

Coxwell Sanitary Trunk Sewer Emergency Repair: By-pass Sewer Tunnel Construction Final Report

Date:	July 28, 2014
To:	Public Works and Infrastructure Committee
From:	General Manager, Toronto Water
Wards:	Ward 29
Reference Number:	P:\2014\Cluster B\TW\pw14011

SUMMARY

This report summarizes the work undertaken to complete the construction of the permanent by-pass tunnel around the damaged section of the Coxwell Sanitary Trunk Sewer (CSTS), including a summary of work completed since the last update report to the March 19, 2013 Public Works & Infrastructure Committee meeting.

A detailed breakdown of all costs incurred associated with this project is also provided; and shows that the total cost incurred for the construction of the by-pass tunnel was \$29,596,823 (net of GST/HST), less than the original contract award of \$31,229,500.00 (net of GST/HST). Due to the severity and extent of damage to the old sewer, an additional cost of \$2,458,140 was incurred to fill the abandoned section of the CSTS; and grouting of the disturbed soil and voids which surrounded the damaged section of the old sewer.

The total cost for professional engineering, legal, and construction services to perform the necessary emergency works required as a direct result of the damaged CSTS, total \$40,228,929 (net of GST/HST). Federal Infrastructure Stimulus Funding of \$9,659,072 was received and helped offset some of the cost to the City.

RECOMMENDATIONS

The General Manager, Toronto Water, recommends that:

1. The Public Works & Infrastructure Committee receive this report for information.

Financial Impact

There are no financial implications resulting from receipt of this report.

DECISION HISTORY

City Council at its meeting of January 27 and 28, 2009, authorized the General Manager, Toronto Water, to retain the various professional and engineering consultants and to procure the various goods and/or services to undertake the engineering design and the construction of physical works to support the implementation of emergency works necessary to address the damaged section of the CSTS. The General Manager was also authorized, subject to certain conditions, to negotiate, and execute on behalf of the City the terms of these agreements with such consultants. A copy of the Council Decision Document can be found at: <http://www.toronto.ca/legdocs/mmis/2009/cc/decisions/2009-01-27-cc30-dd.pdf>

At the May 20, 2009, Public Works & Infrastructure Committee meeting the General Manager, Toronto Water, presented an information report providing an update on the progress made in contingency planning, activities and various options being considered in advancing the work required to address the damaged section of the CSTS. A copy of the report can be found at: <http://www.toronto.ca/legdocs/mmis/2009/pw/bgrd/backgroundfile-21457.pdf>

At the October 6, 2009, Public Works & Infrastructure Committee meeting the General Manager, Toronto Water, presented a follow up information report on the progress made on the various activities being undertaken to address the damaged section of the CSTS and the selection of a by-pass tunnel as the permanent solution. A copy of the report can be found at: <http://www.toronto.ca/legdocs/mmis/2009/pw/bgrd/backgroundfile-23800.pdf>

At the May 18, 2010, Public Works & Infrastructure Committee meeting the General Manager, Toronto Water, presented a report on the progress made on the various activities being undertaken to address the damaged section of the CSTS, and the contract award for the by-pass sewer tunnel. A copy of the report can be found at: <http://www.toronto.ca/legdocs/mmis/2010/pw/bgrd/backgroundfile-29782.pdf>

At the May 16, 2012, Public Works & Infrastructure Committee meeting the General Manager, Toronto Water, presented a report on: progress made in the construction of a permanent by-pass tunnel around the damaged section of the CSTS; challenges experienced during construction that have delayed completion of the project; and emergency measures implemented to mitigate the impacts in the event of a partial or complete failure of the CSTS prior to completion of the permanent by-pass construction. A copy of the report can be found at: <http://www.toronto.ca/legdocs/mmis/2012/pw/bgrd/backgroundfile-46923.pdf>

At the March 19, 2013, Public Works & Infrastructure Committee meeting the General Manager, Toronto Water, presented a report on: progress made in the construction of a permanent by-pass tunnel around the damaged section of the CSTS, including the successful installation of connections between the new by-pass tunnel and the CSTS so as to divert flow around the damaged section of the CSTS and thereby eliminate much of the risk that necessitated this project; challenges experienced during construction that have delayed completion of the project; and emergency measures implemented to mitigate the impacts in the event of a partial or complete failure of the CSTS prior to completion of the permanent by-pass construction. A copy of the report can be found at: <http://www.toronto.ca/legdocs/mmis/2012/pw/bgrd/backgroundfile-46923.pdf>

ISSUE BACKGROUND

During an October 2008 inspection of the CSTS, significant damage was found to about 60 metres of pipe located beneath Barbara Crescent, north of the intersection of Coxwell Avenue and O'Connor Drive. While the initial inspection, as well as subsequent additional inspections, of the sewer showed that it was working as it should, with no backups or flow restrictions, the severity of the observed distress was such that the potential for blockage, or collapse, of the sewer could not be ruled out should there have been further deterioration.

As reported to Public Works & Infrastructure Committee on October 6, 2009, staff explored and evaluated a number of temporary and permanent by-pass options while also continuing to monitor the status of the CSTS. Given the associated site constraints, high flow conditions, and timelines and costs, it was concluded that temporary measures or internal repairs were not feasible and that a permanent by-pass tunnel around the damaged section of the CSTS, extending from about the confluence of the Don River and Taylor-Massey Creek to the intersection of Coxwell Avenue and O'Connor Drive, should be designed and constructed as expeditiously as possible. A design-build approach was selected to reduce the delivery schedule by overlapping the design and construction phases of the by-pass. The consulting engineering firm Hatch Mott MacDonald (HMM) was retained, through a competitive process, as the Owner's Engineer, to act as an agent on behalf of the City, to prepare a preliminary design for the by-pass, and to administer the design-build contract.

In parallel, work also proceeded, on an emergency basis, on the implementation of monitoring programs to detect changes in the condition of the CSTS, and on measures to control the discharge of sewage and help mitigate the environmental impacts in the event the CSTS were to collapse.

COMMENTS

The following summarizes the construction of the by-pass tunnel and provides an update on the construction activities completed since the last report (March 2013) and some of the challenges experienced during this period.

As reported on May 3, 2010, a design-build contract was awarded to McNally Construction Inc. (McNally) on February 26, 2010, in the amount of \$31,229,500.00 (net of GST/HST). McNally began detailed design immediately upon contract award and began construction on April 9, 2010.

The three basic components of the permanent by-pass construction have now been completed (refer to Figures 1, 2 and 3) and consist of:

- i) Entry Shaft: 10 metres deep located in Taylor Creek Park and represents the site where a tunnel boring machine (TBM) was launched and where a permanent diversion connection was made to the existing CSTS (i.e., the upstream connection point);
- ii) Tunnel: 510 metres of segmental concrete-lined 2.7 metre diameter tunnel which by-passes the damaged section of the CSTS; and
- iii) Exit Shaft: 42 metres deep located at the northwest corner of the intersection of Coxwell Avenue and O'Connor Drive, and represents the site from which the TBM was retrieved and where the permanent connection was made to the existing CSTS (i.e., the downstream connection point).

The schedule, contained in McNally's design-build proposal, indicated that construction of the By-pass was to be completed by January, 2011. While the noted Tunnel component of the By-pass and virtually all the work that could be completed at the Entry Shaft was completed in 2011, construction was hampered at the Exit Shaft. The entire project was delayed due to numerous unforeseen construction difficulties (site conditions, mechanical issues, and safety concerns) and challenging ground conditions at the Exit Shaft location. The ground at the base of the Exit Shaft where the existing CSTS lies consists of fine-grained sand/silty-sand in a pressurized aquifer. Excavation in this layer without adequate ground control measures could have resulted in an uncontrolled flow of these sands, which could trigger ground subsidence above. Extra time and precautions were taken during construction at this location due to its close proximity to the damaged section of the CSTS, and to existing homes and infrastructure. The details of such difficulties were reported to the Public Works and Infrastructure Committee on May 16, 2012 and on March 19, 2013.

Construction of all components of the by-pass tunnel were completed on February 1, 2013. The live connections from the old sewer to the new by-pass tunnel were made, at the Entry Shaft and Exit Shaft, respectively, February 21, 2013, thereby diverting the sanitary flow from the damaged section to the new by-pass tunnel.

Update on Additional Activities

Construction

Although the risk of environmental damage had been averted by the completion and operation of the by-pass tunnel, there was still a risk to the community and infrastructure above (e.g., sudden ground subsidence, sinkhole, etc. from a collapse of the damaged pipe). Mitigation of this risk required implementation of two measures. Firstly, the abandoned (by-passed) pipe had to be filled in order to prevent future collapse and, secondly, the ground surrounding the damaged sewer required consolidation in the event that the ground had been significantly disturbed.

The original plan was to issue a separate construction contract, once the by-pass sewer construction was completed, to probe and grout to fill any voids surrounding the sewer that may have resulted from deformation of the damaged sewer from within the de-commissioned tunnel (so as to minimize disruption at the surface along Barbara Crescent); and to stabilize the old section of sewer once a full assessment of the extent and severity of the damage had been completed, and an appropriate method to stabilize the old sewer was developed.

Immediately following the completion of the connections between the new by-pass tunnel and the CSTS (i.e., once the by-pass tunnel was operational) a thorough visual inspection and instrument survey of the damaged section of the CSTS was undertaken.

The inspection of the damaged section of the old sewer revealed conditions worse than those revealed through earlier closed circuit television (CCTV) and sonar inspections (refer to Figures 4, 5 and 6). Cracking and spalling of concrete was more widespread, and active infiltration of groundwater and fine sand was evident. Further, at the point of maximum damage, the crown of the sewer had dropped 1.05 metres while the invert had dropped 0.82 metres. This level of distortion was far in excess of that revealed by the earlier inspections, and reinforced the professional opinion we received, from the outset, that collapse of the sewer was possible and immediate action was required.

Further, due to the groundwater and sand infiltration, it was deemed necessary to fill the abandoned section of sewer as expeditiously as possible in order to eliminate such infiltration, and mitigate the risk of ground subsidence which could result from a collapse of the damaged section. Given the extent and severity of the damage observed, and risk it represented for ground subsidence, McNally's scope of work was expanded to include stabilizing the old sewer and compaction grouting the ground around the old sewer, as expeditiously as possible.

The entire length of the abandoned section of sewer (approximately 360 metres) was completely filled, to prevent the entry of water and silt over time, in two stages. The first stage used self-compacting concrete, because of its shorter lead time, to fill and stabilize the damaged segment of sewer (approximately 80 metres in length) and was completed on March 23, 2013. The second stage used cellular grout, because of its lower unit cost, to fill the remainder of the abandoned sewer, and was completed on May 30, 2013.

Ground consolidation was to be carried out via a process known as compaction grouting, whereby cementitious grout is pumped into holes at a pressure sufficient to force the grout into the loose, disturbed ground, and/or voids (but not enough to cause significant ground heave). McNally was instructed to obtain competitive quotes from two qualified subcontractors prior to authorizing the compaction grouting work, due to the high value of this additional work. Once detailed plans were developed for the compaction grouting work by HMM, licenses to drill and grout on private property negotiated, and utility locates performed, the grouting program began on August 6, 2013. Drilling and grouting took place at 39 strategically-placed locations so as to ensure overlap of grouted zones within the ground layer of fine-grained, sand/silty-sand, as well as complete coverage over the area where ground settlement was observed. Compaction grouting was completed on October 30, 2013. A total of 310 cubic metres of grout was injected into the ground (this is the equivalent of approximately 40 concrete mixer trucks) validating the need for grouting as well as the emergency nature of this project. HMM concluded in a final report that "... *the risk of surface ground movement caused by a collapse ... has therefore been completely mitigated*".

Work was also completed on building the permanent chambers above the by-pass connections at the Entry Shaft and Exit Shaft. This was followed by restoration at both the Entry and Exit Shaft sites, and by landscaping of the two areas. Landscaping followed plans that were developed for both sites, in conjunction with staff from Parks, Forestry and Recreation and a group of local residents. Most of the restoration and landscaping was completed in the Fall of 2013, however, a small portion (asphalt pavement and tree planting) carried over into 2014 due to weather constraints.

Monitoring Program

A comprehensive monitoring program was implemented when the damage to the CSTS was discovered, consisting of flow level, ground subsidence, and sewer condition monitoring via CCTV, to track any changes associated with the damaged CSTS, and to help provide early warning should conditions deteriorate. Flow level and sewer condition monitoring was terminated once the by-pass tunnel was made operational.

Data obtained from the ground monitoring has not indicated any large scale movement. However, a slight, gradually-increasing settlement at the surface above the damaged section of the CSTS has been observed since the monitoring program began. Such movements appear to have been arrested since completion of the compaction grouting program, however,

monitoring is continuing to ensure that conditions are indeed stable. It is anticipated that monitoring will no longer be necessary beyond the Summer 2014.

Summary of Expenditures

The following provides a summary of expenditures incurred in completing the project, detailed in the current and previous staff reports.

To date, Purchase Orders (POs), including amendments, issued for professional engineering, legal, and construction services to perform the necessary emergency works required as a direct result of the damaged CSTS, total \$40,228,929 (net of GST/HST). This amount is comprised of the following types of expenditures:

- \$32,054,963 - McNally construction contract;
- \$4,219,069 - various professional and engineering consultants;
- \$1,780,989 - insurance, legal and real estate services; and
- \$2,173,908 – implementation of works for spill control/treatment in the event of a collapse of the CSTS.

A breakdown of the works completed by McNally, at a total cost of \$32,054,963, consisted of:

- a) \$29,596,823 - construction of the by-pass tunnel;
- b) \$558,840 - filling the abandoned section of the CSTS; and
- c) \$1,899,300 - grouting the disturbed soil surrounding the damaged section of the old sewer.

It should be noted that only item a) was included in McNally's original base scope of work, represented by the original PO issued in the amount of \$31,229,500.00 (net of GST/HST). As noted earlier, items b) and c) were added to McNally's contract when the severity and extent of damage to the old sewer were fully realized upon inspection of the damaged section.

Federal Infrastructure Stimulus Funding of \$9,659,072 has been provided to support the construction of the By-pass.

The following summarizes the procurement of goods and services, supporting the construction of the By-pass and the implementation of emergency contingency measures, to date (net of GST/HST). Three individual POs (as noted below for items d), m) and n)) remain open at this time in order to provide services during the warranty period, which expires on June 6, 2015. Consequently, estimates are included of the costs expected to be incurred under these POs in the figures noted below. All other costs are actual final expenditures.

- a) Additional inspection to assess extent of damage - \$156,555.00 (M.E. Andrews & Associates Limited and D.M. Robichaud Associates Ltd.).
- b) Screening analysis of available options for addressing the damage - \$156,912.27 (MMM Group Ltd.).
- c) Property condition assessments and settlement monitoring above the damaged CSTS - \$909,689.36 (MMM Group Ltd. using Golder Associates as the geotechnical sub-consultant). The original PO amount of \$400,000 was amended for an additional \$300,000 in 2010 to extend the assignment during construction, and amended again for an additional \$200,000 in 2012 to account for the delays in completing construction.
- d) Geotechnical investigation, assessment of permanent relief sewer constructability, and monitoring/advice on post-construction ground movement - \$425,000^a (MMM Group Ltd.

using Golder Associates as the geotechnical sub-consultant). The original PO amount of \$500,000 was amended for an extension in time only, in 2013, to extend the assignment following completion of the compaction grouting.

- e) Preliminary design of a proposed temporary sewage by-pass pumping system - \$127,331.64 (R.V. Anderson Associates Ltd.).
- f) Inspection of other priority/critical trunk sewers in the City's system and screening of unsolicited CSTS repair offers - \$572,834.18 (Andrews Infrastructure). The original PO amount of \$290,000.00 was amended for an additional \$300,000.00 for additional inspections of the CSTS during construction.
- g) Review of alternative by-pass/treatment options - \$584,368.81 (CH2M Hill Canada Limited). The original PO amount of \$497,700.00 was amended for an additional \$40,000.00 for pilot testing of trash nets; and amended for an additional \$46,668.81 for refinement of conceptual designs.
- h) External legal services - \$309,665.39 (Borden Ladner Gervais LLP).
- i) Flow level monitoring upstream and downstream of damaged section of CSTS - \$150,864.32 (Clarifica Inc.).
- j) Expenditures for emergency measures associated with the Keating Channel \$1,300,742.05.
- k) Construction of Massey Creek Sanitary Trunk Sewer Emergency Overflow - \$240,171.43 (Utility Force Inc.).
- l) Supply of galvanized 70 ft. span portable panel bridge - \$98,349.12 (Acrow Bridges).
- m) Competitively-bid consultant assignment for preliminary design of the CSTS By-pass Tunnel, and contract administration services during detailed design and construction of the By-pass Tunnel - \$1,230,000.00^u (Hatch Mott MacDonald).
- n) Design-Build of the permanent By-pass Sewer Tunnel around the damaged section of the CSTS - \$32,054,963.25^u (McNally Construction Inc.). The original PO amount of \$31,229,500.00 was amended for an additional \$1,000,000.00, in 2013, to cover additional costs of compaction grouting and extend the assignment, and amended in 2014 for a reduction of \$600,000.00 to free-up funds no longer need for compaction grouting.
- o) Subsurface location of CSTS - \$10,185.73 (TSH/TBE Subsurface Utility Engineers).
- p) An Owner Controlled Insurance Program, implemented by the City to reduce the perceived risks of the By-pass construction, through our broker - \$1,442,748.47 in premiums paid up to December 31, 2013 (Marsh Canada Limited).
- q) Services for easement negotiation and registration related to By-pass Sewer Tunnel - \$28,574.92 (Facilities & Real Estate Division).
- r) Investigation of Don Valley Parkway bridge abutment to ensure stability due to lowered access road into Entry Shaft site - \$15,469.26 (McCormick Rankin Corporation) and \$29,600.50 (Golder Associates).
- s) Miscellaneous costs including permits, payments to property owners for construction access, archaeological review, etc. - \$383,781.06

^u Figure includes an estimate of the amount required to provide services during the warranty period or to complete finishing work.

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SIGNATURE

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General Manager, Toronto Water

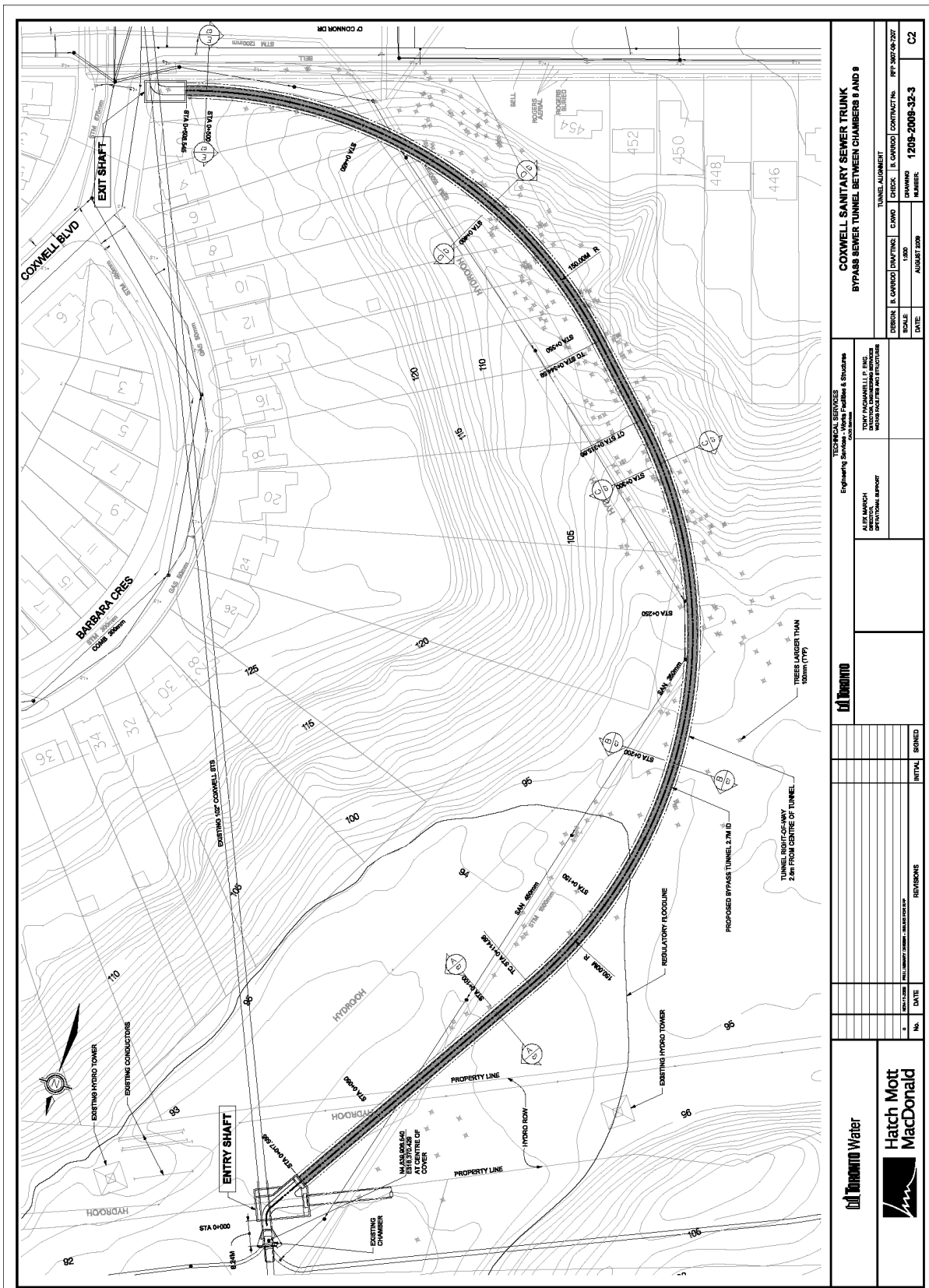


Figure 1 Schematic Diagram of Permanent By-pass Tunnel

COXWELL SANITARY SEWER TRUNK BYPASS SEWER TUNNEL BETWEEN CHAMBERS 8 AND 9			
TECHNICAL SERVICES Engineering Services - Works Facilities & Structures (Professional Engineer)		TUNNEL ALIGNMENT DESIGN: R. CARBOO DRAFTING: C.W.O. CHECK: R. CARBOO CONTRACT No.: RFP 3007-09-207 SCALE: 1:500 DRAWING NUMBER: 1205-2008-32-3 DATE: AUGUST 2009	
AS PER MATCH DRAWING CONTRACT NO. 1205-2008-32-3 PROJECT NO. 1205-2008-32-3 WORK INCLUDES AND EXCLUDES		No. DATE INITIAL SIGNED	
REVISIONS		No. DATE INITIAL SIGNED	

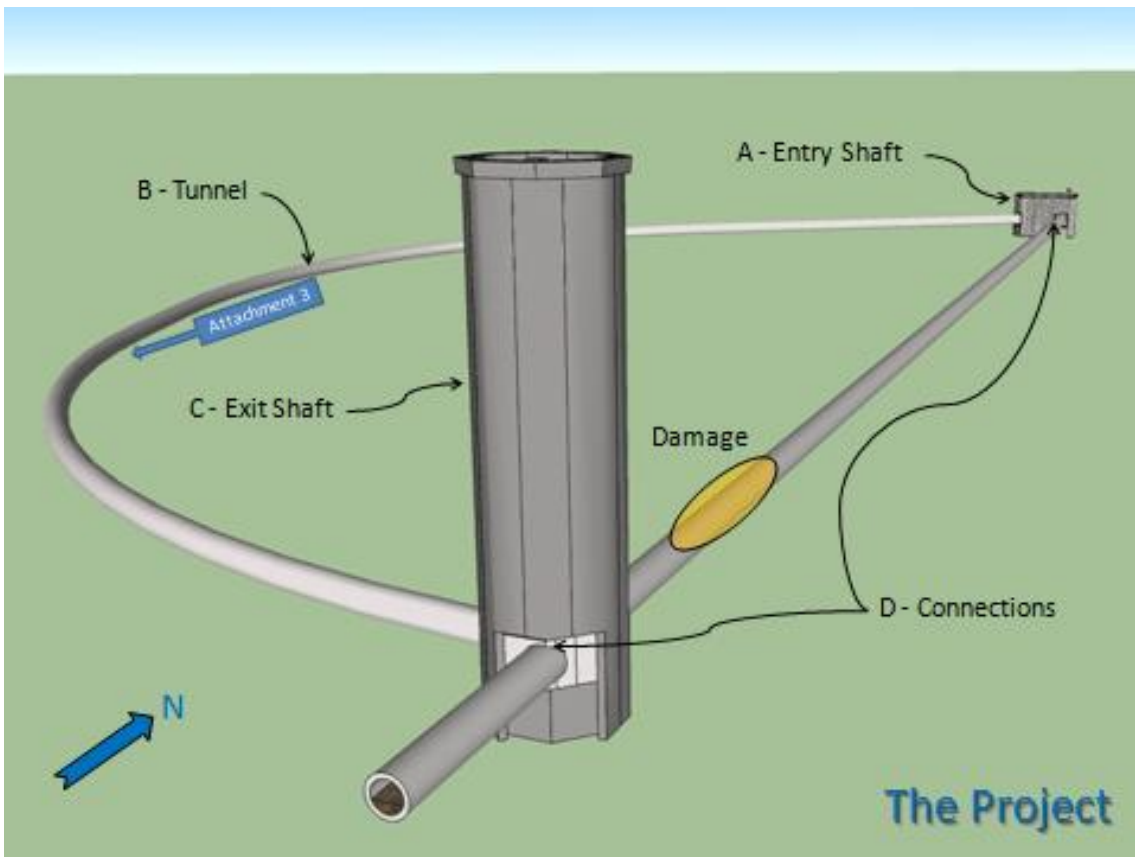


Figure 2 Three-Dimensional Rendering of the Permanent By-pass Tunnel



Figure 3 Photograph of New Permanent By-pass Tunnel



Figure 4 Photograph of damaged CSTS, showing extensive cracking and spalling of concrete.



Figure 5 Photograph of crown of damaged CSTS showing depth of spalled concrete.



Figure 6 Photograph of damaged CSTS, showing additional cracking and settlement of sewer (represented by ponding water).