



## GEO-FOUNDATIONS Contractors Inc.

# Niagara Tunnel – Intake Shaft Grout Curtain



Date: 2007

Technology: Rock Pressure Grouting

Due to be commissioned in 2010, the new 10.4 kilometre long, 14-metre diameter Niagara Tunnel is being built with the help of the world's largest hard rock tunnel boring machine, "Big Becky". The tunnel is being advanced from downstream to upstream. When the tunnel bore breaks through in 2009 to the tunnel's 45-metre deep intake shaft in the middle of the river just upstream from Niagara Falls, Big Becky will be disassembled and extracted piece by piece via the shaft, which has been sealed against water ingress from the river above by a grout curtain designed and constructed in 2007 by Geo-Foundations.

The intake shaft excavation will be 16 metres x 26 metres in plan x 45 metres deep. Above the bedrock river bottom, the river is held back from occupying the shaft excavation by a multiple-cell cofferdam built of sheet piling and rock fill. Below the cofferdam, in the bedrock itself, the grout curtain constructed by Geo-Foundations works to seal the rock fissures – formed by cracks, open horizontal bedding planes and plunging joint networks – that would certainly, without treatment by grouting, let enough water pass into the shaft excavation to cause flooding detrimental enough to halt all further shaft construction. The grout curtain will see its sternest test in the interim between completion of the shaft excavation and the tunnel boring's eventual breakthrough – the grout curtain will have to resist 45 metres of hydrostatic head across its relatively thin width.

Grouting of the fissured bedrock included full depth, fourth-order split spaced holes and employed simultaneous grout injection at multiple holes. A sophisticated suite of drilling and grouting equipment was used, including water-hammer drilling, real-time, response-driven additive dosing to modify grout formulations during grout injection and an automated bulk grout batching plant capable of delivering more than 20 cubic metres of cement grout per hour.



*Site arrangement of drilling and grouting equipment, featuring heated tent for bentonite slurry storage, automated batch plant with cement silo, flow control bin and high pressure water pump for use by water-hammer drilling system*

Grout curtain construction required more than 13,000 lineal metres of drilling and consumed more than 541,000 kg (dry weight) of cement. Several verification holes were drilled and two holes were core sampled and tested for residual hydraulic conductivity as part of grout curtain quality assurance.



*Excavation of intake shaft in progress – November 2007*



*Drilling of 80-metre deep grout curtain holes from atop cofferdam rock fill*