

## Previous Tunnel News

### November 2011 Update

At the intake site, where water will enter the tunnel above Niagara Falls, work continues on disassembly and removal of the Tunnel Boring Machine (TBM). In late August, using a 300-tonne crane, the first of Big Becky's six 60-tonne cutterhead segments was safely lifted to the surface from the intake channel previously excavated in the Niagara River bed. By early September, all four of the cutterhead's outer segments had been lifted to the surface and work continues on removal of the various TBM components.

There are six major sections that comprise the cutterhead of the Tunnel Boring Machine (TBM). Each piece weighs about 60 tonnes, requiring a 300-tonne lift capacity crane to get the job done. The crane will remain on site until it is replaced in November by a larger crane needed to lift and remove Big Becky's 80-tonne main beam. Discussions have begun with the Niagara Parks Commission regarding remediation of the lands near the inlet, including a display of all or part of the cutterhead.

At the outlet end, near the Sir Adam Beck generating stations, work continues on the outlet structure that will incorporate the emergency closure gate and will direct the water flowing through the tunnel into the canals that feed the stations. To construct the complexly shaped outlet structure, the workers install formwork and rebar, and place the concrete in several stages. This work is complicated by the need to keep construction traffic moving in and out of the tunnel while the reinforced concrete outlet structure is being built.

Inside the tunnel, work continues on tunnel crown restoration, installation of the upper two-thirds of the permanent concrete liner, and the grouting needed to permanently secure the concrete lining to the surrounding rock. Installation of the upper two-thirds of the permanent liner has progressed beyond 4.6 km. The tunnel crown restoration is an operation that involves installing rock bolts, wire mesh, steel forms and concrete to fill the area at the top of the tunnel, where excess rock broke away during the tunnel mining. This work has progressed to about 5.3 km, which is just over half way along the tunnel.

STRABAG's plan for repair and reinforcement of the tunnel crown support through the area where initial reinforcements and rock fell in July has been accepted by the Ministry of Labour. Installation of the additional rock bolts, wire mesh and shotcrete is underway from both the intake and outlet ends of the affected area.

### August 2011 Update

While the tunnel mining (TBM excavation) was completed this spring, there are still a number of activities over the next two years to complete the tunnel construction.

At the intake site where the water will enter the tunnel above Niagara Falls, preparatory work to disassemble and remove the Tunnel Boring Machine (TBM) continues. In the coming months, all of the TBM parts will be removed and most will be scrapped. The TBM cutterhead will be preserved, and discussions have begun to determine the best location to display all or part of the cutterhead.

At the other end of the tunnel, workers are busy building the concrete outlet structure that will incorporate the emergency closure gate and will provide a smooth transition for the water flowing out of the tunnel and into the canals that feed water to the Sir Adam Beck hydroelectric stations. This massive structure will be made from reinforced concrete. Workers are now building the structure formwork, installing the rebar and pouring concrete. When completed the outlet structure will be approximately 30 m long, 20 m wide and almost 40 m high.

Inside the tunnel, work continues on the upper two-thirds of the permanent liner, tunnel crown restoration, and grouting. Installation of the upper two-thirds of the permanent liner has progressed to beyond 3.6 km. The tunnel crown restoration is an operation that involves installing rock bolts, wire mesh, and concrete to restore the area at the top of the tunnel, where excess rock broke away during the tunnel mining. This work has progressed to just beyond five km.

On July 2 about 1,000 cubic metres of shotcrete, steel ribs, wire mesh and loose rock fell from the tunnel crown at about six km from the outlet portal. There were no workers in the area at the time and no one was injured. Under order by the Ministry of Labour, STRABAG (the constructor) immediately restricted access to the affected area in the tunnel and began an investigation into the cause.

The investigation, by STRABAG's engineering consultants, identified the cause as a unique geotechnical condition that does not occur at other locations along the tunnel route. A thin layer of relatively brittle Power Glen shale in the tunnel crown buckled under the high horizontal stress and overloaded the rockbolts. Ongoing surveys to monitor convergence (inward movement of the surrounding rock into the tunnel excavation) will permit STRABAG to identify any other areas of concern along the tunnel and reinforce the initial support (with more or longer rockbolts, additional shotcrete, etc.) to prevent another similar incident. STRABAG's plan to repair the affected area is under review by the Ministry of Labour.

As a result of the July 2 incident, work on the invert concrete (lower one-third of the tunnel lining) has been temporarily stopped until remedial work at the fall of ground is completed.

#### **May 13, 2011 Update**

Big Becky breaks through. View the [news release](#), [video](#) and [photos](#) online.

#### **March 24, 2011 Update**

Big Becky, the world's largest tunnel boring machine is almost finished her 10.2 kilometre journey beneath the City of Niagara Falls.

Becky will now stop mining until she mines her last few metres at an event to be held in late April. Other work on the tunnel, including placement of the concrete liner continues.

Attached are first of kind videos of Becky as seen from the other side of the cutter head ([http://www.youtube.com/watch?v=\\_QBHEZysPUM](http://www.youtube.com/watch?v=_QBHEZysPUM)). The shots are taken from what's known as a "grout tunnel". This 300 metre section was built for safety reasons prior to the start of construction. It was constructed using traditional blasting methods. Since the end of the tunnel is under the river, this tunnel allowed crews to seal any fissures in the rock and prevent leakage.

### **March 8, 2011 Update**

Big Becky is nearing the end of her 10.2 km journey - it is expected that the mining will be completed in April. On March 1 the TBM reached a significant milestone, entering the home stretch - a "grout tunnel." The grout tunnel is the upper portion of the tunnel and was previously excavated using drill and blast methods.

While the mining is almost done, the finished tunnel will not be complete until 2013. It is expected that over 400 workers will be employed over the next couple of years, completing the concrete lining of the tunnel and working on the intake and outlet structures. Work to install the concrete lining has also been underway since December 2008. The concrete work on the bottom one third has progressed beyond 6.7 km. Work on the top two thirds of the tunnel lining, which began in May 2010, has progressed more than 1.8 km.

### Cost

As at December 31, 2010 the project has cost \$880 million against a budget of \$1.6 billion. With the TBM breakthrough in April, the risks on the project are diminishing and our confidence in improving upon the approved cost and the December 2013 completion date will increase.

The person at home paying the electricity bill is primarily interested in the cost to them. There is no cost to consumers now, and our estimates show the tunnel will add less than 50 cents to the average monthly bill. This will ultimately be decided by the Ontario Energy Board once the project is completed.

Even with this increase we still have a project that is the lowest cost new Hydro development opportunity for OPG.

### Comparing the 1950s construction to the new Tunnel

We recently received a question about the differences between the two Niagara tunnels built in the 1950s and the third tunnel currently under construction. There are major differences:

- While slightly larger in diameter (15.5 m vs 14.4 m), the 1950s tunnels were, at 8.5 km, shorter than the new 10.2 km tunnel.
- The 1950s tunnels (1951-1954) were excavated using drill and blast methods and caused considerable disruption in the City of Niagara Falls. The environmental approvals for the new tunnel required that it be excavated using a tunnel boring

machine. As a result there has been very little disruption in the City of Niagara Falls.

- In the 50s, there were 5 access shafts spaced along the tunnels, and the excavated rock was trucked through the city. Today there is one route for the rock and the workers i.e. at the tunnel outlet on OPG property. The excavated rock is transported underground by conveyor belt and deposited on OPG property.
- In the 50s, the concrete was delivered through about 100 drop holes along the tunnel route through Niagara Falls. Today, while some of the concrete will be delivered through three drop holes along the 10.2 km route, most of the concrete goes in through the outlet which is located on OPG property near the Sir Adam Beck generating stations.
- In the 1950s, safety was not front and centre. Conflicting records indicate, sadly, that between 8 and 20 workers died as a result of accidents building the 1950s tunnels.

Today, safety is top priority. When the project encountered challenging rock conditions, work was slowed down so that the mining could continue safely. As a result there have been no life threatening injuries suffered by workers building the new Niagara Tunnel. The contractor's safety record continues to be much better than Ontario's heavy construction industry average. Since the start of construction, workers on site have logged more than 4.2 million hours and, in 2010, they worked more than 1 million hours without a lost time accident.

#### **December 30, 2010 Update**

Big Becky, the tunnel boring machine (TBM), resumed normal operations yesterday after crews successfully repaired a steel support beam that developed a crack earlier this month. Becky was restarted December 27 and over the last two days the equipment was tested and recommissioned.

Becky began an unplanned outage on Friday, December 3 to repair the beam. By advancing the timing of a maintenance outage the overall impact to schedule is expected to be minor and within contingencies. The TBM had progressed past the 9.1 km mark of its 10.2 km route when mining was stopped. Other work on the tunnel continued during the mining outage. The arch concrete (upper two-thirds of the tunnel lining) has reached the 1.2 km point. Work on the invert concrete (lower one-third of the permanent lining) also continued and has now advanced over 6.6 km.

Contractor crews recently passed a safety milestone of working 1 million hours on the project without a lost time injury. This is a significant safety achievement, and the project safety record continues to track better than the industry average.

Becky is roughly five stories high, 150 metres long, and weighs about 4,000 tonnes.

#### **December 6, 2010 Update**

The TBM, Big Becky, began an unplanned outage on Friday, December 3 to repair a steel support beam that developed a crack earlier that day. Work to assess the repairs to the beam began quickly over the weekend. By advancing an outage planned for later in the month, the overall impact to schedule is expected to be minor and within contingencies. The TBM had progressed past the 9.1 km mark when mining was stopped. Other work will continue as the welding and flange re-

enforcement on the TBM progress.

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On Thursday, December 2, a significant milestone was achieved on the arch concrete (upper two-thirds of the tunnel lining) when it reached the 1 km point. Work on the invert concrete (lower one-third of the permanent lining) also continues and has now advanced over 6.4 km.

### **November 17, 2010 Update**

Installation of the tunnel concrete lining is well underway. Concrete lining work is expected to continue until the autumn of 2012. The bottom portion of the tunnel concrete, the invert, has progressed over 6.1 km along the tunnel. The arch lining, in the upper two-thirds of the tunnel, is constructed in 12.5 m long sections and, to date, about 900 m has been completed. (You can view the tunnel lining video on the right hand side of this page.)

The ongoing profile restoration process uses steel reinforcements and shotcrete to fill the area where loosened rock in the tunnel crown (overbreak) had to be removed. This work has now advanced about 3 km along the tunnel.

The Tunnel Boring Machine (TBM) is currently about 8.9 km along the 10.2 km route. (about 65 m below the ground surface near the retired Toronto Power generating station.)

With favourable rock conditions and almost no crown overbreak, the TBM has advanced 1.2 km since our August update. Geology at the TBM now includes the Reynales, Neahga, Thorold and Grimsby formations.

### **August 16, 2010 Update**

Concrete work is now underway on the final stage of the permanent tunnel lining (the arch lining in the upper two-thirds of the tunnel). It is one of the last major operations required to complete the tunnel. This work is expected to continue until the autumn of 2012. The concrete lining is poured in 12.5 m sections and, to date, 275 m has been completed since this work began in late May. See a [photo of the lining](#) in image gallery.

The bottom portion of the tunnel concrete lining, the invert, has progressed more than half way along the tunnel. Work on the invert concrete was halted in July to make way for the construction of a ventilation shaft. The ventilation shaft, which was drilled from the surface to the tunnel, will provide a second fresh air supply during construction of the tunnel. Work on the invert concrete resumed in August and about 5.3 km is now complete.

When the Tunnel Boring Machine, Big Becky, was moving through difficult rock conditions, loose rock, called overbreak, was removed from the crown (top) of the tunnel, leaving a gap that must be filled. The gap is now being filled using steel reinforcements and shotcrete. This work, called profile restoration, has advanced over 2 km along the tunnel.

In early May, the Tunnel Boring Machine (TBM) was taken out of service for a planned overhaul. During the two month outage, crews replaced the TBM steering bearing, overhauled the TBM propel cylinders, overhauled one TBM gripper cylinder (the grippers hold the TBM as the cutterhead excavates the rock), and overhauled the TBM rock drills. The time was also used to launch the arch concrete operation and relocate the tunnel conveyor booster station, increasing power to the conveyor that removes excavated rock from the tunnel.

This outage work was completed in late June. With the change in tunnel alignment, improved rock conditions and minimal crown overbreak, the TBM has advanced more than 800 m since that time, and is now more than 7.7 km along the 10.2 km route.

### **July 15, 2010 Update**

In the two months since our last project update, concrete work started on the final stage of the 600 mm permanent tunnel lining – the arch lining in the upper two-thirds of the tunnel. Sometimes called “the beginning of the end,” because it is the last major operation required to complete the tunnel, this work is expected to continue until the autumn of 2012. The concrete lining is poured in 12.5 m sections, and about 200 m has been completed since this work began in late May.

The bottom portion of the tunnel concrete lining, the invert, has progressed about half way along the tunnel. Work on the invert concrete has been halted for a few weeks to make way for the construction of the ventilation shaft, and it is expected to resume in August. The ventilation shaft, being drilled from the surface to the tunnel, will provide a second air fresh supply during construction of the tunnel.

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This outage work was completed in late June and Big Becky has resumed boring the tunnel.

With the change in tunnel alignment, improved rock conditions and minimal crown overbreak, the TBM has now progressed more than 7 km along the 10.2 km route.

### **May 14, 2010 Update**

Since the last update on March 1, 2010 the concrete lining of the tunnel invert (bottom one third) continues to progress and 4.8 km of the 10.2 km tunnel length has been completed. Tunnel crown profile restoration work (to fill areas where loosened rock

over the tunnel has been removed) is continuing and more than 1.3 km has been finished.

The work on the arch (upper two thirds) of the tunnel is also progressing. The first of the two 12.5 m long arch concrete form carriers was moved into the tunnel on May 11 and the first placement of arch concrete is expected by the end of May. As well, installation of the waterproof membrane in the arch began in April.

Work has resumed on the reinforced concrete intake structure on the upstream side of the International Niagara Control Works. (The International Niagara Control Works controls scenic water flow over the Falls in accordance with the 1950 Niagara Treaty.)

Big Becky, the tunnel boring machine (TBM), has advanced over 830 m since March 1st and is now at the 6.9 km point, below Stanley Avenue near Robinson Street. It set a new daily advance record of 25.46 m on May 1. On April 27th Strabag's tunnel crew responded to a small equipment fire about 5.3 km along the tunnel. Emergency procedures were followed, and no one was hurt. Despite the fire, the TBM set a new weekly advance record of 136.29 m during the period from April 26 to May 2.

On May 3rd a planned tunnel boring machine maintenance outage began. The ongoing maintenance, which will continue to late June, includes replacing the TBM trunion (steering) bearing, replacing one TBM propel cylinder, overhauling one TBM gripper cylinder (the grippers hold the TBM as the cutterhead excavates the rock), overhauling the TBM rock drills, extending the tunnel conveyor belt and moving the arch concrete form carriers into the tunnel.

### **March 1, 2010 Update**

Since our last update in December 2009, Big Becky, the tunnel boring machine (TBM), has progressed over 500 m and is now beyond the six kilometre point on its 10.2 km journey beneath the City of Niagara Falls. Currently, Big Becky is operating about 90 m below Stanley Avenue just south of Highway 420. Following the new tunnel route, with improved rock conditions, TBM progress averaged more than 11 m per day in February.

A lot of very interesting work is currently in progress at the tunnel outlet where about 20 workers are busy assembling the equipment needed to install the arch lining. This equipment will be about 450 m in length and will be used to construct the concrete lining in the top portion, the arch, of the finished tunnel. The arch carrier "train" also includes equipment needed to install the waterproofing membrane (a flexible, impermeable material that prevents fresh water in the tunnel from leaking into the surrounding rock).

When completed, the tunnel lining will consist of a layer of shotcrete, installed at the time of boring, a waterproofing membrane and a permanent concrete liner made of unreinforced, cast-in-place, concrete about 600 mm thick. The permanent liner is being installed in two stages, the invert (bottom one-third) first, and then the arch (upper two-thirds) several months later. Construction of the arch lining is scheduled to begin this spring.

The invert liner (bottom part of the finished tunnel) is progressing very well, and crews are now beyond the four kilometre mark – an advance of 775 m since our December

21 update. The [photo gallery](#) has pictures showing installation of the waterproof membrane and the invert concrete lining.

Work on the intake structure, located at the International Niagara Control Works (INCW), about 2 kilometres upstream from the Horseshoe Falls, was suspended for the winter and will resume in the spring. Later this year, well in advance of Big Becky's arrival, workers will build the reinforced concrete intake structure within the cofferdam and rock cut on the upstream side of the INCW.

### *Facts About the Arch Carrier*

- One of STRABAG's subsidiaries, BMTI, designed the arch carriers and another STRABAG subsidiary, BAYSTAG fabricated the arch carriers in their Ravensburg, Germany facility.
- BAYSTAG fabricated the steel components in Europe and shipped them to Niagara Falls in many shipping containers.
- About 20 people are assembling the carrier at the Niagara Tunnel Site.
- The arch carriers move along ledges cast in the invert concrete. Electric motors on each carrier leg drive the wheels that ride along the ledges. Operators will use portable controls to move individual carriers.
- Many of the carriers are used to disconnect the ventilation duct and conveyor from the tunnel crown shotcrete, route these through the other carriers and then reattach the ventilation duct and conveyor to the new concrete liner.
- One carrier is specifically for rolling out, joining and testing the impermeable membrane.
- Two carriers have the two 12.5m long arch shutters (steel forms) used to hold and shape the concrete for the upper two-thirds of the permanent concrete liner.
- Other carriers have passing lanes and parking for off-loading and pumping the concrete into the forms.
- Typically, the whole arch concrete train will advance up to 25 m per day to facilitate placement and curing of 25 m of arch concrete lining per day.
- In total, the arch carrier train is about 450 m long, about 12 m high and weighs about 1,800 tonnes.

### **December 21, 2009 Update**

Following the completion of a planned outage on The Tunnel Boring Machine (Big Becky) and conveyor, and the delays caused by the fall of Queenston shale and a small portion of the tunnel liner on September 11, the Tunnel Boring Machine (TBM) resumed operation on Dec. 8. Since restarting, the TBM has advanced 39m and is now at the 5,457m point, more than half way through the 10.2 kilometre journey.

Outage maintenance included TBM cutterhead repairs, modifications to the dust filters and ventilation ducts, repair of the excavated material conveyors and general maintenance on the other tunneling equipment.

The invert concrete (bottom of the finished tunnel) is now being installed and has advanced over 3,000 m. It is ahead of the target schedule.

Assembly of equipment that will be used to install the tunnel arch (roof) is ongoing.

Work on the intake structure, located at the International Niagara Control Works, about 2 kilometres upstream from the Horseshoe Falls also continues as planned.

#### **November 11, 2009 Update**

Since our last update work has been completed to repair the 25 metre section of the tunnel liner roof that failed. In addition, to further enhance worker safety, wire mesh is now being added below the tunnel crown shotcrete in areas of greater overbreak. Tunnel boring was halted at the 5.4 km point, in September, until tunnel repairs could be completed.

Throughout the past several months work has progressed on the bottom portion of the permanent tunnel, and the liner is well ahead of schedule. Work on the intake structure concrete placement is proceeding as planned.

The Tunnel Boring Machine and conveyor maintenance work that was scheduled to begin in September is now underway. Once this outage is complete, in December we expect the tunnel boring machine to resume digging where it left off in September. The project is on target to meet the revised schedule.

Safety continues to be the number one priority and close attention to safety has paid off. There have been no significant injuries on the project. In fact, the safety record of the contractor is nearly three times better than the construction industry average.

For context, safety has come a long way in the 55 years since the Sir Adam Beck tunnels, and Beck II plant were completed. As many as 20 people were killed on that project, 6 in the 10 months between April 1952 and February 1953. A 30 bed on site hospital was staffed by 2 full time doctors, and 4 full time nurses and treated upwards of 1,600 injuries.

#### **September 17, 2009 Update**

Further to the news release from Friday, September 11, which reported Strabag engineers were working with staff from the Ontario Ministry of Labour to determine a path forward on the fall of Queenston shale and a small portion of the tunnel liner:

- Strabag has informed OPG that the Ontario Ministry of Labour has accepted Strabag's remedial plan to repair the affected area.
- Repairs to the affected area of the tunnel have started.
- To minimize schedule impacts, the maintenance outage that was scheduled to begin in late September has been advanced, and work is now in progress to perform scheduled maintenance on the conveyor system, trucks and trailers and other equipment.
- At this time this is not expected to have an impact on the timing and cost of the project.
- Work required to install the permanent concrete liner continues.

Safety remains the top priority on this project which, when complete, will enable OPG to generate an additional 1.6 billion kilowatt-hours of clean, renewable electricity from the Sir Adam Beck Complex.

[September 11, 2009](#)

Strabag News Release: Work Resumes on Niagara Tunnel Project

[May 22, 2009](#)

2009 First Quarter Financial Results: Ontario Power Generation Releases New In-Service Dates for the Niagara Tunnel Project

[September 5, 2006](#)

Big Becky Begins Boring Under Niagara on September 1, 2006

[August 8, 2006](#)

Ontario Power Generation is Digging for Electricity

[September 14, 2005](#)

Ontario Power Generation Begins Niagara Tunnel Project

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