EXECUTIVE SUMMARY

The Peace Bridge was inspected between July 6th to August 3rd, 2009 by engineers from Clough, Harbour & Associates of Buffalo, NY. The inspection was performed in accordance with the NYSDOT Bridge Inspection Manual, satisfying the requirements of the Uniform Code of Bridge Inspection and also satisfies FHWA requirements.

The overall structural condition of the Peace Bridge is generally satisfactory to good. During this 2009 Inspection, the bridge received a General Recommendation of "5" (out of 7) in accordance with the NYSDOT rating system. A General Recommendation rating of "5" is defined as "minor deterioration, but functioning as originally designed." Under the FHWA rating system, the bridge's superstructure and substructure both received ratings of "6" (out of 9) indicating that "structural elements are sound but may have minor section loss, cracking or spalling."

The bridge has an overall weighted average "Condition Rating" of 3.484 (again out of 7), which has decreased only slightly since 2008. The Condition Rating is a computer-generated value calculated from the inspection's individual ratings assigned for the various bridge components and is intended to be an overall indicator of bridge condition, however, this NYSDOT condition rating is somewhat misleading for large bridges in that its uses the lowest rating among all spans for each element when computing this "weighted average" score.

In general, the General Recommendation of "5" (out of 7) and the FHWA Superstructure and Substructure ratings of "6" (out of 9) best characterize the overall condition of the bridge, as there does exist some notable deterioration, located mostly in non-critical areas, as well as having some minor deterioration in the "primary members". However, these areas of deterioration do not presently have a significant affect on load capacity or on the daily operation of the bridge. The Peace Bridge's primary structural steel members and reinforced concrete substructures are functioning as intended in the original design. The overall load carrying capacity of the bridge is adequate for current legal loads, and its load carrying capacity has not been significantly reduced by deterioration or other conditions reported during this inspection.

The bridge has a National Bridge Inventory (NBI) Sufficiency Rating of 58.7%, which is relatively low, but is also somewhat misleading in that, within the Sufficiency Rating formula, the bridge does receive full value for its structural condition, but the rating is reduced, solely due to the bridge having less than standard geometrical features and also having some functional obsolescence. It should be noted that out of a possible 55% for Structural Adequacy and Safety, the Peace Bridge received 55% with no points deducted.

The majority of structural components of the bridge are generally in good condition, with nearly all deficiencies appropriately characterized as "minor" or "localized" deterioration. None of the damage or deficiencies observed during this inspection can be described as "widespread" or "severe" in nature. The bridge has minor to moderate deterioration to deck elements and superstructure steel in the typical trouble spots of the expansion joints, construction joints and along curb lines, where salt and water can leak in, or infiltrate and promote corrosion to steel and deterioration to concrete elements.

The majority of what can be characterized as "prevalent" or "widespread" damage generally occurs to **non-structural** elements of the bridge, such as the curbs, railing posts, sidewalks, catwalks and the utility lines running along the catwalk. The major structural elements of the bridge, such as the mass concrete piers, the arch ribs, truss members, main girders and floorbeams are typically in good to very good condition.

Of the structural elements, the concrete deck continues to experience the most notable salt and water damage, particularly around the expansion joints, construction joints and along both curb lines. The past two inspections have reported a noticeable increase in deck damage directly beneath the curb lines, however, this deck deterioration along its edges remains localized and cannot yet be characterized as "widespread". The deck, along with the sidewalk and the wearing surface requires continued maintenance to maintain its structural capacity. The deck has required numerous repairs and full-depth patches, which are beginning to overlap. Despite the localized salt damage and recent repairs to the deck and sidewalk, the deck is currently fully functional and remains in serviceable condition.

The structural steel on the bridge, which comprises the majority of the superstructure components, is typically in very good condition, with very little "active" corrosion, since the vast majority of the paint system, away from the joints, is still in tact and remains functional to protect against corrosion.

The inspection report documents all deficiencies on the bridge and is the basis for the bridge maintenance program. Some repairs have already been made concurrent with the 2009 inspection and other improvements are already scheduled for 2010.

As a result of this 2009 inspection, 1 Red Structural Flag was issued (*ie; immediate repair required*), and 1 Yellow Structural Flags (*ie; significant structural problems that do not require immediate repair*), and no Safety Flags (*ie; non-structural problems that affect traffic or pedestrian safety*) were issued.

Red Flag: At two separate North Curb Stringer (N.C.S.) locations in Span 20, 1 out of 2 web connection angles were completely cracked through, full height and were no longer functioning.

- North Curb Stringer (N.C.S.) on the End (American) side of FB 169.
- North Curb Stringer (N.C.S.) on the Begin (Canadian) side of FB 171.

This Red Flag was immediately repaired by Peace Bridge Maintenance welding the cracked angles, and the two damaged angles have been subsequently replaced completely and now have full capacity.

Yellow Flag: A small crack was observed emanating from the cope of the South Curb Stringer on the End (American) side of FB 142. The crack measures 7/16" and is partially attributable to reduced section due to "old" corrosion. This crack needs to continue to be monitored, and should be scheduled for repair within the next year.

In addition to the 2 Flags, the inspection did result in several other noteworthy conditions of a structural nature being observed, which are currently being addressed by the Authority maintenance staff and its consultant engineer. Each of these conditions is of a relatively minor nature such that issuance of formal "Flag Reports" is not yet warranted. A brief summary of each of the serious conditions warranting repair or further investigation in the near future is outlined below:

1. At 2 floorbeam locations (FB27 & FB28), there is significant section loss to the webs of all 16 trolley stringers (8 in Span 32 at FB27, and 8 in Span 33 at FB28) located directly under the deck joint between FB27 & FB28 (above Pier 32). The reduced web section is attributable to "old" corrosion, mostly due to "previous" joint leakage. These stringers are in relatively "short" skewed "end bays" between floorbeams and as such, many of these stringers do not experience as high of loading as most of the stringers on the bridge, but nevertheless, they potentially carry high shear forces, and these damaged webs should be considered for repair.

2. There is significant section loss, including perforations, to the webs of Curb Stringers in multiple locations, including in Span 12 (within Canadian Girder Spans), and in Spans 20, 26, & 28 (Arch Spans). The reduced section is primarily due to "previous" joint leakage, although some of the areas have some minor to moderate active corrosion. The following 9 Curb Stringers in Spans 12 and 20 have active corrosion and should be repaired or at a minimum, be continued to be monitored on an annual basis :
   - South Curb Stringer (S.C.S.) on the End (American) side of FB204 (Span 12), 1" diameter hole
   - North Curb Stringer (N.C.S.) on the End (American) side of FB173 (Span 20), 25% Loss
   - South Curb Stringer (S.C.S.) on the End (American) side of FB173 (Span 20), 1¼" diameter hole
   - North Curb Stringer (N.C.S.) on Begin (Canadian) side of FB163 (Span 20), 2 small holes
   - South Curb Stringer (S.C.S.) on the End (American) side of FB161 (Span 20), ¾" diameter hole
   - North Curb Stringer (N.C.S.) on the End (American) side of FB101 (Span 26), 41% section loss
   - North Curb Stringer (N.C.S.) on the Begin (Canadian) side of FB94 (Span 26), ¼" diameter hole
   - North Curb Stringer (N.C.S.) on the End (American) side of FB93 (Span 26), 49% section loss
   - North Curb Stringer (N.C.S.) on the End (American) side of FB79 (Span 28), 37% section loss

3. There was severe spalling with debonded reinforcement, affecting the full sidewalk width at:
   - North sidewalk at the Begin side of FB106.
   - North sidewalk at the End side of FB88.
   - North sidewalk at the Begin side of FB84.

   These locations have since been repaired under maintenance contract, subsequent to this year's field inspection.

4. The South edge of the deck is severely spalled and crumbling along the south curb stringer between FB 103 & FB 104, affecting a 9 ft. length that is at least 2 ft. wide and up to 5" deep. This location is still at a relatively minor stage of deterioration, and needs to be closely monitored during next year's inspection to determine the rate of deterioration and whether further action is required.

Each of these conditions has been added to the Authority's Maintenance List, along with other more routine maintenance tasks.

Despite periodic, localized damage occurring to deck and stringer elements, typically arising as a result of impact, fatigue, corrosion or salt & water damage, the bridge will continue to be capable of safely carrying loads for many years, with continued preventative maintenance, repairs and painting. This relatively positive forecast is in large part due to good maintenance practices over the history of the bridge. Maintenance programs on the Peace Bridge need to continue with diligence to seal out and prevent salt & water damage, prevent corrosion, and to quickly repair areas of advanced deterioration that do arise, so as to ensure safety and prolong the useful life of the bridge. Maintenance of the Peace Bridge should continue with it current emphasis of preventing salt and water infiltration by sealing the wearing surface, sidewalks, curblines and joints, and also preventing corrosion by scheduling painting programs, thereby ensuring safety and extending the service life of the bridge.

EXECUTIVE SUMMARY

This report summarizes the results of the scour investigation performed at Piers 2, 3, 4 and 5 of the Peace Bridge over the Niagara River between Fort Erie, Ontario and Buffalo, New York. The purpose of this report is to investigate and determine the possible presence of scour at the Peace Bridge river piers.

Scour is the hole left behind when sediment (silt, sand and rock) is washed away from the bottom of a river. Although scour may occur at any time, scour action is especially prevalent during flood events. Scour is also typical in waterways with swift flowing currents. Turbulent waters, such as found near irregularities in waterways, are also a major cause of scour. Swiftly flowing and turbulent waters have more energy than calm water, which can lift and carry sediment down river.

The scour investigation for Piers 2, 3, 4 and 5 was performed by Ocean Surveys, Inc (OSI) of Old Saybrook, Connecticut. The investigation was performed during the period May 24-27, 2005. The results of the investigation consist of series of river bottom elevation data points adjacent to Piers 2 through 5. This information was used to construct cross sections, contour maps, and 3-D models of the river bottom surface.

Due to the shallow water depths around Pier 6 OSI could not deploy their vessel in order to determine the presence of scour. Parsons performed visual inspections to determine riverbed conditions for locations along the pier. The observation of soil overburden at elevations above the footing indicated that scour has not occurred at Pier 6. Given the slow flowing current found at Pier 6 scour is not considered a concern along that foundation.

The conclusions of this report are based on comparison of the results stated above with the results of the 1968, 1987 and 1991 Foundation Evaluations prepared by Golder Associates of Mississauga, Ontario, as well as the original design plans for the Peace Bridge.

Based on this investigation, there is no evidence to indicate the presence of scour conditions that would adversely affect the stability of the river piers (Piers 2 through 6) of the Peace Bridge. Parsons recommends that the Peace Bridge continue to conduct underwater surveys of the river piers every 5 years (at a minimum) as established by NYSDOT. Survey methods should have the same level of, or greater accuracy for contour and elevation data collection than was currently performed.

1. Executive Summary

The Peace Bridge has served continuously for 80 years as a vital international transportation link between Canada and the United States. For some time, deterioration of the structure's reinforced concrete deck has been observed. This report addresses the condition of the structural deck and overlying wearing course. Results of a technical evaluation and recommended maintenance measures are presented.

Figure 1.1 – Peace Bridge over the Niagara River

Based on the results of the latest (2007) general inspection of the Peace Bridge, the overall structural condition of the Peace Bridge is generally good. The USDOT/FHWA National Bridge Inventory Sufficiency Rating for the Peace Bridge is 55 points out of a possible 55 points for the category of Structural Adequacy and Safety.

An evaluation of the physical condition of the bridge deck was carried out under this study utilizing non-destructive testing techniques. The evaluation consisted of a visual inspection of the wearing course and a survey of anomalies within the deck using ground penetrating radar (GPR). Due to the recent nature of these tests, this data is considered representative of existing conditions. Results of past testing including core sampling, half-cell potential method tests and laboratory tests to determine chloride ion content, compressive strength and petrographic examinations are referenced throughout this report.

In general, test results and observations indicate that the structural deck is in an overall acceptable condition. The fact that most of the original deck remains serviceable is exceptional. The density and soundness of the deck concrete are good, but the concrete is contaminated with chlorides with areas of reinforcing steel corrosion. Transverse cracks are widespread on the underside of the deck at reinforcing bar locations. These cracks are accompanied by spalls, delaminations, efflorescence, and exposed reinforcing bars indicating

corrosion of bottom mat reinforcing. Concrete cover below the bottom reinforcing steel is less than one inch in thickness in several areas of the deck, and in some areas the concrete has not been well consolidated under the bars. These conditions are less than adequate to protect the bars from deterioration. Lack of air entrainment in the original concrete makes the structural deck susceptible to freeze-thaw damage.

To date, the latex modified concrete (LMC) wearing course has performed satisfactorily. Necessary repairs of pavement breakouts have been minimal. The LMC wearing course is in generally good condition except where it is cracked. Typically, cracks are isolated and occur over floor beams. Recently, surface runoff penetration into these cracks has been reduced or eliminated by routing and sealing these cracks on a routine basis. Installation of the closed drainage system and resealing of the transverse deck cracks in 2002 have reduced water infiltration into the structural deck.

Current GPR survey results indicate no significant problems. Although areas of debonding between the LMC and structural deck and areas of delamination in the structural deck were found and confirmed under this investigation, these areas were isolated and most may not require repair in the immediate future. Proper maintenance of the LMC overlay including deck crack sealing, and repair of breakouts promptly after occurrence will insure favorable performance of the deck.

At the time of original installation the LMC overlay was expected to have a service life of 10 to 15 years with minimal maintenance. Guidelines set forth by the NYSDOT suggest that the service life of a concrete overlay constructed in conjunction with local partial or full depth repairs, similar to those performed on the Peace Bridge in 1988, have an estimated service life up to 25 years. Studies and experiences of other transportation agencies have concluded that the decline in the serviceability of the wearing surface is expected to be gradual rather than sudden and widespread. Service life of 20 years and beyond is not uncommon for LMC overlays on reinforced concrete decks. Prompt and proper maintenance is most important for extending the serviceability of the LMC wearing course and the useful life of the deck of the Peace Bridge.

Based on the annual inspection results and evaluation contained in this report, the Peace Bridge deck remains in remarkable condition for its age. It is recommended that the remaining service life of the bridge deck be extended as long as possible through maintenance and necessary repairs. The deterioration of the deck system is unlikely to accelerate suddenly during the next decade and necessitate an emergency deck replacement project. However, potholes and deck breakouts are unpredictable. If deck maintenance requirements reach the point where traffic becomes unacceptably disrupted, the replacement schedule should be accelerated.

The preparation of deck replacement studies should be considered in future years so that construction can start when needed. The outcome of the current EIS process will play a major role in determining the schedule for studies and replacement. From initiation of

design to start of construction, time must be allotted for programming funds, preparing design options, obtaining permits, preparing final plans and specifications, reviewing the construction documents, soliciting contractors, and bidding and awarding the project. It is important to remember that distress such as concrete delamination is a progressive form of failure, and the condition of the deck will continue to deteriorate while these tasks are carried out.

Deck monitoring along with diligent maintenance will help ensure the longevity of the Peace Bridge deck. Recommendations to accomplish this are included in Section 8 of this report.