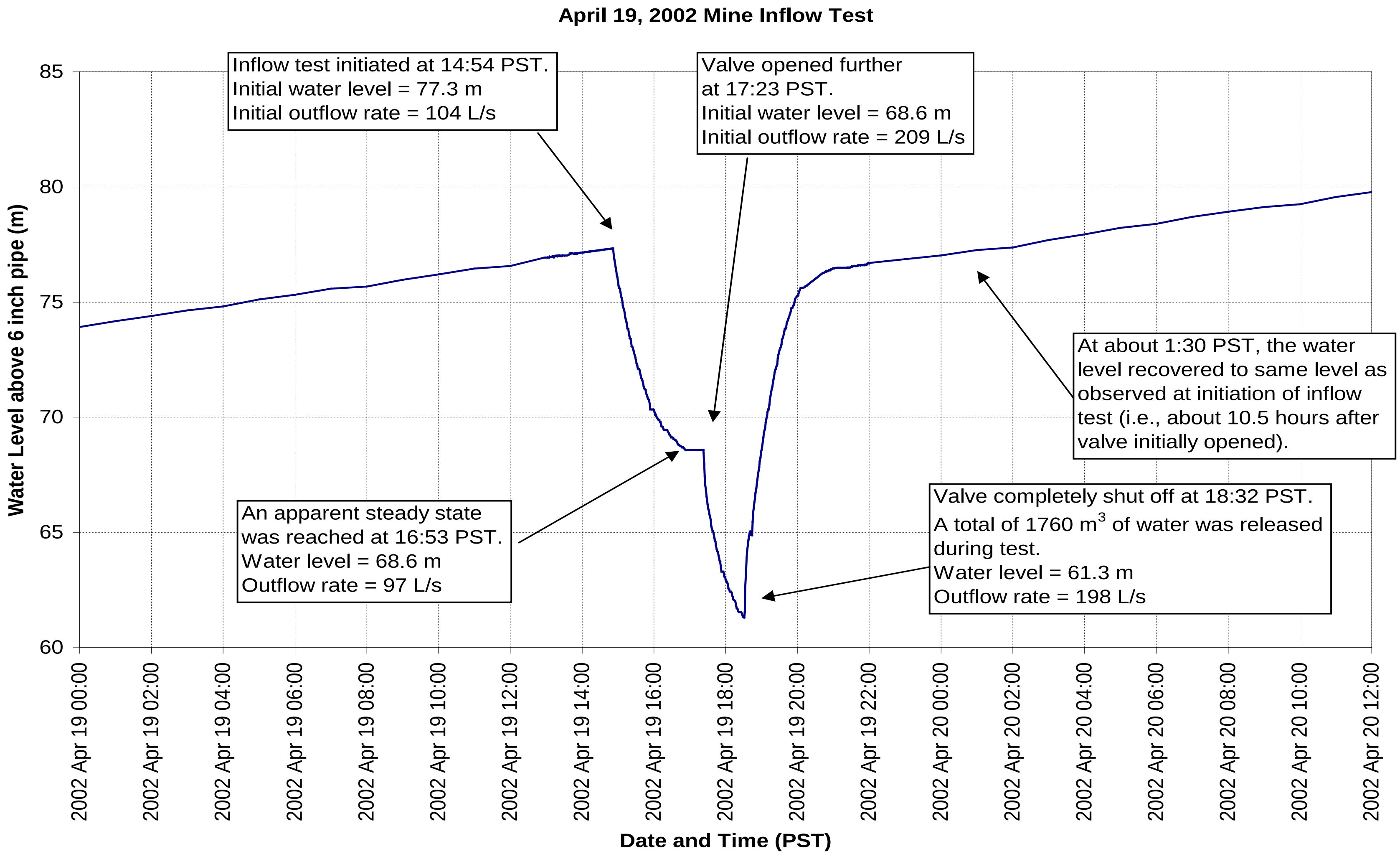
Evidence of Internal Pervious Blockage



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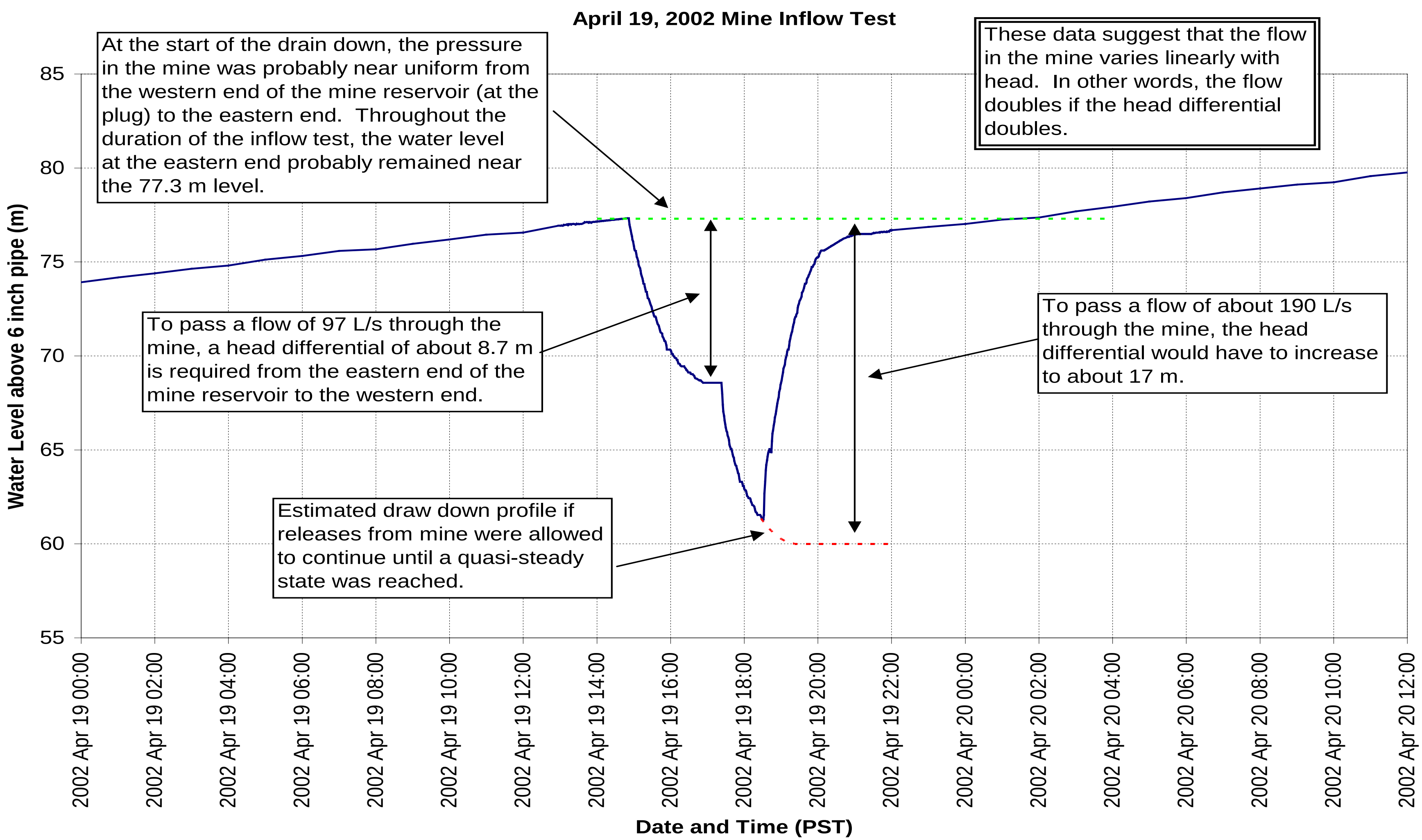
Interpretation of April 19 Inflow Test



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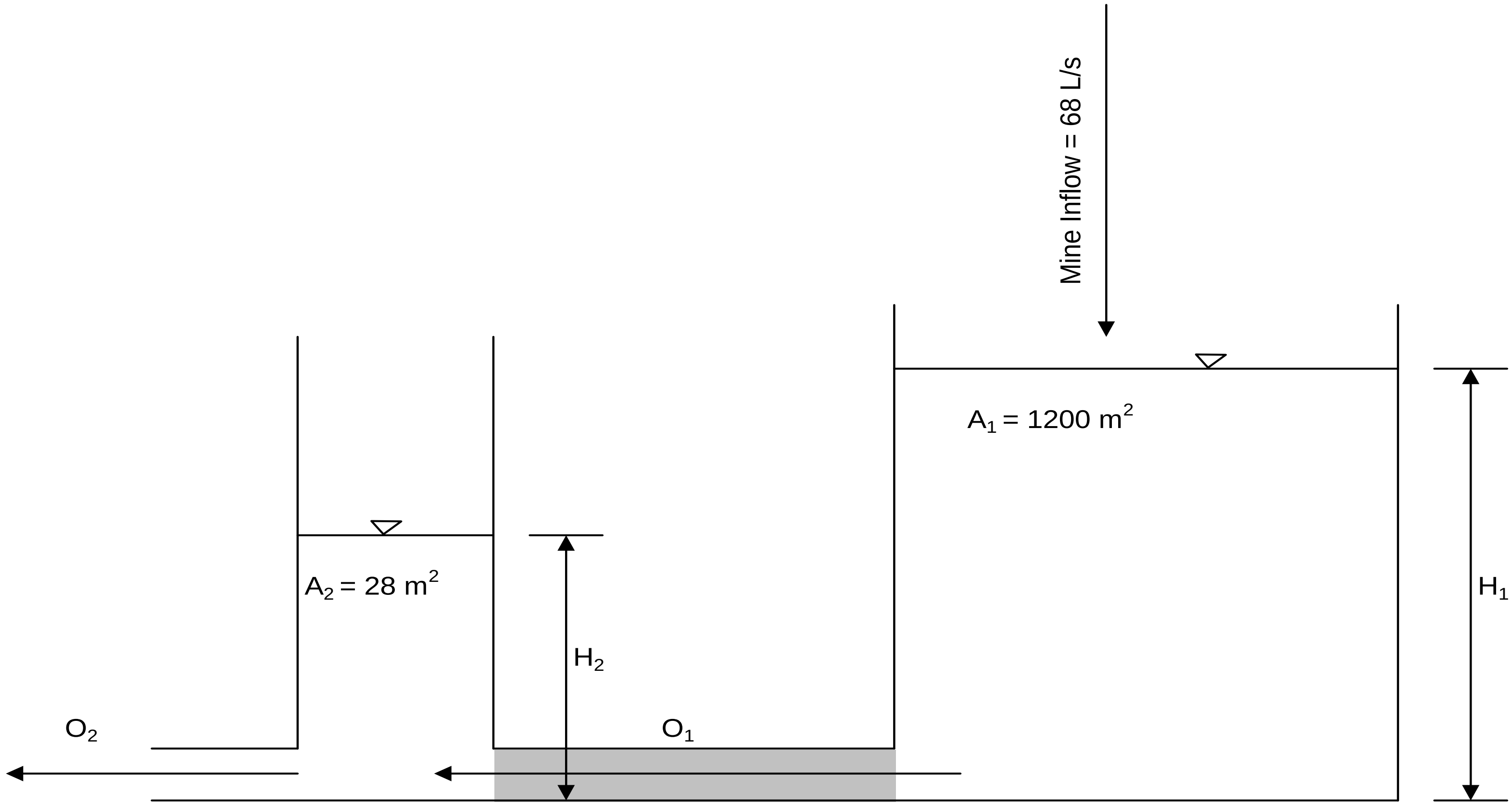
Simple Hydraulic Model



O_2 = measured discharge

$O_1 = C\ (H_1 - H_2)$

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Acknowledgements

- Terry Johnson – Underground Shift Boss / BC Mining Museum Manager
- Proconn Tunneling and Mining – Mine Rehabilitation and Construction
- Kirk McMillan – Remote Environmental Services (4100 Weir Instruments)
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- RST Instruments – Geotechnical Instrumentation
- Cassandra Hall and Foundex Drilling – 4100 Plug Investigation
- Al Morrison and Gary Stevenson – 4100 Plug Stability Review

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