Office of the Auditor General / Bureau du vérificateur général

AUDIT OF BRIDGE MAINTENANCE PROCESS FOR A SPECIFIC BRIDGE

2009

VÉRIFICATION DU PROCESSUS D'ENTRETIEN DES PONTS DANS UN CAS PRÉCIS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Introduction

The Office of the Auditor General (OAG) received through the Fraud and Waste Hotline information regarding concerns with the rehabilitation work for a bridge in the City, which deteriorated significantly after the rehabilitation work was completed in 2004. As a result of the rapid deterioration of the work completed in 2004, a second rehabilitation contract was issued in 2007 for essentially the same work as the 2004 contract.

The OAG decided to carry out, in addition to the Audit of the Bridge Maintenance Process (presented in a separate and concurrent report), an audit of the bridge reported through the Fraud and Waste Hotline. Please make reference to the Audit of the Bridge Maintenance Process for background information not contained in this report.

Background

The following information was extracted from the project files and the background information provided by the City.

The bridge is located on the Jock Trail in the former Township of Goulbourn, in Lots 9 and 10 of Concessions II and III, approximately 2.5 km east of Dwyer Hill Road and 0.5 km west of Munster Road. The Jock Trail is the road allowance between Concessions II and III.

Based on the data in the Structure Information Management System (SIMS), a plaque on the bridge, and drawings of rehabilitation works done in 1994, the bridge was designed and constructed in 1947.

The bridge is a single lane structural steel truss bridge with laminated timber deck. The bridge is 6.4 m± wide and spans 17.2 m± between supports. The bridge abutments are constructed of concrete on spread footings.

Prior to 1994, the bridge deck was a concrete deck supported on structural steel stringers and beams. In 1994, the Township of Goulbourn retained a consultant to design repairs to the bridge. The repairs comprised replacing the deck and a number or stringers and beams; reinforcing some of the steel truss members; repairs to the concrete abutments; and placing rock protection for scour prevention of the concrete abutments. The concrete deck was removed and replaced with a new laminated timber deck.

It is not clear from the 1994 drawings, but it would appear that the laminated timber deck was constructed without lateral slope to allow drainage of the deck. From the 1994 drawings it can be concluded that the bridge slopes less than 0.3% along the road.

In August 2004 the timber deck failed and was replaced. In 2007, the timber deck installed in 2004 was also replaced.

Audit Objectives

Audit Objective #1: Examine and evaluate the studies, designs, processes and methodologies pertaining to the design and construction of the 2004 and 2007 bridge deck repairs.

Audit Objective #2: Determine whether the studies, designs, processes and methodologies are consistent and compliant with all relevant policies, procedures, legislation and regulations

Audit Scope

The scope of the audit comprised the overall City processes used for the maintenance of the subject bridge, including the bridge inspections, bridge database, methodology used for assigning maintenance priority, bridge rehabilitation processes, and bridge rehabilitation contract oversight and control.

It is important to note that the audit did not include a physical inspection of the structure and the condition of the structure was not confirmed during the audit.

Findings

The 2004 design assignment was deficient as follows:

1. In 2004, the consultant did not investigate the reasons why the deck failed, although the Infrastructure Management Senior Engineer noted in an email dated August 17, 2004 that the deck drainage was inadequate, as evidenced by staining indicating ponding on the deck. The Senior Engineer noted that: "The breaks have all occurred on the driver side eastbound lane. Staining on the underside of the deck indicates that water may be ponding along the centreline of the bridge and weakening the decking under the driver's side wheels, i.e., closest to the centreline". The consultant did not consider lack of drainage and the effect of moisture on the timber as a potential cause of the deck failure.
2. The 2004 design was carried out without an adequate field survey of the structure, which would have disclosed that the stringers were not at the same level.

3. The 2004 consultant did not take into account in the design that the timber deck placed in 1994 had been levelled with steel plates (shims). As a result, the contract documents did not make provision for the shims and they were included as an extra to the contract. Consequently, the City had to pay the contractor a higher cost for the supply and installation of the shims than if the shims had been included in the contract documents. If the shims were indeed required, the contract documents should have included the shims, including specifications and details.
4. The site instruction issued by the consultant recommending that shims be used to level the deck did not provide specifications or details for the shims. Management advise that the shims were restrained on the interior stringers by nailing plates that extended from the wood deck to the stringers on both sides of the shims, and they consider that there was no need to make a physical connection of the shims. The consultant should have provided a detail requiring that the shims be affixed to the bridge beams to prevent the shims from moving. In fact, the 2007 deck replacement drawings provide several details for the connection of the shims to the deck and the steel stringers.
5. The design of the deck in 2004 did not provide cross-fall to provide drainage of the deck. Poor drainage results in ponding of water on the deck, which contributes to the premature failure of the timber deck. Moisture is a significant factor in deterioration of wood structures, and efficient removal of water is essential to prevent premature damage to wood. The fact that the November 2005 inspection of the timber deck showed rotting of some of the timber in the deck indicates that the moisture problem was severe. The consultant should have made provisions for moisture control in 2004. In fact, in the 2007 design, the same consultant recommended adding waterproofing and a wearing surface to the timber deck to reduce moisture in the deck.
6. The additional stringers recommended by the consultant were added as a precaution against heavy axle loads, but their need was not fully justified by the consultant during the design work. The stringers were not required because the structure was posted as "No Trucks" after the 2004 contract.

Construction of the 2004 contract was deficient as follows:

1. The shims used to level the timber decking were not attached to the top flanges of the stringers. Lacking a detail provided by the consultant, the carpenter used nailing plates that extended from the wood deck to the steel stringers on each side of the shims. This method of restraint was not adequate, as evidenced by the subsequent vibrations, excessive noise and excessive displacements of the timber deck. In fact, the 2007 deck replacement drawings show details to connect the timber deck, the shims, and the steel stringers together.

2. The shims were constructed of plain steel, which rusted very quickly. As a minimum, the shims should have been galvanized. It is noted that the consultant site instruction specifies galvanized shims and the Inspector's notes also indicate the shims were galvanized. This discrepancy would indicate that the Inspector did not notice that the shims were not, in fact, galvanized.
3. The contractor had the carpenter provide and install the steel shims, although a carpenter is not qualified for structural steel work. The shims should have been provided and installed by the structural steel sub-contractor.
4. The actual cost of construction was $90,225, which is $31,742 higher than the original contract due to the addition of stringers, changes required to the nailing pattern and the stringer connectors, and the steel shims. Management have indicated that the additional cost resulted from additional temporary signs and the shimming. The cost of the stringers is not justified by the eventual posting of the bridge for NO TRUCKS.

The City's project management of the 2004 and 2007 rehabilitation work was deficient as follows:

1. No one questioned the design of the deck without shims, although the IM Senior Engineer had mentioned it in his email, noted above.
2. The reasons for failure of the deck were not fully investigated, even though the IM Senior Engineer noted evidence of water ponding on the deck and suggested that they could have weakened the deck along the failure area. The visual observations should have been followed up by the consultant.
3. The additional stringers proposed by the consultant were accepted without requiring further justification from the consultant. The cost of the additional stringers was unnecessary because the bridge was posted for No Trucks.
4. Management have indicated that one of the reasons for not investigating the deck failure in 2004 was that the deck had been in service for 10 years and therefore it had reached its life expectancy; consequently, Management have indicated that the deck failure was not unexpected. If this was the case [which we do not accept as accurate], the City should have been ready to replace the deck in 2004 or earlier. Therefore, justification for design shortcomings on the basis of "lack of time".
5. Once the 2004 deck failed in 2005, no one questioned the consultant's design or suggested that failure could be due to design deficiencies. During the design work done in 2006 and 2007 there was no documentation or communications that address why the 2004 design did not work properly and why the deck had to be replaced after only two years of service.
6. Management have indicated that they do not consider that the 2004 deck failed, although they replaced the deck as a result of noise complaints due to noise

resulting from the deck moving against the steel stringers, due to the shims not being totally effective. However, they exonerate the consultant from any fault, justifying the problems with the 2004 design on the basis of complications due to the variable depth shims required and that installation of variable depth shims would have been very time consuming and that a short time was available before winter. It should be noted that in our opinion, the deck did fail in serviceability.

7. Management have indicated that placement of the shims was complicated by variable sag and twisting of the stringers. There is no documentation in the file to indicate that the consultant addressed the reasons for sagging and twisting of the stringers, notwithstanding that such deformations could be indicative of serious structural deficiencies of the stringers. The City's Project Manager should have addressed this issue when replacing the timber deck.
8. The City agreed to classify the deck design as a "pilot project", essentially removing all responsibility from the consultant and assuming all potential exposure to liability itself. Given that this was the second failure of the deck, this decision protects the consultant and not the City. This is particularly concerning when one considers that the design of timber decks is well established.
9. Once the deck failed one year after construction, the City should have requested a third party to review the design and construction, in order to determine who was at fault regarding the failure. Alternatively, the City should have reviewed the cause of the failure.
10. The cost of the engineering design for the 2007 deck replacement was $12,600, plus GST, and the corresponding cost of construction was $84,970, plus GST. The total additional cost was $97,570 plus GST.
11. Part-time inspection may have been a factor in the failure of the 2004 deck, as evidenced by the fact that the contractor appears to have used plain steel shims instead of galvanized steel shims, but the Inspector did not correct this deficiency. In the 2007 contract, the Inspector was absent from the site for some of the days when the contractor was placing the connectors between the deck, the shims and the steel stringers.

Recommendations and Management Responses

Recommendation 1

That the City refer this file to Legal Services to determine the feasibility of obtaining compensation from the consultant and the 2004 contractor for the costs of design and construction of the 2007 deck repair.

Management Response

Management agrees with the recommendation. Files will be referred to Legal Services for review in Q4 2009.

Recommendation 2

That the City undertake the work themselves or requests proposals from a different consultant in cases where recently constructed works fail prematurely, to ensure that the original design is subject to adequate peer review.

Management Response

Management agrees with the recommendation.

Effective immediately, Infrastructure Services will ensure that in cases where work is to be done as a result of construction works that have failed prematurely, requests for proposal will be sought from a different consultant or the work will be undertaken by the City.

Recommendation 3

Given that in the 2004 contract the Inspector did not notice that the shims were not galvanized, and in the 2007 contract the Inspector was not on site at all times when the deck was being placed, that the City ensure that projects in which part-time construction inspection will be provided be arranged such that the Inspector has detailed instructions and sufficient decision latitude to allow the Inspector to ensure that critical construction steps are inspected.

Management Response

Management agrees with the recommendation.

The reference to provisions for part-time inspections is consistent with the Infrastructure Services department's Inspection Manual for City Construction Contracts.

Recommendation 4

Given the information provided by Management regarding sagging and twisting of the steel stringers, that the City arrange for a different consultant to inspect the bridge, with particular regard to the existing sagging and twisting of the steel stringers.

Management Response

Management agrees with the recommendation. This inspection will be completed by Q2 2010.

Conclusion

The design and construction of the 2004 deck replacement of the structure that was the subject of a Fraud and Waste Hotline report (i.e., Conley Bridge) had several

deficiencies that were directly responsible for the failure of the deck in 2005. The additional cost to the City due to the premature failure of the deck is $97,570 plus GST. The City should consider action regarding the design and construction administration against the consultant and the contractor involved in the 2004 contract. The subsequent design of the second deck replacement in 2007 should have been carried out by the City or a different consultant.

Acknowledgement

We wish to express our appreciation for the cooperation and assistance afforded the audit team by management and staff.

RÉSUMÉ

Introduction

Le Bureau du vérificateur général (BVG) a reçu, par l'intermédiaire de la Ligne directe de fraude et d'abus, des renseignements relatifs aux travaux de réhabilitation d'un pont dans la Ville, qui s'est considérablement détérioré après que des travaux de réhabilitation ont été exécutés en 2004. À la suite de la détérioration rapide des travaux exécutés en 2004, un deuxième contrat pour des travaux de réhabilitation a été attribué en 2007 pour les mêmes travaux, ou presque, que ceux réalisés en 2004.

Le BVG a décidé d'effectuer en complément de la vérification du processus d'entretien des ponts (présentée simultanément dans un rapport séparé), une vérification du pont signalé par l'intermédiaire de la Ligne directe de fraude et d'abus. Pour obtenir l'information contextuelle n'apparaissant pas dans ce rapport, veuillez consulter le rapport de vérification du processus d'entretien des ponts.

Contexte

Les renseignements qui suivent sont tirés des dossiers de projets et des renseignements généraux fournis par la Ville.

Le pont en question est situé sur le sentier Jock, dans l'ancien Canton de Goulbourn, sur les lots 9 et 10 des concessions II et III, à environ 2,5 km à l'est du chemin Dwyer Hill et à 0,5 km à l'ouest du chemin Munster. Le sentier Jock est une emprise routière séparant les concessions II et III.

Selon les données du système de gestion de l'information sur les ouvrages (*Structure Information Management System,* ou SIMS), selon une plaque apposée sur l'ouvrage et selon les plans de travaux de réhabilitation exécutés en 1994, le pont a été conçu et construit en 1947.

Il s'agit d'un pont à une seule voie (qui le traverse) à fermes en acier profilé et à structure en bois d'œuvre laminé. Le pont a environ 6,4 m± de large et s'étend sur 17,2 m± entre ses piliers. Ses appuis d'extrémité sont en béton et reposent sur des semelles de fondation.

Avant 1994, le tablier du pont était en béton et était soutenu par des longerons et par des poutres en acier de structure. En 1994, le Canton de Goulbourn a embauché un consultant pour la conception de réparations à effectuer au pont. Les réparations consistaient à remplacer le tablier et un certain nombre de longerons et de poutres; à renforcer certaines des fermes en acier; à réparer les appuis d'extrémité en béton; à placer une protection en pierre pour la protection contre l'affouillement des

appuis d'extrémité en béton. Le tablier de béton a été retiré et remplacé par un nouveau tablier en bois laminé.

D'après les dessins de 1994, bien que ce ne soit pas clair, il semble que le tablier en bois laminé ne comporte pas de pente latérale pour en permettre le drainage. À partir de ces mêmes dessins, on peut conclure que le pont est incliné de moins de 0,3 % le long de la route.

En août 2004, le tablier en bois s'est brisé et a été remplacé. En 2007, le tablier en bois installé en 2004 a été remplacé de nouveau.

Objectifs de la vérification

Objectif 1 : Vérifier et évaluer les études, conceptions, processus et méthodologies relatifs à la conception et à la construction dans le cadre des travaux de réparation du tablier exécutés en 2004 et en 2007.

Objectif 2 : Déterminer si ces études, conceptions, processus et méthodologies sont compatibles avec toutes les politiques, procédures, lois et règlements pertinents et s'y conforment.

Portée de la vérification

La portée de la vérification s'étendait à l'ensemble des processus de la Ville utilisés pour l'entretien du pont concerné, dont les inspections, la base de données sur les ponts, la méthodologie utilisée pour établir les priorités d'entretien, les processus de réhabilitation de pont, de même qu'à la surveillance et au contrôle des contrats de réhabilitation de pont.

Il est important de noter que la vérification n'incluait pas une inspection physique de l'ouvrage et que sa condition n'a pas été confirmée au cours de la vérification.

Constatations

Le travail de conception réalisé en 2004 était incomplet sous les aspects suivants :

1. En 2004, le consultant ne s'est pas penché sur les causes de la détérioration du tablier, même si l'ingénieur principal de la Gestion de l'infrastructure avait fait remarquer, dans un courriel daté du 17 août 2004, que le drainage du tablier était inadéquat, comme le démontraient des taches laissées par les flaques d'eau sur le tablier. L'ingénieur principal a remarqué que « Les fissures sont toutes survenues du côté du conducteur, sur la voie en direction est. Les taches sur la face inférieure du tablier indiquent que l'eau pourrait s'accumuler le long de la ligne centrale du pont et affaiblir le tablier sous les roues des véhicules du côté du conducteur, c.-à-d. près de la ligne centrale. » Le consultant n'a pas tenu

compte de l'insuffisance de drainage et de l'effet de l'humidité sur le bois en tant que causes possibles du bris du tablier de bois.

2. Les plans réalisés en 2004 ont donné lieu à des travaux exécutés sans qu'une enquête adéquate sur le terrain ait été réalisée, ce qui aurait permis de voir que les longerons n'étaient pas à la même hauteur.

3. Le consultant de 2004 n'a pas tenu compte dans sa conception que le tablier en bois installé en 1994 avait été nivelé à l'aide de plaques d'acier (cales de réglage). En conséquence, les documents du contrat ne prévoyaient pas de telles cales et elles ont été ajoutées en supplément par l'entrepreneur. La Ville a donc eu à payer l'entrepreneur un prix plus élevé pour l'achat et l'installation de cales de réglage que si celles-ci avaient été incluses dans les documents du contrat. Si ces cales de réglage étaient nécessaires, les documents du contrat auraient dû les inclure et en préciser les caractéristiques et les détails.

4. Les directives relatives au site données par le consultant recommandaient que des cales de réglage soient utilisées pour niveler le tablier, mais ne donnaient ni de caractéristiques ni de détails. La direction a indiqué que les cales de réglage étaient fixées aux longerons intérieurs par des plaques de clouage partant du tablier en bois vers les longerons sur les deux côtés des cales, et a jugé qu'il n'était pas nécessaire de relier les cales entre elles. Le consultant aurait dû préciser que les cales de réglage devaient être fixées aux poutres du pont pour les empêcher de bouger. En fait, en 2007, les dessins du remplacement du tablier donnent de nombreux détails sur la façon de relier les cales au tablier et aux longerons en acier.

5. La conception du tablier réalisée en 2004 ne comportait pas de pente transversale visant à assurer le drainage du tablier. Le drainage insuffisant a entraîné la formation de flaques d'eau sur le tablier du pont, ce qui a contribué à sa détérioration prématurée. L'humidité constitue un facteur important de détérioration des ouvrages en bois et un drainage efficace de l'eau est essentiel pour prévenir les dommages prématurés au bois. L'inspection du tablier du pont de novembre 2005 a révélé de la pourriture sur le tablier de bois, ce qui confirme que le problème d'humidité était grave. Le consultant aurait dû prévoir des dispositions pour le contrôle de l'humidité dès 2004. En fait, dans la conception de 2007, le même consultant a recommandé d'ajouter un imperméabilisant et un revêtement de surface au tablier de bois afin d'y réduire l'accumulation d'eau.

6. Les longerons supplémentaires recommandés par le consultant ont été ajoutés par mesure de précaution pour protéger le pont lors du passage de véhicules lourds, mais leur nécessité n'a pas été pleinement justifiée par le consultant au cours de la conception. Les longerons n'étaient pas nécessaires, parce qu'une enseigne interdisait aux camions d'emprunter le pont après les travaux de 2004.

Les travaux de construction dans le cadre du contrat de 2004 étaient inadéquats pour les raisons suivantes :

1. Les cales de réglage utilisées pour niveler le tablier de bois n'étaient pas fixées aux brides supérieures des longerons. Comme il ne disposait pas de suffisamment de détails de la part du consultant, le menuisier a utilisé des plaques de clouage reliant le tablier de bois et les longerons d'acier de chaque côté des cales de réglage. Cette méthode de retenue n'était pas adéquate, comme l'ont démontré les vibrations, le bruit excessif et les déplacements excessifs du tablier constatés par la suite. En fait, les dessins du remplacement du tablier de 2007 montraient des détails précisant comment relier entre eux le tablier de bois, les cales et les longerons d'acier.

2. Les cales de réglage étaient en acier ordinaire et ont rouillé très rapidement. Elles auraient dû au moins être galvanisées. On a noté que les directives du consultant pour le site précisaient que des cales de réglage galvanisées étaient nécessaires et les notes de l'inspecteur indiquaient que ces cales étaient galvanisées. Cette divergence semble indiquer que l'inspecteur n'avait pas remarqué, en fait, que les cales n'étaient pas galvanisées.

3. L'entrepreneur a demandé au menuisier de fournir et d'installer les cales de réglage, même si celui-ci n'était pas qualifié pour exécuter des travaux à l'aide d'acier de structure. Les cales de réglage auraient dû être fournies et installées par le sous-traitant spécialisé en acier de structure.

4. Le coût réel des travaux de construction a été de 90 225 $, soit 31 742 $ de plus que le montant prévu dans le contrat original en raison de l'ajout de longerons, des changements exigés dans le mode de clouage, dans les fixations des longerons et dans les cales de réglage en acier. La direction a indiqué que les coûts supplémentaires ont été causés par la signalisation temporaire supplémentaire et par le nivellement par calage. Le coût des longerons n'est pas justifié, puisque éventuellement, on a installé de la signalisation précisant que le pont est INTERDIT AUX CAMIONS.

La gestion des travaux de réparation par la Ville en 2004 et en 2007 était déficiente pour les raisons suivantes :

1. Personne ne s'est interrogé relativement à la conception du tablier sans recours aux cales de réglage, même si l'ingénieur principal de la GI en avait parlé dans le courriel mentionné précédemment.
2. Les raisons pour la détérioration du tablier n'ont pas fait l'objet d'une enquête complète, même si l'ingénieur principal de la GI avait signalé une accumulation

d'eau sur le tablier et suggéré qu'elle pourrait avoir fragilisé le pont là où il s'est brisé. Les observations visuelles de l'ingénieur auraient dû faire l'objet d'un suivi de la part du consultant.

3. Les longerons supplémentaires proposés par le consultant ont été acceptés sans qu'on demande de justification de sa part. Les coûts des longerons supplémentaires n'étaient pas nécessaires, parce que le pont était interdit aux camions.

4. La direction a indiqué que l'une des raisons pour lesquelles le bris du tablier n'avait pas fait l'objet d'une enquête en 2004 est que celui-ci était en place depuis 10 ans et qu'il avait donc atteint la fin de sa vie utile; en conséquence, la direction a indiqué que le bris du tablier n'avait rien d'inattendu. Si cela avait été le cas [ce que nous n'estimons pas comme exact], la Ville aurait dû être prête à remplacer le tablier en 2004 ou avant. Conséquemment, la justification des faiblesses dans la conception de l'ouvrage est fonction du « manque de temps ».

5. Une fois que le tablier de 2004 s'est brisé en 2005, personne ne s'est interrogé sur la conception proposée par le consultant ou n'a suggéré que le bris aurait pu être causé par des carences dans la conception. Au cours des travaux de conception réalisés en 2006 et en 2007, il n'existe aucune documentation ni communication expliquant pourquoi la conception de 2004 n'a pas fonctionné correctement et pourquoi le tablier a dû être remplacé après deux ans seulement.

6. La direction a indiqué qu'elle ne considérait pas que le tablier de 2004 était déficient, même s'il a été remplacé à la suite de plaintes en raison du bruit qu'il faisait en heurtant les longerons d'acier parce que les cales de réglage n'étaient pas entièrement efficaces. Toutefois, ils ont dégagé le consultant de toute faute, en justifiant les problèmes avec la conception de 2004 par des complications causées par des cales de réglage qui auraient dû être d'épaisseur variable et que l'installation de ces cales d'épaisseur variable aurait été longue et qu'il restait peu de temps avant l'hiver. Il est à noter qu'à notre avis, le tablier était déficient.

7. La direction a fait savoir que l'installation de cales de réglage était compliquée par le degré de fléchissement variable et la torsion des longerons. Il n'y a dans le dossier aucun document indiquant que le consultant sait pencher sur les raisons de ce fléchissement et de cette torsion des longerons, malgré le fait que de telles déformations pourraient être le signe d'importants défauts structurels des longerons. Le gestionnaire de projet de la Ville aurait dû se pencher sur cette question lors du remplacement du tablier de bois.

8. La Ville a convenu de classer la conception du tablier du côté des « projets pilotes », ce qui, essentiellement, dégage le consultant de toute responsabilité et fait en sorte que la Ville prend en charge toute éventuelle responsabilité possible de sa part. Compte tenu du fait que le tablier se brisait pour la deuxième fois, cette décision protège le consultant et non la Ville, ce qui est particulièrement

préoccupant lorsqu'on considère que la conception de tabliers en bois est un travail bien établi.

9. Lorsque le tablier s'est brisé, un an après sa construction, la Ville aurait dû demander une vérification de la conception et de la construction par un tiers, afin de déterminer qui était responsable du problème. La Ville aurait aussi pu rechercher elle-même les causes de cette défaillance.
10. Le coût de la conception en ingénierie pour le remplacement du tablier en 2007 s'est chiffré à 12 600 $, plus la TPS, alors que les coûts de construction ont été de 84 970 $, plus la TPS. Au total, les travaux ont coûté 97 570 $ plus la TPS.
11. Une inspection partielle aurait pu être un facteur dans le bris du tablier en 2004, comme le démontre le fait que l'entrepreneur semble avoir utilisé des cales de réglages en acier ordinaire au lieu d'acier galvanisé, ce que l'inspecteur n'a jamais corrigé. Lors du contrat de 2007, l'inspecteur était absent du site lors des quelques jours où l'entrepreneur plaçait les fixations entre le tablier, les cales de réglage et les longerons en acier.

Recommandations et réponses de la direction

Recommandation 1

Que la Ville transfère le dossier aux Services juridiques afin qu'on évalue la possibilité d'obtenir une compensation du consultant et de l'entrepreneur ayant réalisé les travaux en 2004 pour les coûts de conception et de construction des réparations du tablier réalisées en 2007.

Réponse de la direction

La direction est d'accord avec cette recommandation. Les dossiers seront transférés aux Services juridiques à des fins d'examen au cours du quatrième trimestre de 2009.

Recommandation 2

Que la Ville exécute les travaux elle-même ou lance un appel de propositions auprès d'un autre consultant lorsque des ouvrages récemment construits montrent des défaillances prématurées, afin de s'assurer que la conception originale fasse l'objet d'un examen adéquat par des pairs.

Réponse de la direction

La direction est d'accord avec cette recommandation.

À compter de maintenant, les Services de l'infrastructure s'assureront que lorsque des travaux doivent être exécutés à la suite de travaux de construction prématurément défectueux, un appel de propositions sera demandé à un consultant différent ou les travaux seront réalisés par la Ville.

Recommandation 3

Compte tenu du fait que lors du contrat de 2004, l'inspecteur n'avait pas remarqué que les cales de réglage n'étaient pas galvanisées, et que lors du contrat de 2007, l'inspecteur n'était pas sur les lieux en tout temps lorsque le tablier a été installé, que la Ville fasse de sorte que les projets pour lesquels l'inspection de la construction à temps partiel est prévue soient exécutés de façon à ce que l'inspecteur ait en mains des directives détaillées et dispose de suffisamment de latitude pour veiller à ce que les étapes essentielles de la construction fassent l'objet d'une inspection.

Réponse de la direction

La direction est d'accord avec cette recommandation.

La référence à des dispositions pour d'éventuelles inspections à temps partiel est conforme au Manuel sur les inspections relatives aux contrats de construction de la Ville des Services d'infrastructure.

Recommandation 4

Compte tenu de l'information fournie par la direction concernant l'affaissement et la torsion des longerons en acier, que la Ville fasse en sorte qu'un autre consultant inspecte le pont, en accordant une attention particulière à l'affaissement et à la torsion actuels des longerons d'acier.

Réponse de la direction

La direction est d'accord avec cette recommandation. Cette inspection sera effectuée d'ici le deuxième trimestre de 2010.

Conclusion

La conception et la construction pour le remplacement du tablier de 2004 de l'ouvrage faisant l'objet d'un rapport à la Ligne directe de fraude et d'abus (c.-à-d. le pont Conley) comportent de nombreuses déficiences directement responsables du bris du tablier en 2005. Les coûts supplémentaires pour la Ville de cette détérioration prématurée sont de 97 570 $, plus la TPS. La Ville devrait envisager des poursuites contre le consultant et l'entrepreneur en cause lors des travaux de 2004 relativement à la gestion de la conception et de la construction. La conception pour le remplacement du deuxième tablier, en 2007, aurait dû être exécutée par la Ville ou par un consultant différent.

Remerciements

Nous souhaitons exprimer notre reconnaissance au personnel et à la direction pour leur collaboration et l'aide qu'ils ont apportée à notre équipe au cours de la réalisation de cette vérification.

1 BACKGROUND

The Office of the Auditor General (OAG) received through the Fraud and Waste Hotline information regarding concerns with the rehabilitation work for a bridge in the City, which deteriorated significantly after the rehabilitation work was completed in 2004. As a result of the rapid deterioration of the work completed in 2004, a second rehabilitation contract was issued in 2007 for essentially the same work as the 2004 contract.

The OAG had originally identified an audit of the Bridge Maintenance Process in the 2008 Audit Plan that was presented to Council. The OAG decided to examine the overall bridge maintenance procedures of the City of Ottawa, and to include in the audit process the bridge reported through the Fraud and Waste Hotline.

The audit of the bridge reported through the Fraud and Waste Hotline is presented in this separate and concurrent report. Please make reference to the Audit of the Bridge Maintenance Process for background information not contained in this report.

1.1 Responsible Business Unit

The City's Infrastructure Services Branch is responsible for the maintenance of bridges, culverts, retaining walls, and the structural components of transit stations. Architectural, electrical, and mechanical components of the transit stations are maintained by the Real Property Asset Management Branch.

The business units responsible for the bridge maintenance process are the Infrastructure Management (IM) and the Construction Services divisions of the Infrastructure Services Branch (ISB).

1.2 Bridge and Road Description

The following information was extracted from the project files and the background information provided by the City.

The bridge is located on the Jock Trail in the former Township of Goulbourn, in Lots 9 and 10 of Concessions II and III, approximately 2.5 km east of Dwyer Hill Road and 0.5 km west of Munster Road. The Jock Trail is the road allowance between Concessions II and III.

Based on the data in the Structure Information Management System (SIMS), a plaque on the bridge, and drawings of rehabilitation works done in 1994, it was concluded that the bridge was designed and constructed in 1947.

The bridge is a single lane structural steel truss bridge with laminated timber deck. The bridge is 6.4 m± wide and spans 17.2 m± between supports. The bridge abutments are constructed of concrete on spread footings.

Prior to 1994, the bridge deck was constructed of concrete supported on structural steel stringers and beams. In 1994, the Township of Goulbourn retained a consultant to design repairs to the bridge. The repairs comprised replacing the deck and a number or stringers and beams; reinforcing some of the steel truss members; repairs to the concrete abutments; and placing rock protection for scour prevention of the concrete abutments. The concrete deck was removed and replaced with a new laminated timber deck.

It is not clear from the 1994 drawings, but it would appear that the laminated timber deck was constructed without lateral slope to allow drainage of the deck. From the 1994 drawings it can be concluded that the bridge slopes less than 0.3% along the road.

In addition, the 1994 drawings show that the bridge was designed using loads for posting, noted as L1 = 16 tonnes, L2 = 25 tonnes, and L3 = 35 tonnes. The bridge had been correctly posted for these loads.

In August 2004 the timber deck failed and was replaced with a new one. In 2007, the timber deck installed in 2004 was replaced again.

1.3 Background Information

1.3.1 Infrastructure Management

The Infrastructure Services Branch comprises four divisions, namely Infrastructure Management, Construction Services – West, Construction Services – East, and Construction Services – Development.

The City's Infrastructure Management Division is in charge of asset management for all linear assets of the City, including roads, bridges, watermains, sanitary sewers and storm sewers.

The Bridge Maintenance Program is managed by the Infrastructure Management Division, assisted in the delivery of the required services by the Construction Services West and East divisions. Infrastructure Management works with Construction Management East and West divisions of Infrastructure Services Branch, for the implementation of the bridge maintenance process. Construction Services is responsible for management of the detailed condition assessments, renewal options evaluations, preliminary and detailed design, tendering, and construction inspection and contract administration.

1.3.2 Legislative Requirements

Maintenance and inspection of municipal bridges and other similar structures are carried out in accordance with provincial legislation and regulations, and standards set by the Ministry of Transportation of Ontario (MTO). Provincial legislation regarding the inspection and maintenance of bridges comprise Public Transportation and Highway Improvement Act, R.S.O. 1990, c. P.50 and Standards for Bridges, Ontario Regulation 104/97. The Regulation specifically refers to standards set by MTO in publications on this subject, including the Ontario Structure Inspection Manual, the Structural Manual and Structure Rehabilitation Manual, and the Ontario Bridge Management System. In addition, the Province of Ontario adopted the Canadian Highway Bridge Design Code as the bridge design code, subject to modifications noted in the Structural Manual.

The Federal Government has no jurisdiction over maintenance of municipal bridges.

2 AUDIT OBJECTIVES AND CRITERIA

Audit Objective #1: Examine and evaluate the studies, designs, processes and methodologies pertaining to the design and construction of the 2004 and 2007 bridge deck repairs.

Audit Objective #2: Determine whether the studies, designs, processes and methodologies are consistent and compliant with all relevant policies, procedures, legislation and regulations

3 AUDIT SCOPE

The scope of the audit comprised the overall City processes used for the maintenance of the subject bridge, including the bridge inspections, bridge database, methodology used for assigning maintenance priority, bridge rehabilitation processes, and bridge rehabilitation contract oversight and control.

The audit encompassed the following tasks:

- Review legislative framework, as part of the Audit of Bridge Maintenance Process;
- Review background data;
- Conduct interviews with individuals involved in the inspection, design, and construction of the renewal of the subject bridge; and,
- Prepare draft report for fact verification.

3.1 Review Legislative Framework

This review is largely governed by the following legislation:

- Public Transportation and Highway Improvement Act, R.S.O. 1990, c. P.50; and,
- Ontario Regulation 160/02 made under the Public Transportation and Highway Improvement Act Amending O. Reg. 104/97 (Standards For Bridges).

In addition, the Ontario Highway Bridge Design Code, the Canadian Highway Bridge Design Code, the Structural Manual, the Ontario Structure Inspection Manual, the Structure Rehabilitation Manual and the Drainage Design Manual were considered in this audit.

3.2 Interviews

Interviews were held with City staff involved in the various components of the inspection, design, and construction administration of the two bridge renewal projects, including senior management, division managers, program manager and project managers.

3.3 Review Background Data

Background data available from the City was collected and reviewed. This included the structure inspection sheets, condition surveys, renewal options reports, preliminary and detailed design, tender documents, construction administration files, construction inspection data, quality assurance data, and as-built drawings.

3.4 Correspondence Reviewed

The correspondence files for the project maintained by the City were reviewed in detail.

3.5 Documents Examined

The audit included a review of the documents listed in Sections 3.3 and 3.4, together with the review of notes and related correspondence.

Other documents prepared by the City, collected and reviewed as part of the audit included:

- Guidelines for Infrastructure Renewal Options Analysis, December 2007;
- Project Manager's Procedures Manual, 2006; and,

- Inspection Manual for City's Construction Contracts, May 2003.

4 FINDINGS

The results of the examination are summarized in the following table.

Structure No.	Structure Name	Comments by OAG Review
753090	Jock Trail Bridge Jock Trail Rd Overpass at Creek (i.e., Conley Bridge)	• File provided contains 2004 contract. • It appears that work was done due to very poor condition of bridge. • Correspondence file Aug. 2004 to Dec. 2004 - bridge was rehabilitated in 1994. Timber deck failed in Aug. 2004, required emergency repairs. • Preliminary design examined five options. IM requested lifecycle cost analysis, but it is not included in file. • Contract based on Request for Quotations, awarded to 2nd lowest bidder due to lowest bidder not meeting bonding requirements. • Condition inspection upon failure of deck. • Renewal options report prepared. • Records of construction and as-built drawings provided upon request. • Design of original repairs was done without adequate survey.

4.1 2003 Inspection

Bridge Primary Components comprise the bridge superstructure (in turn classified as beam and slab, truss, or arch systems), abutments, piers and columns, Approaches, Hydraulics and General. The rating codes are:

6-Very Good	5–Good	4-Fair	3-Poor	2-Urgent	1-Critical	0-Not applicable

The Inspection Sheets for the visual inspection done in August 2003 are included in Appendix A. The following is a summary of the Inspection Sheets information. It is noted that this inspection was carried out about one year before the failure of the timber deck in 2004.

Component	Rating	Comments
General		
02. Vibration	5	Some vibration with light load.
Beam & Slab		

Component	Rating	Comments
05. Deck/Slab Soffit	5	Rust stain adjacent to top flange.
06. Longitudinal Beams	5	Light rust.
07. Transverse Beams	5	Light rust.
10. Bracing System	5	Light rust. One deformed member at each end of structure.
Truss System		
14. Diagonals & Verticals	5	Minor plow damage each side.
Abutments		
17. Foundations		Not visible.
18. Main Wall	4	Numerous cracks and scaling. Map cracking at repairs. Cracks and delaminations at top of abutment face.
19. Wing Walls	4	Cracks and stain visible (efflorescence). Small spalls. Concrete deterioration as southwest and southeast corners, Picture 1 of heavy deterioration at northwest corner.
21. Bearings	5	Steel plates.
Piers & Columns		
Superstructure		
27. Wearing Surface	5	Transverse laminated wood deck: checking and splitting.
28. Expansion Joints	4	Deck joints comprised of steel angles with evazote foam joint seal. Replace seals, both joints leak. Plow damage to steel angles at each end. See picture 2.
31. Curbs	5	Wood curbs (4x4s): splitting, plow damage.
34. Fascia	5	Ends of deck timbers.
35. Deck Drains		
36. Parapets		
37. Railings	3	Steel tube (2R pipe) not structurally adequate. Pipe separated at northwest. Replace or repair at north end corners (picture 3).
38. Coating System	5	Minor surface rust.
40. Electrical Equipment		
Approaches		
42. Wearing Surface	5	Asphalt: pitted, gatored.
45. Guide Rails	5	SBGR west end treatments: Northwest end treatment damaged, guiderail. Replace or repair unsupported by 2 posts.
46. Signs & Postings	5	Load limits.
Hydraulics		
Miscellaneous		
53. Plaques	5	Two at each end of structure (pictures 3, 4).

The note on item No. 46 – Signs & Posting indicates that the bridge was posted for load limits. This was in conformance with the 1994 rehabilitation works.

4.2 2004 Inspection

Correspondence in the files for the structure indicates that a 400 x 1,200 mm section of the timber decking failed on June 1, 2004 and was replaced. The file indicates that a public complaint was received by the City on August 13, 2004; upon inspection, the City found two failed sections of the deck, one 1,200 x 1,200 mm and a second 1,200 x 2,400 mm, on the driver's side of the eastbound lane. The City covered the holes with plywood and closed the lane. The bridge was marked for one-lane car traffic; no trucks were allowed on the bridge.

On August 16, 2004, as a result of the deck failure as described above, the bridge was inspected in an unscheduled inspection. At the time, the inspection noted unusually large deflection of the deck upon loading with a small truck, and started an investigation of damage to the timber decking. The Inspection Sheets for the visual inspection done in August 2004 showed that the structure rating was D, the same as in 2003. The 2004 Inspection Sheets provide ratings for the following components and properties of the bridge:

Component	Rating	Comments	Recommendations
General			
01. Deflection	3	Unusually large deflection by small truck INVESTIGATION OF DAMAGE TO TIMBER DECKING.	
04. Damage	4	Plywood covers placed over areas of broken timber decking. Cause unknown.	Repair
Beam & Slab			
05. Deck/Slab Soffit	2	Deck deteriorating rapidly, extensive splitting, checking.	Repair or replace
Superstructure			
27. Wearing Surface	2	Pressure treated 2x6 (nominal).	Repair
Approaches			
46. Signs & Postings	5	Load limits.	

This inspection record also noted that the bridge was posted for load limits.

The August 2004 inspection was not a scheduled inspection, but was initiated by failure of the laminated timber deck. The following observations were made by the Senior Engineer in Infrastructure Management after the August 2004 failure [words in square brackets added for clarification and explanation]:

- In June 2004, the timber deck failed and was repaired. On August 13, 2004 the deck failed again, this time in two areas (one 1,200 x 1,200 mm and another one 1,200 x 2,400 mm).

- All breaks in the timber deck occurred on the driver side of the eastbound lane.
- The timber decking appears to be constructed from low-grade timber based on the character of the failures, visual observation of the significant number of random breaks throughout the underside of the deck and the exposed ends of the 2x6 planks (mostly heart wood, very wide growth rings, edge knots, poor slope of grain, etc.).
- There is very little sign of wear on the top surface. There are patches of fractured wood with missing chunks and cracks, visual evidence of wood failure.
- Crown built into the longitudinal beams was removed by shims placed between the underside of decking and top of the steel beam flanges.
- Staining on the underside of the deck indicates that water may be ponding along the centreline of the bridge and weakening the decking under the driver's side wheels, i.e., closest to the centreline.
- There is no file for this structure (was Twp. of Goulbourn structure). [Subsequently, the City received a copy of the 1994 drawings from the consultant and has them in the bridge database].

4.3 2004 Contract

4.3.1 Design

The consultant that was retained to design the structure repairs done in 2004 was the consultant who designed the rehabilitation done in 1994.

The consultant was selected based on having prepared the 1994 design for rehabilitation of the structure. The consultant provided a draft proposal on August 26, 2004 for deck repair options, detailed design, and tendering and construction administration. We noted that the final proposal is not on file, but the authorization is for the same fee amount.

The City approved the proposal and retained the consultant, partly on the basis that the consultant firm was already familiar with the bridge, since they prepared the rehabilitation contract in 1994.

The consultant carried out an inspection of the structure and submitted a September 10, 2004 letter draft report to the City, with the following five options, ranging from repairs to replacement of the structure:

Option	Estimated Construction Cost By Consultant	Observations by Bridge Consultant
1. Repair damaged portions of deck	$20,000	Poor condition of the deck would require further repairs in the near future.
2. Replace deck with new timber deck	$25,000	Relatively short life expectancy of new deck, compared to the remainder of the structure's life.
3. Replace deck with concrete deck	$35,000	Not feasible. Would result in posted load limit of less than 10 tonnes.
4. Replace truss with precast box beams	$200,000	Meets all requirements of the bridge code, and provides extended use of substructure, which is in good condition. The useful life of the substructure is 20-30 years before major rehabilitation would be required.
5. Replace entire structure	$500,000	Service life of 75 years, meets all requirements of the bridge code, and would require relatively long road closure period.

The consultant states in the September 10, 2004 report that "extensive water staining was also noted on the soffit" [emphasis added]. However, the effect of water was not addressed in the design.

The correspondence contains an email from the City's Project Manager to the bridge consultant with comments on the letter draft report. The file does not contain a copy of the final letter report.

The City considered that the repair option was not acceptable because the remainder of the deck could fail in other spots after the deck is repaired. Ultimately the City selected **Option 2 – Replace deck with new timber deck** because it would restore the bridge function to pre-damage conditions and allow winter maintenance to proceed. The City considered that Options 4 and 5 were not justified due to the very low traffic volumes projected for the next 10-15 years on Jock Trail Road, the period of extended life provided by the timber deck replacement option.

On September 24, 2004 the consultant submitted via email a preliminary General Arrangement drawing [which shows the bridge in plan, in elevation, and typical section] for circulation. The consultant recommended adding new stringers, as an added precaution to the "perhaps rapid deterioration of the timber and heavy axle

loads that may have precipitated the deck failure". The consultant estimated that the additional cost of the added stringers would be $15,000.

The question that this comment raises is "if the deck is designed to the requirements of the CHBDC, why concern with "heavy axle loads ", as the deck should be able to carry the legal highway loads, unless the strength of the structure is not adequate. In addition, the consultant mentions the "rapid deterioration of the timber", but does not address the issue further. The same email notes that, given the relatively good condition of the bridge it is expected that it will last beyond 10 years once the deck is replaced.

In our opinion, the new design did not address or investigate the potential reasons for the failure of the deck. In particular, there was no assessment of the reason for the rapid deterioration of the deck from 2003, when it was given a rating of 5, to August 2004, when it failed twice (in June and August).

The recommendation for the additional stringers, added as a precaution against heavy axle loads, did not result in a change in the posting of the bridge. In fact, the City posted the bridge with NO TRUCKS signs. In our opinion, the consultant did not provide sufficient justification for the additional stringers, and the City accepted the recommendation without critical examination of the need for the stringers.

In reviewing the design presented in the 2004 drawings, we noted the following:

1. The deck was designed flat, with no cross-fall. As noted previously, the bridge deck must be provided with adequate drainage, as required by the bridge code.

   Bridge deck drainage of the roadway shall be achieved by providing a minimum 2% transverse cross-fall[1] and by providing a minimum longitudinal grade of 0.5%, except where, for limited lengths, vertical curves or super-elevation transitions preclude this.

2. There is no indication on the drawings of the grade at the bridge. Based on the information on the 1994 drawings, we can ascertain that the road is essentially flat, and that the bridge itself has a nominal longitudinal (along the road) grade of less than 0.3%. This longitudinal grade is lower than the grade required by the bridge code, as noted above.
3. Two members of the steel trusses were built-up to correct deformation due to a collision.

Management have indicated that the design replaced the failed deck with a new one without consideration of drainage because of the tight schedule required for re-opening the road to traffic by early December 2004. In addition, management have advised that the deck had reached its life expectancy and therefore its failure was

[1] Cross-fall is the drop in elevation from the center to the edge of the road.

"not unexpected", thus removing the need to evaluate the reasons for the deck failure. Putting aside that we do not agree with this assessment of life expectancy for the wood deck, we note based on management's comment that if the deck failure was not unexpected, the City should have planned earlier for replacement of the deck.

4.3.2 Construction Inspector's Notes

From the Construction Inspector's notes it was observed that:

1. The stringers were fabricated too short for the site. The consultant recommended that a longer bracket and a backing plate (shim) be placed where required, with longer bolts. In reviewing the file, we noted that the shop drawings for the new stringers were not in the file.
2. The consultant was on site for clarification regarding the location of the drilled out holes for the nuts and bolts, because of conflicts with nailing of the timber deck.
3. Galvanized levelling steel plates (shims) were required over new and old stringers to level the new timber deck. In this regard, we note that the original deck, constructed in 1947, had been provided with cross-fall, but the 1994 design appears to have eliminated the cross-fall. In repairing the deck in 2004, the shims maintained this shortcoming in deck drainage.
4. In addition, we note that the Site Instruction issued by the consultant did not include a detail for the shims, and it did not provide any indication that the shims would require fastening to the stringers. The shims as provided were 2" wide steel plates of varying thicknesses.
5. The Inspector's notes indicate that they would be galvanized, but inspections of the shims in 2005 by the City and in 2006 by the consultant show that the shims had a lot of corrosion, which indicates that the shim plates were made of plain, not galvanized, steel.
6. The welder fixed the bridge nailing at the east and west end. This note indicates that there was a problem with the nailing work.
7. The carpenter placed the new timber deck and the shims discussed above. The shims used were 2" flat bars, with varying thickness to accommodate the bridge deck elevations. We would expect that the steel erector should be the subcontractor responsible for installing the steel levelling plates (shims). The procedure used on this bridge transferred responsibility for part of the steel work to the carpenter. In addition, the consultant does not appear to have attended the site to examine the placement of the shims.
8. As a result of the lack of a detail for the shims and for their connection to the stringers and the deck, the carpenter used nailing plates placed on each side of

the shims. Such connection was inadequate, contributing in large part to the subsequent problems with the deck's performance.

9. The City's Inspector's notes discuss the use of galvanized steel shims, but the contractor installed plain steel shims; the Inspector did not notice this change, which may have been missed due to the Inspector being charged with part-time inspection duties.

From the Project Manager's correspondence file, we found the following:

1. Final detailed design drawings were included.
2. Design Consultant Site Instructions which indicated the following:
   - Change of clip angle for connections to accommodate the short stringer beams – 13 mm filler plates or L127x89x9.5 painted with two coats of zinc rich paint.
   - Change gauge and pitch of bolt spacing for built up members. Metal shims to be used as required to fill gap between the top of existing stringers to the underside of the deck to provide level surface for deck. As noted previously, the drawings show no detail of the steel shims or their connection to the stringers.

Substantial completion of the project was given as December 8, 2004. As-built drawings[2] in file are based on 90% submission. On the copy of the drawings in the file, the Construction Inspector noted that they do not correspond to the as-built drawings in the system (i.e., the network storage). Based on our examination of the drawings in the server, this question has not been resolved.

4.4 2005 Inspection

In accordance with the procedures set for the renewal of bridges, the bridge was inspected in November 2005 prior to the expiry of the 12-month warranty period. During the inspection, the bridge Inspector noted problems with the deck. However, there is no record of follow-up with the design consultant or the contractor.

Specifically, the 2005 inspection noted the following:

Component	Rating	Comments	Recommendations
General			
01. Deflection	5	Some vibration with light load.	
Beam & Slab			
05. Deck/Slab Soffit	5	Laminated wood (2x4).	

[2] As-built drawings are a set of drawings based on the design drawings, indicating changes that were made during construction. For example, variations in final location, elevations, materials, details, etc.

Component	Rating	Comments	Recommendations
06. Longitudinal Beams	5	Light to medium rust especially in bottom flanges.	
07. Transverse Beams	5	Light rust.	
10. Bracing System	5	Light rust; one slightly deformed member at each end.	Monitor
11. Connections	5	Light rust.	
Truss System			
12. Top Chord	5	Light rust and few areas with medium rust jacking.	
13. Bottom Chord	5	Light rust.	
14. Diagonals & Verticals	5	Minor plow damage.	Monitor
Abutments			
17. Foundations		Not visible.	
18. Main Wall	4	Severe disintegration at northwest and southwest corners. Severe efflorescence at corners.	Monitor
19. Wing Walls	4	Weathering with light to medium scaling and efflorescence.	Monitor
20. Ballast Wall	5	Partially visible – light efflorescence and staining.	
21. Bearings			
Superstructure			
27. Wearing Surface	5	Laminated wood: small checks and few planks with medium rot.	Treat wood
28. Expansion Joints	4	Deteriorating compression seal and plow damage of armouring.	Replace seals
31. Curbs	6	Wood curbs: small splits and checks.	
34. Fascia	5	End of deck timbers: Splits with some broken ends.	
37. Railings	3	Steel tube (2R pipe) not structurally adequate; pipe separated at northwest and northeast corners. Light rust.	
38. Coating System	5	Light surface rust.	
Approaches			
42. Wearing Surface	4	Medium ravelling at armouring. Severe gatoring in west. Projection of armouring.	Pad at armouring
46. Signs & Postings	5	Load limits: NO TRUCKS.	
Miscellaneous			
53. Plaques	3	Two at east end: Northeast damaged.	

Management have advised that they do not believe that the 2005 inspection report reflects problems with the deck, but notes minor issues to be monitored; vibrations are noted. We consider, based on the 2005 inspection report and the photos filed in SIMS, that the report records a number of problems with the new deck, namely:

a) Vibration with light load is sufficiently unexpected that the Inspector made a note of it in the record.

b) The Inspector noted a few planks with medium rot. Examination of the photos shows that the problem appears to be on all bridge quadrants.

4.5 2007 Contract

An email to the City from the consultant who designed the 2004 deck replacement, dated July 28, 2006, discussed repair options for the deck. The consultant indicated that the repair options could include:

a) Remove the existing shims and replace them with full width new shims.

b) Add shims at the stringer edges for full width support of the timber deck.

In both options noted, the consultant recommended adding tie-rods through the deck to stringer flanges for positive bearing on the stringers. This is significant in that it shows that the consultant recognized that the original construction installation had been deficient.

More significantly, the consultant recommended adding a gap filler and waterproofing layer and a thin asphalt-wearing surface on top of the deck, to eliminate water ingress and reduce vibrations and noise.

Following the July 28, 2006 email, the same consultant who designed the 2004 deck replacement was asked to provide a proposal for the new repairs. The proposal included an option for replacement of the structure. The City directed the consultant to revise the proposal to include only the deck replacement design, and the corresponding tendering and specialist services during construction.

The August 2006 proposal by the consultant indicates the following observations based on a visual examination of the bridge on July 27, 2006:

a) The existing timber deck shows movement of individual timber boards under wheel loads and even under pedestrian loads, in several areas.

b) In two areas, each about 1.5 m long and 1.0 m wide, the individual deck timbers deflect 5 to 10 mm.

c) The deck surface has localized surface damage due to snow plow or other heavy vehicles.

d) The shims installed between the stringer flanges and the timber deck show advanced rust formation and rust stains already affect the timber surface.

e) There is evidence of salt and water penetrating through the deck.

f) Timbers show gaps 2 to 3 mm wide.

The consultant indicates that the present condition of the timber deck shows several performance deficiencies, which will progress in time.

The file record contains no discussion of why the 2004 project failed. This may be explained in part by the fact that the City considers that the bridge deck was structurally sound and did not fail. This comment by Management brings into question the reason why the deck was replaced by a new one.

In October 2007 during a meeting the City's Project Manager agreed to consider this a "pilot project" due to the type of deck being used. In the same meeting, the consultant informed the City that the consultant had done an internal quality control review of the design, which had resulted in two areas of concern, namely the possibility that the shim material used could separate from the stringer and that the bolts used to secure the deck could be damaged by a snow plow.

The October 2, 2007 Meeting Report No. 1 states in Item 2.0:

"All agreed that since the repairs to the bridge are non-standard in nature, particularly with respect to the shimming detail, the work would be considered as a "pilot project".

The Meeting Report states that an internal quality control review by the consultant of the design drawings revealed two concerns:

1. Planitop 23 Repair Mortar specified as shim material may debond from the steel stringer flanges due to the disparity in the flexural properties of the steel stringers and the mortar.
2. The dome bolts holding the timber deck panels in place protrude above the top of the deck, exposing them to damage from snow plow blade.

The City paid the consultant the fees for the redesign as per the proposal.

4.6 Discussion

Our review of the files and drawings for this project revealed the following issues with the management of this project:

1. There was no investigation of the potential reasons for the 2004 failure of the timber deck. The IM Senior Engineer noted that the deck had stains showing

that there might have been water ponding on the deck, toward the driver side of the eastbound lanes. He also noted that the crown on the longitudinal beams was removed by shims placed between the underside of the decking and the top of the steel beam flanges.

2. The consultant recommended additional stringers[3] as an added precaution to the "perhaps rapid deterioration of the timber and heavy axle loads that may have precipitated the deck failure". We believe that this recommendation should have been supported by calculations. In addition, if the rating of the bridge did not change, there should have been no reason to add the additional stringers.
3. Furthermore, we consider that the lack of drainage was a likely reason for the localized failure of the timber deck. Failure of the deck in 2004 could have been the result of rotting of the timber deck due to the lack of drainage of the deck. However, this was not investigated by the consultant.
4. The selection of Option 2 for implementation was not preceded by a formal Renewal Options Analysis based on life cycle costs. However, the IM Senior Engineer indicated that "full superstructure replacement and complete replacement options are not justified due to the very low traffic volumes and any realistic growth in that traffic over the next 10-15 years, the period of extended life provided by the timber deck replacement option."
5. No shop drawings for the new stringers were on file and there is no record that the shop drawings were produced. Consequently, the stringers were fabricated too short for the span and had to be adjusted in the field to fit properly. The contractor should have been required to provide shop drawings.
6. Although the original deck was shimmed to level the deck, the design of the 2004 deck replacement did not account for the shims, but the designer assumed that the top of the beam flanges were at the same level. It would appear that the consultant did not thoroughly inspect the deck or the structure prior to engaging in the design of the new deck. This is more obvious when one considers that the IM Senior Engineer had already pointed out that the existing timber deck had been levelled using shims.
7. During construction and as a Site Instruction, the consultant recommended shims to level the deck, but did not provide any detail or requirements for the placing and support of the shims.
8. The shims were placed by the carpenter. In our opinion, the general contractor or the structural steel fabricator should have provided and installed the shims.

[3] Stringers are longitudinal beams that support the timber deck and transfer the loads to the header beams; these in turn transfer the load to the trusses at their joints.

9. The Ontario Highway Bridge Design Code, 3rd Edition, which was in effect in 1994, required that bridge decks be provided with adequate drainage (Clause 1-8.4), including a minimum 2% cross-fall. Therefore, the design did not meet the OHBDC requirements for drainage. The Canadian Highway Bridge Design Code, 1st Edition, which was in effect in 2004, and 2nd Edition, which was in effect in 2007, have the same requirement. We do not understand why the structure deck would be designed flat, when the Code requires that bridge decks be provided with minimum 2% cross-fall for drainage.
10. When the deck failed again in 2005 one year after it was replaced new, no one within the City questioned how a new deck, replaced very recently, could have failed so soon after completion. There is absolutely no record of any discussion with the consultant or the contractor regarding design issues or construction defects.
11. It is notable in the file that the second failure of the deck was caused by movement of the deck as a result of deflection of the stringers and separation of the deck from the supports. The steel shims placed in 2004 moved or fell off due to lack of proper connection to the stringers or the deck.
12. Apart from the 2005 inspection done by IMD, the division was not involved in resolution of the second set of repair options.

4.7 Deficiencies Noted

In our opinion, the design of the 2004 contract work was deficient as follows:

1. In 2004, the consultant did not investigate the reasons why the deck failed, although the IM Senior Engineer noted in an email dated August 17, 2004 that the deck drainage was inadequate, as evidenced by staining indicating ponding on the deck. The Senior Engineer noted that: "The breaks have all occurred on the driver side eastbound lane. Staining on the underside of the deck indicates that water may be ponding along the centreline of the bridge and weakening the decking under the driver's side wheels, i.e., closest to the centreline". The consultant did not consider lack of drainage and the effect of moisture as a potential cause of the deck failure.
2. The 2004 design was carried out without an adequate field survey of the structure, which would have disclosed that the stringers were not at the same level.
3. The 2004 consultant did not take into account in the design that the timber deck placed in 1994 had been levelled with steel plates (shims). As a result, the contract documents did not make provision for the shims and they were included as an extra to the contract. Consequently, the City had to pay the contractor a higher cost for the supply and installation of the shims than if the shims had been included in the contract documents. If the shims were indeed

required, the contract documents should have included the shims, including specifications and details.

4. The site instruction issued by the consultant recommending that shims be used to level the deck did not provide specifications or details for the shims. Management advises that the shims were restrained on the interior stringers by nailing plates that extended from the wood deck to the stringers on both sides of the shims, and they consider that there was no need to make a physical connection of the shims. The consultant should have provided a detail requiring that the shims be affixed to the bridge beams to prevent the shims from moving. In fact, the 2007 deck replacement drawings provide several details for the connection of the shims to the deck and the steel stringers.
5. The design of the deck in 2004 did not provide cross-fall to provide drainage of the deck. Poor drainage results in ponding of water on the deck, which contributes to the premature failure of the timber deck. Moisture is a significant factor in deterioration of wood structures, and efficient removal of water is essential to prevent premature damage to wood. The fact that the November 2005 inspection of the timber deck showed rotting of some of the timber of the deck indicates that the moisture problem was severe. The consultant should have made provisions for moisture control in 2004. In fact, in the 2007 design, the same consultant recommended adding waterproofing and a wearing surface to the timber deck to reduce moisture in the deck.
6. The additional stringers recommended by the consultant were added as a precaution against heavy axle loads, but their need was not fully justified by the consultant during the design work. The stringers were not required because the structure was posted as "No Trucks" after the 2004 contract.

Construction of the 2004 contract was deficient as follows:

1. The shims used to level the timber decking were not attached to the top flanges of the stringers. Lacking a detail provided by the consultant, the carpenter used nailing plates that extended from the wood deck to the steel stringers on each side of the shims. This method of restraint was not adequate, as evidenced by the subsequent vibrations, excessive noise and excessive displacements of the timber deck. In fact, the 2007 deck replacement drawings show details to connect the timber deck, the shims, and the steel stringers together.
2. The shims were constructed of plain steel, which rusted very quickly. As a minimum, the shims should have been galvanized. It is noted that the consultant site instruction specifies galvanized shims and the Inspector's notes also indicate the shims were galvanized. This discrepancy would indicate that the Inspector did not notice that the shims were not, in fact, galvanized.

3. The contractor had the carpenter provide and install the steel shims, although a carpenter is not qualified for structural steel work. The shims should have been provided and installed by the structural steel sub-contractor.
4. The actual cost of construction was $90,225, which is $31,742 higher than the original contract due to the addition of stringers, changes required to the nailing pattern and the stringer connectors, and the steel shims. Management have indicated that the additional cost resulted from additional temporary signs and the shimming.

The City's project management of the 2004 and 2007 rehabilitation work was deficient as follows:

1. No one questioned the design of the deck without shims, although the IM Senior Engineer had mentioned it in his email, as noted above.
2. The reasons for failure of the deck were not fully investigated, even though the IM Senior Engineer noted evidence of water ponding on the deck and suggested that they could have weakened the deck along the failure area. The visual observations should have been followed up by the consultant.
3. The additional stringers proposed by the consultant were accepted without requiring further justification from the consultant. The cost of the additional stringers was unnecessary because the bridge was posted for No Trucks.
4. Management have indicated that one of the reasons for not investigating the deck failure in 2004 was that the deck had been in service for 10 years and therefore it had reached its life expectancy; consequently, Management have indicated that the deck failure was not unexpected. If this was the case [which we do not accept as accurate], the City should have been ready to replace the deck in 2004 or earlier. Therefore, justification for design shortcomings on the basis of "lack of time".
5. Once the 2004 deck failed in 2005, no one questioned the consultant's design or suggested that failure could be due to design deficiencies. During the design work done in 2006 and 2007 there was no documentation or communications that address why the 2004 design did not work properly and why the deck had to be replaced after only two years of service.
6. Management have indicated that they do not consider that the 2004 deck failed, although they replaced the deck as a result of noise complaints due to noise resulting from the deck moving against the steel stringers, due to the shims not being totally effective. However, they exonerate the consultant from any fault, justifying the problems with the 2004 design on the basis of complications due to the variable depth shims required and that installation of variable depth shims would have been very time consuming and that a short time was available before winter.

7. Management have indicated that placement of the shims was complicated by variable sag and twisting of the stringers. There is no documentation in the file to indicate that the consultant addressed the reasons for sagging and twisting of the stringers, notwithstanding that such deformations could be indicative of serious structural deficiencies of the stringers. The City's Project Manager should have addressed this issue replacing the timber deck.
8. The City agreed to classify the deck design as a "pilot project", essentially removing all responsibility from the consultant and assuming all potential exposure to liability for itself. Given that this was the second failure of the deck, this decision protects the consultant and not the City. This is particularly concerning when one considers that the design of timber decks is well established.
9. Once the deck failed one year after construction, the City should have requested a third party to review the design and construction, in order to determine who was at fault regarding the failure. Alternatively the City should have reviewed the cause of the failure.
10. The cost of engineering design for the 2007 deck replacement was $12,600, plus GST, and the corresponding cost of construction was $84,970, plus GST. The total additional cost was $97,570 plus GST.
11. Part-time inspection may have been a factor in the failure of the 2004 deck, as evidenced by the fact that the contractor appears to have used plain steel shims instead of galvanized steel shims, but the Inspector did not correct this deficiency. In the 2007 contract, the Inspector was absent from the site for some of the days when the contractor was placing the connectors between the deck, the shims and the steel stringers.

5 RECOMMENDATIONS AND MANAGEMENT RESPONSES

Recommendation 1

That the City refer this file to Legal Services to determine the feasibility of obtaining compensation from the consultant and the 2004 contractor for the costs of design and construction of the 2007 deck repair.

Management Response

Management agrees with the recommendation. Files will be referred to Legal Services for review in Q4 2009.

Recommendation 2

That the City undertake the work themselves or requests proposals from a different consultant in cases where recently constructed works fail prematurely, to ensure that the original design is subject to adequate peer review.

Management Response

Management agrees with the recommendation.

Effective immediately, Infrastructure Services will ensure that in cases where work is to be done as a result of construction works that have failed prematurely, requests for proposal will be sought from a different consultant or the work will be undertaken by the City.

Recommendation 3

Given that in the 2004 contract the Inspector did not notice that the shims were not galvanized, and in the 2007 contract the Inspector was not on site at all times when the deck was being placed, that the City ensure that projects in which part-time construction inspection will be provided be arranged such that the Inspector has detailed instructions and sufficient decision latitude to allow the Inspector to ensure that critical construction steps are inspected.

Management Response

Management agrees with the recommendation.

The reference to provisions for part-time inspections is consistent with the Infrastructure Services department's Inspection Manual for City Construction Contracts.

Recommendation 4

Given the information provided by Management regarding sagging and twisting of the steel stringers, that the City arrange for a different consultant to inspect the bridge, with particular regard to the existing sagging and twisting of the steel stringers.

Management Response

Management agrees with the recommendation. This inspection will be completed by Q2 2010.

6 CONCLUSION

The design and construction of the 2004 deck replacement of the structure that was the subject of a Fraud and Waste Hotline report (i.e., Conley Bridge) had several deficiencies that were directly responsible for the failure of the deck in 2005. The additional cost to the City due to the premature failure of the deck is $97,570 plus GST. The City should consider action regarding the design and construction administration against the consultant and the contractor involved in the 2004 contract. The subsequent design of the second deck replacement in 2007 should have been carried out by the City or a different consultant.

7 ACKNOWLEDGEMENT

We wish to express our appreciation for the cooperation and assistance afforded the audit team by management and staff.

Appendix A – Bridge Inspection Sheets

2003 Inspection

Bridge Primary Components comprise the bridge superstructure (in turn classified as beam and slab, truss, or arch systems), abutments, piers and columns, Approaches, Hydraulics and General. The rating codes are:

6-Very Good	5–Good	4-Fair	3-Poor	2-Urgent	1-Critical	0-Not applicable

The Inspection Sheets for the visual inspection done in August 2003 showed that the structure rating was D. The Inspection Sheets provide ratings for the following components and properties of the bridge:

Component	**Rating**	**Comments**
General		
01. Deflection		
02. Vibration	5	Some vibration with light load.
03. Alignment	5	
04. Damage	5	
Beam & Slab		
05. Deck/Slab Soffit	5	Rust stain adjacent to top flange.
06. Longitudinal Beams	5	Light rust.
07. Transverse Beams	5	Light rust.
08. Diaphragms		
09. Stringers		
10. Bracing System	5	Light rust. One deformed member at each end of structure.
11. Connections		
Truss System		
12. Top Chord	5	
13. Bottom Chord	5	
14. Diagonals & Verticals	5	Minor plow damage each side.
Arch System		
15. Ribs or Barrel		
16. Spandrels		
Abutments		
17. Foundations		Not visible.
18. Main Wall	4	Numerous cracks and scaling. Map cracking at repairs. Cracks and delaminations at top of abutment face.
19. Wing Walls	4	Cracks and stain visible (efflorescence). Small spalls. Concrete deterioration as southwest and southeast corners, Picture 1 of heavy deterioration at northwest corner.
20. Ballast Wall	5	
21. Bearings	5	Steel plates.

Component	Rating	Comments
Piers & Columns		
22. Foundations		
23. Stem		
24. Columns		
25. Cap Beams		
26. Bearings		
Superstructure		
27. Wearing Surface	5	Transverse laminated wood deck: checking and splitting.
28. Expansion Joints	4	Deck joints comprised of steel angles with evazote foam joint seal. Replace seals, both joints leak. Plow damage to steel angles at each end. See Picture 2.
29. Fixed Joint	4	
30. Median Joints		
31. Curbs	5	Wood curbs (4x4s): splitting, plow damage.
32. Sidewalks		
33. Median		
34. Fascia	5	Ends of deck timbers.
35. Deck Drains		
36. Parapets		
37. Railings	3	Steel tube (2R pipe) not structurally adequate. Pipe separated at northwest. Replace or repair at north end corners (Picture 3).
38. Coating System	5	Minor surface rust.
39. Mechanical Equipment		
40. Electrical Equipment		
Approaches		
41. Settlement		
42. Wearing Surface	5	Asphalt: pitted, gatored.
43. Curbs & Gutters		
44. Slope Stability	5	
45. Guide Rails	5	SBGR west end treatments: Northwest end treatment damaged, guiderail. Replace or repair unsupported by 2 posts.
46. Signs & Postings	5	Load limits.
Hydraulics		
47. Ditches	5	
48. Rip Rap		
49. Substructure Scour		
50. Channel Flow	5	
51. Freeboard Adequacy	5	
52. Flooding		
Miscellaneous		
53. Plaques	5	Two at each end of structure (Pictures 3, 4).

The note on item No. 46 – Signs & Posting indicates that the bridge was posted for load limits. This was in conformance with the 1994 rehabilitation work.

2004 Inspection

Component	Rating	Comments	Recommendations
General			
01. Deflection	3	Unusually large deflection by small truck INVESTIGATION OF DAMAGE TO TIMBER DECKING.	
02. Vibration			
03. Alignment			
04. Damage	4	Plywood covers placed over areas of broken timber decking. Cause unknown.	Repair
Beam & Slab			
05. Deck/Slab Soffit	2	Deck deteriorating rapidly, extensive splitting, checking.	Repair or replace
06. Longitudinal Beams			
07. Transverse Beams			
08. Diaphragms			
09. Stringers			
10. Bracing System			
11. Connections			
Truss System			
12. Top Chord			
13. Bottom Chord			
14. Diagonals & Verticals			
Arch System			
15. Ribs or Barrel			
16. Spandrels			
Abutments			
17. Foundations			
18. Main Wall			
19. Wing Walls			
20. Ballast Wall			
21. Bearings			
Piers & Columns			
22. Foundations			
23. Stem			
24. Columns			
25. Cap Beams			
26. Bearings			

CITY OF OTTAWA - AUDIT OF BRIDGE MAINTENANCE PROCESS FOR A SPECIFIC BRIDGE
APPENDIX A – BRIDGE INSPECTION SHEETS

Component	Rating	Comments	Recommendations
Superstructure			
27. Wearing Surface	2	Pressure treated 2x6 (nominal).	Repair
28. Expansion Joints			
29. Fixed Joint			
30. Median Joints			
31. Curbs			
32. Sidewalks			
33. Median			
34. Fascia			
35. Deck Drains			
36. Parapets			
37. Railings			
38. Coating System			
39. Mechanical Equipment			
40. Electrical Equipment			
Approaches			
41. Settlement			
42. Wearing Surface			
43. Curbs & Gutters			
44. Slope Stability			
45. Guide Rails			
46. Signs & Postings	5	Load limits.	
Hydraulics			
47. Ditches			
48. Rip Rap			
49. Substructure Scour			
50. Channel Flow			
51. Freeboard Adequacy			
52. Flooding			
Miscellaneous			
53. Plaques			

This inspection record also noted that the bridge was posted for load limits.

2005 Inspection

Component	Rating	Comments	Recommendations
General			
01. Deflection	5	Some vibration with light load.	
02. Vibration	5		
03. Alignment	5		
04. Damage	5		
Beam & Slab			
05. Deck/Slab Soffit	5	Laminated wood (2x4).	
06. Longitudinal Beams	5	Light to medium rust especially in bottom flanges.	
07. Transverse Beams	5	Light rust.	
08. Diaphragms			
09. Stringers			
10. Bracing System	5	Light rust; one slightly deformed member at each end.	Monitor
11. Connections	5	Light rust.	
Truss System			
12. Top Chord	5	Light rust and few areas with medium rust jacking.	
13. Bottom Chord	5	Light rust.	
14. Diagonals & Verticals	5	Minor plow damage.	Monitor
Arch System			
15. Ribs or Barrel			
16. Spandrels			
Abutments			
17. Foundations		Not visible.	
18. Main Wall	4	Severe disintegration at northwest and southwest corners. Severe efflorescence at corners.	Monitor
19. Wing Walls	4	Weathering with light to medium scaling and efflorescence.	Monitor
20. Ballast Wall	5	Partially visible – light efflorescence and staining.	
21. Bearings			
Piers & Columns			
22. Foundations			
23. Stem			
24. Columns			
25. Cap Beams			

Component	Rating	Comments	Recommendations
26. Bearings			
Superstructure			
27. Wearing Surface	5	Laminated wood: small checks and few planks with medium rot.	Treat wood
28. Expansion Joints	4	Deteriorating compression seal and plow damage of armouring.	Replace seals
29. Fixed Joint			
30. Median Joints			
31. Curbs	6	Wood curbs: small splits and checks.	
32. Sidewalks			
33. Median			
34. Fascia	5	End of deck timbers: Splits with some broken ends.	
35. Deck Drains			
36. Parapets			
37. Railings	3	Steel tube (2R pipe) not structurally adequate; pipe separated at northwest and northeast corners. Light rust.	
38. Coating System	5	Light surface rust.	
39. Mechanical Equipment			
40. Electrical Equipment			
Approaches			
41. Settlement			
42. Wearing Surface	4	Medium ravelling at armouring. Severe gatoring in west. Projection of armouring.	Pad at armouring
43. Curbs & Gutters			
44. Slope Stability			
45. Guide Rails	5		
46. Signs & Postings	5	Load limits: NO TRUCKS.	
Hydraulics			
47. Ditches	5		
48. Rip Rap			
49. Substructure Scour			
50. Channel Flow	5		
51. Freeboard Adequacy	5		
52. Flooding			

Component	Rating	Comments	Recommendations
Miscellaneous			
53. Plaques	3	Two at east end: Northeast damaged.	

Appendix B – Bridge Photos

Conley Bridge, Jock Trail Road

City of Ottawa

Looking west from east approach

Looking west at bridge

Looking west at bridge

Looking west

Looking east from west approach

South end of west abutment

South west wingwall

Looking north (upstream) on west bank

View of east abutment

South elevation

West abutment

Detail of steel stringer and deck clip

End view of timber deck (south side)

View of deck, north curb and barrier, east expansion joint