

**DEH CHO BRIDGE – PHASE 1
FORT PROVIDENCE, NORTHWEST TERRITORIES**

REVIEW OF SUBSTRUCTURE DESIGN AND CONSTRUCTION

Prepared for:

Associated Engineering (BC) Ltd.
300 - 4940 Canada Way
Burnaby, BC V5G 4M5

Attention: Mr. Leslie Mihalik, P.Eng.

and

The Government of the Northwest Territories
Department of Transportation
4510 50 Avenue
P.O. Box 1320
Yellowknife, NT X1A 2L9

Attention: Mr. Kevin McLeod, P.Eng.

Prepared by:

Levelton Consultants Ltd.
150 - 12791 Clarke Place
Richmond, BC V6V 2H9

N.A. Cumming, FACI, P.Eng.
Executive Vice President

Reviewed by: R.F. Riffell, P.Eng, (BC, MB)
Principal

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1. INTRODUCTION

The Government of the Northwest Territories (GNWT) is undertaking the construction of the Deh Cho Bridge. The initial part of the work, now known as Phase 1, comprised the construction of eight piers, all of which are located within the Mackenzie River. The GNWT entered a Concession Agreement with the Deh Cho Bridge Corporation (DCBC), the scope of which included the design and construction of the bridge. The general contractor engaged by the DCBC for the work completed prior to June 17, 2009 was Atcon Construction Ltd. From June 17, 2009 until March 2010 the general contractor was Ruskin Construction Ltd.

A third contract was executed in March 2010 between the GNWT and Ruskin Construction for Phase 2 of the project, which entails construction of the superstructure, abutments, approach fills, and other miscellaneous work. Sargent and Associates Engineering Ltd. has been engaged as the Design Coordinator, and the design of the superstructure is being undertaken by Infinity Engineering Ltd.

Levelton Consultants Ltd. has been engaged by Associated Engineering (BC) Ltd. and the GNWT to conduct an audit of the Phase 1 work. This report describes the scope of the audit and its findings.

2. BACKGROUND

The substructure work comprising Phase 1 includes eight piers, each consisting of a reinforced concrete footing, lower buttress and upper buttress. Each upper buttress is protected by a structural steel ice armour component. A structural steel bent surmounts each pier. A rendering of a typical pier assembly, schematic drawing and several photos are included in Appendix A.

The design of the bridge was originally undertaken by J.R. Spronken and Associates Ltd. (JRS). In February, 2008, prior to the start of construction, JRS withdrew from the project and responsibility as the Engineer of Record passed to Jivko Engineering (Jivko). In January 2009 Sargent and Associates Engineering Ltd. (S&A) was engaged to investigate the JRS design of the superstructure; S&A engaged Infinity Engineering to assist. The geotechnical consultant for the project was EBA Engineering Consultants Ltd. EBA also had involvement in certain materials testing activities for various parties as the work progressed.

Atcon Construction Ltd. was awarded the prime construction contract by the DCBC and undertook through Atcon Industrial Services, a related company, to fabricate the steel ice armour components and pier bents at their facilities in New Brunswick. Construction of the concrete elements of the piers was subcontracted to Ruskin Construction Ltd. Construction of the concrete piers and fabrication of steel components began in 2008. In June 2009 the on-site work was taken out of the hands of Atcon, and Ruskin became the general contractor responsible for completion of the substructure. Work under this contract was completed in March 2010. Atcon, through their subsidiary AIS, continued to fabricate the steel components.

In early 2010 a further reorganization of the project occurred. Ruskin Construction became the prime contractor to complete the bridge, S&A was engaged as the Design Coordinator, and Infinity Engineering was engaged as the Engineer of Record to complete the design of the superstructure. Infinity's responsibility includes design of certain retrofit measures to make the Phase 1 piers and pier bents compatible with their design.

During construction of the Phase 1 work a number of issues arose. These related to concrete deficiencies (particularly at Piers 3S and 2N), design changes to the pier bents, fabrication of the pier bents, erection of the pier bents, and sourcing and placement of the scour protection rock.

Work on Phase 2 began in March 2010 and continues.

3. SCOPE

The scope of the audit undertaken by Levelton includes only the Phase 1 work and was intended to:

- Confirm that continuity of design responsibility has been established and that design issues arising during construction have been satisfactorily addressed by the Engineer of Record;
- Confirm that proper construction review and quality control/quality assurance have been completed, and that general compliance to the specifications and contract requirements has been established;
- Where closure on design and construction compliance cannot be established, identify the issues and deficiencies in order that appropriate closure can be completed during Phase 2.

4. APPROACH

To complete the audit Levelton undertook the following:

- Review of large volumes of documents contained in some 112 three-ring binders, obtained by the GNWT from Jivko Engineering;
- Review of other documents obtained from the GNWT, Associated Engineering, Atcon Construction, Ruskin Construction, and EBA Engineering;
- Review of inspection and testing records prepared by Atcon, Sargent and Associates Engineering Ltd. and their subconsultants during the steel fabrication process;
- Interviews with numerous people involved in the design and construction process.

Levelton also had direct involvement with certain repairs to Pier 2N and has relied on this involvement.

On September 24, 2010 a preliminary copy of this report was released to the interested parties. Written comments on the contents of the report were received from Ruskin and S&A. Additional interviews have been held with Ruskin, Allnorth, EBA, GNWT and Jivko to clarify certain details. Additional review of documents has been done on the basis of the comments received. As of November 4, 2010 no substantive response has been received from Atcon or the Trustee acting on their behalf, although a letter was received indicating that the timing of their response was uncertain.

This report reflects information received by Levelton as of November 4, 2010.

5. FINDINGS

5.1 ENGINEER OF RECORD – PHASE 1

The original design was prepared by J.R. Spronken and Associates Ltd. Sealed drawings dated 21 September 2007 were Issued For Construction. At the outset of the Phase 1 construction JRS withdrew from the project (Appendix B, Tab M). Jivko Engineering (Jivko) was then engaged by the DCBC to assume responsibility as the Engineer of Record. No formal appointment of Jivko in this capacity has been located, however an abundance of documentation makes it clear that Jivko was acting in the capacity of the Engineer of Record during the fabrication and construction process. This was confirmed verbally by Mr. Jivko Jivkov, P.Eng. to

Levelton in a meeting of May 18, 2010. Hence, for purposes of this audit, Levelton has established that JRS has taken responsibility for the original design by sealing and issuing the IFC drawings.

The record confirms that Jivko has accepted responsibility for design changes and has addressed design-related issues arising during construction. It remains to be determined whether the modifications to the design during Phase 1, and subsequently by Infinity during Phase 2, have extinguished JRS's responsibility for the original design, as implied in their letter of February 20, 2008. This is a legal and regulatory matter that is beyond the scope of this audit.

During the construction and fabrication process numerous questions and requests for clarification were directed to Jivko by Atcon and Ruskin. Jivko responded to many such requests, but in many cases definitive answers were not given. Although there were often references to pending follow-up, in virtually all such cases no follow-up documentation was found. It appears that all of the issues were resolved, usually verbally, to the satisfaction of Allnorth's QC Manager except as discussed herein.

Based on Levelton's review of the available documents, we are unaware of any remaining significant unresolved issues other than those discussed herein.

The GNWT engaged BPTEC-DNW Engineering Ltd. as the Territorial Advisor. BPTEC engaged several subconsultants to assist with the review of various aspects of the JRS design. Accordingly, BPTEC reviewed the design of the substructure and were involved in review of certain design issues and remedial work during construction. TY Lin International reviewed the design of the superstructure. BPTEC has advised Levelton verbally that they (BPTEC) were satisfied with the JRS design concept and have so advised the GNWT.

The GNWT has confirmed that they have issued written confirmation of:

1. Conceptual design approval (2006);
2. Design Review Reports 1, 2 and 3;
3. Certificates for the Substructure Piers 1-4N and 1-4S, with the qualification that the construction must be done in accordance with all the standards and signed off by the Engineer (which presumably refers to the designated Engineer of Record).

Refer to Appendix B, Tab A.

Design Report No. 3 is a comprehensive summary of the design review process and findings. It was issued in April 2009, at a time when construction of the four south piers was essentially complete. A number of design issues were raised, which were referred to the DCBC and their designers.

5.2 QUALITY CONTROL¹

As the general contractor Atcon had primary responsibility for quality control of its work and the work of its subcontractors and suppliers. The Special Provisions 1.2.3 Earthworks, 1.3.3 Foundation Works and 1.4.3 Steel Superstructure Works require that the Contractor appoint a qualified Professional Engineer to design methodology and procedures for the delivery of the work in accordance with the Plans and Specifications. The Professional Engineer is also required to design and implement a quality control program during the work and to certify that the completed work is in accordance with the Plans and Specifications and the applicable CSA

¹ For purposes of this report, Quality Control is defined as the activities undertaken by the General Contractor, their subcontractors and suppliers to confirm that the work and materials produced are in compliance with the requirements of the contract.

standards. It appears that the responsibility for QC was delegated to Ruskin and AIS for the Foundation Works and Steel Superstructure, respectively. Little or no evidence of an organized, comprehensive project-wide quality control program operated by Atcon has been located. It is evident from the record that this was a contentious issue between Atcon and Jivko. See Section 5.13.

Atcon's main subcontractors were Atcon Industrial Services (AIS), a related company, for the steel fabrication, and Ruskin Construction Ltd. for the on-site construction. Ruskin engaged Allnorth Consultants Ltd. to provide quality control services during construction. The Allnorth representative responsible for quality control on behalf of Ruskin was Mr. Don Williams, P.Eng. The quality control activities undertaken by Ruskin and Allnorth entailed preparation of Work Procedures, Inspection and Test Plans for each component, and certification checklists. A number of Nonconformance Reports (NCRs) were issued and resolved. These documents have been reviewed for each pier component.

Based on Levelton's review of the quality control documents, it appears that Allnorth and its quality control staff have performed their quality control obligations in a professional manner, with adequate scope and documentation, and in the interest of the owner.

Fabrication of the steel components began in early 2008. AIS prepared a QC Manual and was conducting internal QC activities. Mr. Derrick Locke is identified as AIS's QC Manager, however it is Levelton's understanding that Mr. Locke was not a Professional Engineer registered in New Brunswick at the time. It appears that the designated professional engineer responsible for quality control was Mr. Dale Robertson, P.Eng., a welding engineer employed by AIS. AIS engaged Technico Inc. to conduct visual inspection and nondestructive testing. Numerous internal quality control reports and related documentation were produced, however it is evident from the independent QA reports that AIS's QC program was not well organized, and that it lacked effectiveness. This is discussed in further detail in Sections 5.3, 5.12 and 5.13.

Turnover Packages were prepared by AIS for each of the major components, which are currently in the possession of Sargent and Associates. They have not been transmitted to Jivko or to the GNWT. Levelton was granted access to review these documents, but has not been able to make copies for a detailed review.

5.3 QUALITY ASSURANCE²

During the design review process the issue of quality management was raised by the GNWT and its advisors as requiring more attention. Despite this, it is evident that no formal project-wide quality assurance program was in place, but it is clear that Jivko was undertaking some related activities in the capacity of the Engineer of Record. These included on-site review and approval of the construction work, review of Ruskin's and AIS's QC records, involvement in resolution of deficiencies, and processing of payment certificates. Where design issues arose they were referred to Jivko for resolution. It appears from the record that Jivko representatives were on site essentially full time from June 2008 through late March 2010. At least seven individuals were involved, however for the majority of the time only one was present on site.

Notwithstanding this, Mr. Jivkov has advised Levelton (meeting of May 18, 2010) that Jivko was not given a formal mandate or budget for a comprehensive quality assurance program, and they relied heavily on the QC activities of Ruskin and Atcon/AIS.

In the late summer of 2008 Jivko appointed Sargent and Associates Engineering Ltd. to conduct in-plant quality assurance of the steel fabrication by AIS. S&A retained Geocon Atlantic to conduct in-plant review and surveillance of the fabrication. Geocon's first report was issued on

² For purposes of this report, Quality Assurance is defined as the activities undertaken by the Owner and their designated consultants to monitor the Contractor's QC activities to assure themselves that the Contractor's QC program is effective and provides assurance that the work and materials produced comply with the requirements of the contract.

October 22, 2008. At the time S&A/Geocon began their work steel fabrication had been under way for a number of months, and most components were in a state of partial completion, summarized as follows:

- ♦ Pier Armour: Piers 1-4S and 4N were completed and shipped prior to S&A/Geocon arrival;
Pier 1-3N was completed while S&A/Geocon were on site at AIS.
- ♦ Pier Bents: Were in the following state of production when S&A/Geocon arrived at AIS:

P1S – 37%	P1N – 30%
P2S – 48%	P2N – 22%
P3S – 92%	P3N – 47%
P4S – 74%	P4N – 38%

Geocon produced 55 reports between October 22, 2008 and November 6, 2009. It is evident from these reports that AIS's QC program was not well organized, and significant deficiencies in the QC process and the fabrication work were noted.

Based on Levelton's review of the Geocon records it appears that the QA work undertaken by Geocon is well-documented and appears to have been thorough and competent. It should be noted, however, that the scope of Geocon's review and surveillance cannot be considered as a substitute for proper QC by AIS.

During the course of this audit, Levelton was granted access to S&A's records, some of which have not been transmitted to Jivko or the GNWT. The records retained by S&A contain formal Turnover Packages prepared by Atcon for each of the major components of the steel fabrication work. For the portion of work completed prior to S&A/Geocon's involvement, there was no independent verification or review of AIS's work or QC activities. S&A/Geocon noted considerable variability in Atcon's approach to QC and extensive deficiencies in the QC testing itself.

After the commencement of their involvement, S&A became aware that the record did not contain sufficient detail to qualify the plate utilized in the bent fabrication for fracture-critical elements, as required by CSA S6-00, the Canadian Highway Bridge Design Code. An investigation into the development of a recovery plan for existing fracture-critical members was begun by S&A, but was subsequently terminated by Jivko in favour of an alternate approach to resolving the issue. This is discussed further in Section 5.13.

Owing to the disparities in the early Atcon QC identified by S&A/Geocon, Levelton's confidence in the integrity of the early Atcon QC is limited. The extent to which the early AIS/Technico QC work is documented in the Turnover Packages requires further review.

5.4 FOOTING BEARING SURFACE APPROVAL

Piers 1 to 4 South bearing soils were not inspected by the geotechnical consultant, EBA Engineering Consultants Ltd., prior to pouring footing concrete. To verify that the footings were founded on the intended soils and that pre-pour clean-up of loose or softened soils was done, test holes were drilled through the footings as detailed in the EBA Engineering Consultants report issued April 2010. EBA issued a letter on October 30, 2008 approving the bearing soil at Piers 1 to 4 South. See Appendix B, Tab B.

Ruskin began drilling for the Pier 2 South Footing on the basis of the footing elevation shown on the original design drawings. With about 20% of the drilling complete at the east end of the footing a design change was issued by Jivko (Field Change Notice FCN 001, July 6, 2008) raising the bearing elevation by 1.5 m. This resulted in about 20% of the footing area being drilled to an elevation 1.5 m deeper than required. This is addressed in NCR No. 1, October 28, 2008, which is included in Appendix B, Tab C. The over-drilled area was excavated and filled

with concrete as detailed in the P2S Cofferdam Excavation and Remediation Work Plan and accompanying inspections, also included in Appendix B, Tab C. This NCR was satisfactorily closed and signed by Jivko.

Bearing soils were inspected at Piers 1 and 2 North and Piers 3 and 4 North, and approved by EBA Engineering Consultants Ltd. prior to pouring footing concrete as documented in their letters of October 6, 2009 and September 24, 2009 respectively. See Appendix B, Tab D.

Based on Levelton's review of the available documents, it is concluded that there are no outstanding construction issues with respect to the bearing soils at Piers 1-4 South and 1-4 North.

5.5 CONCRETE SUPPLY

Atcon retained responsibility for supply of concrete to Ruskin from the start of construction through June 2009. This was subcontracted to Rowe's Construction Ltd. EBA inspected and tested the aggregate production from the Hwy 3 Km 87 pit, approved it for concrete production, and prepared concrete mix designs supported by trials. EBA also provided testing of concrete during production and placement. This is documented in EBA reports of June 10, July 18, August 25, and September 1, 22 and 30, 2009. After June 2009 Ruskin supplied the concrete from a dedicated site batch plant.

The frequency of testing meets or exceeds the requirements of CSA A23.1-04. Levelton has reviewed the available test records and found that strengths exceeded the design requirements in all cases. There are no significant deficiencies in the test records.

Deficiencies with aggregate gradation (excessive fines) were cited as a concern with respect to Piers 1-4 South, but concrete strengths remained above the specified strengths, and Levelton does not consider this to be of significance.

5.6 CONSTRUCTION – PIERS 1-4 SOUTH CONCRETE ELEMENTS

Certification documents have been completed by the Quality Control Manager, Don Williams, P. Eng. of Allnorth Consultants Ltd. See Appendix B, Tab E. The certifications list Work Procedure Plans and Inspection Test Plans for various components of the work and provide verification that works were completed in accordance with the contract plans, specifications and applicable CSA standards. In most cases this is confirmed by a signature of a Jivko representative.

In all cases where Work Procedure Plans and Inspection Test Plans were found in the documentation provided to Levelton, the ITPs confirmed the line item inspections as certified by the Quality Control Manager, Don Williams, P.Eng. Quality Control Certification of Piers 1, 2, 3 and 4 South are for the most part supported by ITPs, however concrete strength, rebar inspection and as-built location are excluded from the scope of Allnorth's certifications, since these items were reportedly inspected by the owner's engineer (Jivko) or information in the possession of Atcon was not made available to Allnorth's Quality Control Manager. The reason for exclusion of the rebar placement has not been reconciled, since placement of rebar is clearly within Ruskin's scope.

Levelton has reviewed the concrete test reports prepared by EBA and determined that there are no significant deficiencies in strength or air entrainment.

With respect to Piers 1-4 South Lower and Upper Buttresses, signatures by Jivko representatives on the Allnorth ITPs appear to confirm that the rebar inspection was done and found to be acceptable, however no formal rebar inspection reports have been located. In the case of the Pier 2S Lower Buttress, the Rebar Spacing line item is not signed by Jivko. Notes on the Allnorth Footing certifications refer to verbal approval of rebar by Jivko, however similar signatures do not appear on the certifications, and again, no rebar inspection reports have been located.

Mr. Jivkov has advised verbally (meeting of October 19, 2010) that all rebar for the south piers was inspected and accepted as compliant with the contract, and that evidence of such is contained in the payment certificates and supporting documents. Review of Payment Certificates No's. 5, 7, 9, 11, and 12 indicate that rebar received and placed in Piers 1-4S up to December 2008 was inspected and approved by Jivko.

It appears that surveys of the as-built locations were completed but not provided to Allnorth. It is Levelton's understanding that any remaining deficiencies related to the as-built locations and alignment of the piers are being dealt with as part of the Phase 2 work.

The drilling program used to check the footing bearing surface (See Section 5.4) encountered zones of poor quality concrete in the Pier 3 South Footing. Extensive remedial work was done, which involved the construction of a thickened reinforced concrete slab on the top of the east end of the footing. The design of this repair was approved and sealed by Jivko (Appendix B, Tab F), and repairs were satisfactorily completed and certified by Allnorth. Details and the status of the repair are contained in separate Levelton memoranda dated May 6, 2010 and June 7, 2010, which are included in Appendix C. Additional work is required to investigate the possible presence of one area on the top of the footing where a depression in the concrete surface may have left rebar exposed. If the presence of exposed rebar is confirmed, repairs will be required.

5.7 CONSTRUCTION – PIERS 1-4 NORTH CONCRETE ELEMENTS

Piers 1-4N were constructed by Ruskin acting as the general contractor. Certification documents for Piers 1-4 North have been completed by the Quality Control Manager Don Williams, P. Eng of Allnorth Consultants Ltd. See Appendix B, Tab G. The certifications list Work Procedure Plans and Inspection Test Plans and provide verification that works were completed in accordance with the contract plans, specifications and applicable CSA standards. Nonconformance Reports listed with the certifications are reported as being corrected and/or resolved to the Owner's satisfaction.

In all cases where Work Procedure Plans and Inspection Test Plans were found in the documentation provided to Levelton, the ITPs confirmed the line item inspections as certified by the Quality Control Manager, Don Williams, P.Eng. Where specific ITPs were not located, details and comments are included with the individual Pier Reports which form the Appendix of Levelton's July 9, 2010 report, in Appendix C.

Although there are some missing individual ITPs in the documentation available to Levelton Consultants as of November 4, 2010, there is, in Levelton's opinion, sufficient overall inspection documentation and daily report information to provide confidence that Allnorth's Quality Control Certifications of the Pier Footings, Lower Buttress and Upper Buttress in Piers 1, 2, 3 and 4 North are representative.

5.8 THERMAL CRACKING

Considerable effort was made to protect and heat the buttress concrete while curing in very cold weather. Temperature differentials between the buttress core and the surface exceeded specified limits of 25°C during curing in cold weather, raising concerns of potential thermal cracking. Jivko requested Ruskin to address the issue of possible thermal cracking, who in turn engaged Allnorth to investigate and report on the possible effects. Thermal cracking was addressed in the February 25, 2010 Quality Control Memo No. 12, following an investigation by Ruskin, and Quality Control Manager, Don Williams P. Eng. Mr. Williams wrote, *"...if cracking does exist it should have a minimal effect on the piers"*. A copy is included in Appendix B, Tab H. No further documentation related to this issue has been located, and it is inferred that the Allnorth memo submitted in response to the Jivko request was accepted by Jivko as a satisfactory resolution of the issue.

5.9 PIER 2 NORTH LOWER BUTTRESS

A zone of poor quality concrete 1 to 1.5 m thick was discovered in the lower buttress of Pier 2 North. The poor quality concrete occurred as result of an error which resulted in fly ash and cement being placed in the opposite silos. The silos were later cleaned and their contents inspected and approved. The zone of poor concrete was removed to expose sound concrete and reinstated as detailed in the Levelton Consultants Pier 2 North Rehabilitation letter dated May 6, 2010, which is included in Appendix C.

5.10 PIERS 3 AND 4 NORTH FOOTINGS

Following dewatering of the cofferdam three areas with exposed rebar were discovered on the Pier 3 North Footing and one area on Pier 4 North Footing. All areas were repaired and inspected to the satisfaction of the Owner's representative (Jivko) as noted in Quality Control Memo No. 6 dated October 28, 2009 (Appendix B, Tab I).

5.11 CONSTRUCTION – SCOUR PROTECTION ROCK

5.11.1 South Piers

The Special Provisions dated February 14, 2008 require that scour protection rock consist of limestone obtained from an existing quarry located at Hwy 3 Km 156. A gradation specification is given, which was modified to a smaller size range on October 22, 2008.

Section 1.3.11 of the Special Provisions stipulates other requirements for the production and placement of the rock. Briefly, the requirement is for blasted rock with 80% of particle sizes between 200 and 600 mm. It is required that a 1.5 m wide scour protection berm be placed immediately after installation of the sheet pile cofferdams. There is a further requirement for underwater inspection of the scour protection.

Scour protection rock for Piers 1-4S was obtained from the designated quarry at Hwy 3 Km 156. This source was approved by Jivko, although it appears that no formal testing of physical properties and durability was conducted. Hence, the basis of the source approval is uncertain.

The rock was reportedly produced and transported in raw form to the site by Rowe's Construction, and screened there. EBA Engineering was retained by Rowe's to conduct gradation tests on the rock during placement. EBA produced three reports, which are included in Appendix B, Tab L. The following points arise from the EBA reports, which appear to pertain to Piers 1-4S:

- ♦ The initial site visit was made on November 6, 2008 at which time two samples of stockpiled rock were obtained and assessed for gradation. It was stated that there was no specification, but an agreement had been reached that required rock for all but the upper 600 mm to be coarser than 100 mm. Jivko Jivkov was on site monitoring placement of the rock and was apparently satisfied. EBA concluded that the gradation was suitable for the lower course of scour protection, i.e. all but the upper 600 mm. The source of the rock was not identified, but it was observed by EBA that the material appeared to break down during handling and placement.
- ♦ EBA made a second site visit on December 2-3, 2008, at which time blasted rock from the Highway 3 Km 155 quarry was sampled. A revised specification for the blasted rock is cited, which requires particle size between 200 and 600 mm, which is a reference to the October 22, 2008 revision of the specification. Testing by EBA found that essentially 100% of the blasted rock was finer than the specification allowed. On the same day samples were taken of boulders obtained from Highway 1 Km 151 and Highway 3 Km 87 sources. It was found that the boulder samples essentially complied with the cited specification. To arrive at an acceptable gradation there was discussion of a 4:1 blend of boulders to blasted rock.

- ♦ A third site visit was made by EBA on January 27, 2009. The report refers to a 2:1 blend of boulders to blasted rock. EBA monitored the proportioning and assessed the gradation of the resulting blend, and concluded that it was in compliance with the specification cited.

The EBA reports make reference to placement of rock within the sheet pile cofferdams, however no reference is made to placement of the required scour protection berm on the outside of the cofferdam after installation of the sheet piles. The EBA reports imply that the scour protection rock was to be placed in two layers, with the upper 600 mm layer being of coarser gradation than the underlying material. No reference to this configuration has been seen in the design documents. It is Levelton's understanding that the scour protection rock was placed within the cofferdams, after which the sheet piles were removed, which allowed the rock to spill out and settle at its natural angle of repose. This being the case, it is unlikely that the two-layer configuration has been achieved.

At the time of writing, Levelton has been able to confirm source approval for the scour protection rock, but the basis of the approval is uncertain. The fact that at least some of the material did not meet the gradation specification and was observed to break down during placement is cause for concern, particularly since the matter of scour protection was raised as a critical issue by the Territorial Advisor during the design review (Deh Cho Bridge Project Conceptual Review Report, September 7, 2004). Levelton has been unable to confirm placement approval from the available documents. Review of the payment certificates prepared by Jivko confirms that only partial payment was made to Atcon in respect of delivery of the material to the site. No further payment was made for processing or placement of the scour rock.

5.11.2 North Piers

The Special Provisions dated July 22, 2009 allow scour rock to be obtained from two approved sources: Hwy 3 Km 232 or Hwy 3 Km 272. The gradation specification is a further modification of the previous specification, and allows material larger than 100 mm. The basis for the source approval or modified gradation is not clear.

5.11.3 General

There was considerable controversy among the various parties as to the acceptability of scour rock material, its gradation and placement. Levelton has not been able to verify from the available records that the as-placed material complied with the contract requirements or was approved by Jivko. Although Mr. Jivkov has stated verbally (meeting of October 19, 2010) that in the end he was satisfied with the scour rock as placed, Levelton is not confident that appropriate source approval, gradation and placement have been achieved.

A significant quantity of scour rock has been placed, and a bathymetry survey was done in August 2009. It is understood that an additional survey has been recently completed and that an analysis is under way to determine the condition of the scour protection rock on both the North and South piers.

The matter of the scour rock is under discussion and review, and remains to be resolved as part of the Phase 2 work.

5.12 STEEL FABRICATION – PIER ARMOUR

AIS has completed ITP Checklists and a Turnover Package for all eight pier armour components. The checklists do not appear to include specific references to technical specification requirements. There was no independent quality assurance review in place for Pier Armours 1-4S and 4N. It is noted that the checklists refer to Inspection and Test Plans, but no formal ITPs were found in the documents, and limited linkage to the specifications was established.

It appears that certain challenges to accurate fit-up of the armour were encountered in the field. In some instances, the longitudinal complete penetration butt joint welds in the plating were

replaced by an alternate design involving doubler plates and partial penetration welds and/or lap joint (fillet welds). The engineering authority that motivated the changes and the implication of the changes to design and performance are unclear in the written records examined to date, however Mr. Jivkov has confirmed verbally (meeting of October 19, 2010) that this design change was done under his direction and accepted.

5.13 STEEL FABRICATION – PIER BENTS

Based on Levelton's review of the Geocon records it appears that the QA work undertaken by Geocon is well-documented and appears to have been thorough and competent. Geocon has prepared a set of 55 quality assurance reports, No. 55 of which provides a comprehensive summary of the QA activities and findings; it is included as Appendix B, Tab M. The report is accompanied by a "Punch List" of deficiencies and QC issues, most of which were closed but some remained outstanding at the time and were referred to S&A and AIS for review. The Pier 2N documentation had not been submitted at the time of Report No. 55. The report notes two outstanding NCRs to be closed, as well as a number of RFIs. Collectively, there were a number of issues that were left for S&A and AIS to review and resolve where necessary. S&A have indicated that they are satisfied with the fabrication work completed under their review, and Levelton has concluded that there has been sufficient due diligence to support the acceptance of that work, subject to satisfactory resolution of the outstanding NCRs and Punch List items noted in Report No. 55.

For the portion of work completed prior to S&A/Geocon's involvement, there was no independent verification or review of AIS's work or QC activities, however Geocon has stated, "*Any deficiencies found by Owner QA during monitoring and review were corrected when found and/or stated in NCRs, RFIs and Punch list.*" S&A/Geocon noted significant deficiencies in AIS's QC activities, and Levelton has not developed confidence that the QC activities can be relied on without independent verification by S&A/Geocon.

Failure to identify horizontal elements of the Pier Bents as fracture-critical as required by CSA S6-00 was evident in email correspondence as of July 17, 2008. It was further noted in Jivko's Payment Certificate No. 7 dated September 20, 2008 that clear indication of fracture-critical members was omitted from the contract drawings, at which point fabrication was well-advanced. The Contractor had been instructed to discontinue the fabrication of the fracture-critical members until an appropriate plan and procedures for fabrication of fracture-critical members was in place. Ultimately a concept involving post-tensioning of the fracture-critical members was developed and implemented. There was considerable effort spent on resolving this issue, however final resolution in a manner that is consistent with the Infinity design is currently in process as part of the Phase 2 work.

Jivko Payment Certificates 11, 12 and 25 make reference to the need for Atcon to submit complete quality control records in order to permit processing of payments. Certificate No. 26 dated December 15, 2009 states, "*The Engineer confirms that all sections of the Pier Bents were received on site in good order and recommends payment of the balance of the prorated total ...*"

It is noteworthy that Jivko has issued a letter dated October 7, 2009 verifying that Pier Armour 1-4N, base plate templates for Pier 1-4 (N or S not stated) and Pier 1 (N or S not stated) lower bent section have been inspected and found to be within specification. Subsequently on January 18, 2010 the Deh Cho Bridge Corporation issued a letter signed by Jivko Jivkov and Andrew Gamble, confirming that "*...all sections of the Pier Bents North fabricated in the Atcon's shop (sic) in Miramichi, NB meet the quality requirements specified in the contract and the established geometric tolerances.*" Copies of both letters are included in Appendix B, Tab J. Also included is an email from Jivko dated September 23, 2009 accepting the geometric fit of the four template rings for the north piers, and the fit of the lower section of Bent 1N. Although AIS has prepared formal Turnover Packages for these components, due to the lack of independent quality assurance and the apparent deficiencies in the QC activities by AIS, Levelton has not

seen adequate documentation to support acceptance of the fabrication work completed prior to S&A/Geocon's engagement.

5.14 ERECTION – STEEL PIER SECTIONS

Certification documents for steel erection for Piers 1-4 North have been completed by the Quality Control Manager Don Williams, P. Eng of Allnorth Consultants Ltd. See Appendix B, Tab K.

The Allnorth Consultants' certifications of Piers 1 to 4 North Steel Sections are limited to the assembly and erection of the pier steel components and do not provide certification of the fabrication of the pier steel components themselves.

In all four cases, the Certifications declare that the *“Pier steel is not ready for installation of superstructure.”* The Certification notes, along with the associated NCRs, identify component deficiencies and the modification steps required to complete the assembly of the components. Although there are some missing ITPs in the documentation at hand as of November 4, 2010 there is, in our opinion, sufficient overall inspection documentation to provide confidence that the Allnorth Quality Control Certifications of the assembly of the steel components in Piers 1, 2, 3 and 4 North are representative of their state of assembly at the time of certification. It is Levelton's understanding that the outstanding modifications and assembly deficiencies noted in the NCRs and Certification notes are to be completed in Phase 2.

It is significant that Allnorth Consultants' Certifications of the steel Sections, Piers 1 to 4 North are conditional upon the DCBC letter dated January 18, 2010 (Appendix B, Tab K) authorizing Ruskin Construction to proceed with installation of the steel elements provided, subject to eight conditions. Allnorth has described the steel components as deficient in both their Certification notes and the associated NCRs; such deficiencies principally deal with dimensional and mating surface issues between components. Levelton's review of the documents at hand as of November 4, 2010 combined with information provided during an interview of Mr. Dennis Sargent, P.Eng. raise concerns that there is inadequate documentation of the fabrication of bridge steel components prior to Sargent's involvement in late 2008. Explanatory component documentation will need to be found before Levelton will be able to substantiate Jivko's approval of the bridge steel components referred to in the DCBC/Jivko Engineering letter to Ruskin Construction: Deh Cho Bridge Construction - Erection of North Pier Bents, dated: January 18, 2010 (Appendix B, Tab J).

No certifications or related documents pertaining to the erection and fit-up of Piers 1-4S have been located.

5.15 EARTHWORKS

The earthworks include approach fills at the north and south abutments and associated armour rock. Review of the Jivko payment certificates and supporting details indicates that a substantial amount of work was done and approved by Jivko, however the work was not completed at the time Atcon's on-site work was discontinued. EBA was retained by Rowe's Construction to provide density testing on an as-and-when-required basis during construction of the approach fills. Levelton has been advised by EBA that the density test results did not cover the entirety of the work, but the testing that was done generally indicated satisfactory results. Review of certain records included with the payment certificates supports this. There is no information on source approval of the material.

Levelton has been advised by EBA that they are extensively involved in remedial work now under way on both approach fills, and that work is proceeding satisfactorily as part of the Phase 2 scope. EBA anticipates that all outstanding deficiencies and uncertainties will be resolved, and that upon completion they will be in a position to recommend acceptance of the approach fills.

5.16 OUTSTANDING NONCONFORMANCE REPORTS

Levelton has located two sets of NCRs in the documents: two raised by Jivko, and thirty-two raised by Allnorth. They appear to be numbered and tracked separately. The two Jivko NCRs pertain to the change in bearing surface elevation at Pier 2S and the Pier 3S Footing repair, and appear to have been closed satisfactorily as discussed above.

Allnorth NCRs 1 through 21 have been satisfactorily closed and endorsed by Jivko. NCRs 22 through 32 remain open and are being dealt with as part of the Phase 2 work.

6. SUMMARY AND RECOMMENDATIONS

6.1 GENERAL

Levelton's review of the documentation and information referenced above, found significant deficiencies in document control, quality control and quality assurance. It is also evident that a number of technical issues remain unresolved or that documentation of the resolution is lacking. In some cases work is under way as part of the Phase 2 scope to resolve the issues.

It is possible that production of additional documents by one or more of the Phase 1 participants may provide clarification and allow closure of certain issues. On Levelton's recommendation, a preliminary issue of this report was provided to Atcon, Jivko, Ruskin, EBA, Allnorth, Spronken and Sargent and Associates to allow them to correct any inadvertent misstatements of fact and to provide any additional documentation in their possession that would clarify the unresolved issues. Ruskin provided a written response with a number of comments on details in the report, and certain clarifications have been made. Sargent provided a comprehensive written response clarifying a number of items, which have been incorporated into this report. Brief responses were obtained from Jivko and the Trustee acting for Atcon, however no technical details or additional documents were provided. Additional discussions were held with Jivko, Ruskin, Allnorth, Sargent, GNWT and EBA. The GNWT provided some additional documents.

This issue of the report reflects the information received as of November 4, 2010. If significant additional information is subsequently provided, an addendum may be issued at the discretion of Levelton and the GNWT.

Table 1 was prepared in consultation with the GNWT and Associated Engineering. It provides a summary of the major issues identified by Levelton and their status. Further commentary appears in Sections 6.2 through 6.6 below. The reader is advised that the conclusions and recommendations presented are subject to the remarks in Section 6.7.

6.2 DESIGN RESPONSIBILITY

It has been established that J.R. Spronken and Associates Ltd. has issued sealed IFC drawings and has therefore assumed responsibility for the original design of the substructure. This is further confirmed in their letter of February 20, 2008. The design concept was reviewed by BPTEC on behalf of the GNWT and was found to be acceptable. This was confirmed by BPTEC in an email to Levelton on August 11, 2010. The GNWT has reported that they have additional documentation on file confirming acceptance of the Spronken substructure design.

Design Report No. 3 of April 2009 identifies a number of design issues, and "*serve(s) as a record of the technical issues that need complete resolution leading to the acceptance and approval of the design in accordance with the Concession Agreement and the Canadian Highway Bridge Code (sic).*" These issues were referred back to the DCBC and the designers, S&A and Infinity. **Levelton recommends that S&A/Infinity confirm that all design issues raised in the report have been satisfactorily addressed.**

Certain design issues arose during fabrication and construction. They were addressed by Jivko acting in the capacity of Engineer of Record. Two significant issues remain outstanding:

1. Compliance of the Pier Bents to the fracture-critical requirements of CSA S6-00;
2. Dimensional tolerances at certain splice connections in the Pier Bents.

Both of these issues are under review as part of the Phase 2 work. **It is Levelton's recommendation that they be resolved to the satisfaction of Infinity Engineering and Sargent and Associates as part of their Phase 2 involvement.**

J.R. Spronken's letter of February 20, 2008 (Appendix B, Tab M) states, "*Spronken will not be liable for any changes, modifications, or interpretations whatsoever to its drawings and all such changes, modifications or interpretations must be reviewed, approved and certified by a duly qualified design engineer in accordance with prudent engineering practice and the applicable professional standards.*" In view of the fact that certain modifications were made during construction of the piers, and subsequently to accommodate the Infinity superstructure design, **it is recommended that this matter be carefully reviewed by the GNWT and the current designers to ensure that proper continuity of design responsibility is established.** Ideally, Infinity's scope should be expanded to include review and certification of the substructure design to ensure full compatibility with their superstructure design.

6.3 CONSTRUCTION – REINFORCED CONCRETE ELEMENTS

The South Pier Certifications prepared by Allnorth are incomplete, however after review of relevant documents and interviews with Jivko, Ruskin and Allnorth, Levelton has concluded that the outstanding issues regarding rebar inspection and concrete strength have been resolved.

Remaining outstanding issues related to alignment and location of the piers should be addressed as part of the Phase 2 work, and it is understood that this is in progress.

The top surface of the Pier 3S footing should be examined in the area of the suspected depression to determine whether rebar has been left exposed. If so, appropriate repairs should be completed. It is noted that this defect, if it exists, is relatively minor and the requirement for action is not urgent. The investigation and repairs can be completed during or shortly after the Phase 2 construction at the convenience of the GNWT.

A design change during construction resulted in the bearing surface at Pier 2S being raised by 1.5 m after excavation had begun. **Levelton's review found that this issue had been satisfactorily resolved, but recommends it be reviewed by S&A/Infinity and EBA to ensure there is no impact on the Phase 2 superstructure design.**

Levelton recommends that the concrete elements of Piers 1 through 4 North be accepted based on Allnorth's certifications and Jivko's endorsement of them.

6.4 STEEL ELEMENTS

Sargent and Associates had significant involvement in the steel fabrication beginning in late summer 2008. There are Turnover Packages prepared by AIS in S&A's possession that should be incorporated into the project record. **Levelton recommends that the GNWT arrange with Sargent and Associates to formally submit this documentation.**

Based on Levelton's review of the available S&A/Geocon documentation and the Turnover Packages in S&A's possession it is believed that work completed under their review has been done satisfactorily, and that appropriate certification is in place. There remains significant uncertainty as to the status of work completed prior to S&A's involvement. Although AIS has prepared and submitted formal Turnover Packages to S&A, Levelton's review of their QC records did not provide confidence that the requirements of the contract have been met. **Levelton recommends that Atcon be requested to identify the professional engineer responsible for Quality Control pursuant to Special Provision 1.4.3, and to submit Turnover Packages with the appropriate certifications completed.**

Geocon's Report No. 55 (Appendix B, Tab N) makes note of a number of outstanding issues that were referred to AIS and S&A. **It is recommended that S&A review these items to determine whether further action is required.**

Levelton further recommends that S&A's scope be expanded to conduct whatever further review and testing are required in their discretion to enable them to extend their certification to encompass all components fabricated by AIS and incorporated into the project under Phase 1.

With respect to the erection and fit-up of the North Pier steel, there are a number of deficiencies and unresolved issues noted in Allnorth's certifications and the open NCRs. There is a lack of documentation pertaining to the erection and fit-up of the South Piers. Levelton is aware that some of these issues are being addressed within the scope of the Phase 2 work. Furthermore, modifications to the pier designs are being done under Infinity's direction. In order to ensure continuity of responsibility and to ensure that all outstanding items are properly resolved, **Levelton recommends that Infinity's scope be expanded to include the erection, fit-up and modifications to the Pier 1-4N and 1-4S steel components.**

6.5 SCOUR PROTECTION ROCK

The records available to date have not established an appropriate basis for source approval nor proper placement of the scour protection rock. It is also evident that there were deficiencies in the material gradation and it is uncertain as to whether the gradation was ultimately acceptable. This matter is ongoing as part of the Phase 2 work and remains to be resolved. **Levelton recommends that the scour protection rock materials and placement be reviewed by a qualified consultant as part of the Phase 2 scope.**

6.6 EARTHWORKS

Work is under way on remediation of the north and south approach fills, under the direction and monitoring of EBA. **Levelton recommends that this work proceed as planned, with EBA to provide certification of compliance when it is complete.**

6.7 DISCLAIMER

The information, conclusions and recommendations contained in this report are based on a review of an extensive set of documents provided by the GNWT, which were copied from Jivko Engineering. It is noted that some documents were illegible in the form received. It is further noted that the Jivko documents pertaining to Pier 2S, 3S and 2N appear to be incomplete.

Levelton has also sought and reviewed certain other documents from its own files, the GNWT, EBA Engineering Consultants, Sargent and Associates, Associated Engineering, Ruskin Construction and other sources, however Levelton is aware that the documents in hand do not constitute a complete record. No documents have been received from Atcon.

On September 24, 2010 a preliminary copy of this report was released to the interested parties. Written comments on the contents of the report were received from Ruskin and S&A. Additional interviews have been held with Ruskin, Allnorth, EBA, the GNWT and Jivko to clarify certain details. Additional review of the available documents has been done on the basis of the comments received. As of November 4, 2010 no substantive response has been received from Atcon or the Trustee acting on their behalf, although a letter was received indicating that the timing of their response was uncertain.

This report reflects information available and received as of November 4, 2010.

The reader is advised that it is likely that additional documents exist, or that documents reviewed by Levelton exist in later forms, which if produced, may change the conclusions and recommendations made herein. If significant additional information or clarification comes to light

after the issuance of this report, addenda may be issued at the discretion of Levelton and the GNWT.

Table 1: Summary of Findings

Serial	Item	Description	Action Required	Remarks
01	Documentation completeness: Overall, Phase 1 of the project had poor record and documentation control, leaving many gaps and uncertainties in QC and QA.	Overall QC/QA was disjointed and did not cover all aspects of the work. There was no formal QC program in place by Atcon. QC of steel fabrication by AIS was disjointed and lacked clear direction and focus.	Atcon should be requested to submit AIS Turnover Packages and certifications required by the Special Provisions. Arrangements should be made with S&A to submit Turnover Packages.	Contractors were responsible for QC and were obligated to carry out this service. Evidence shows this was not completed to the level expected for a project of this size and complexity. Allnorth appears to have conducted their duties reasonably well on behalf of Ruskin.
02	Quality Assurance.	No evidence that a comprehensive, project-wide QA program was in place. Jivko had a more or less continuous presence on site by one individual, although there was a lack of continuity and oversight. The scope of these activities is unclear.		Jivko retained Sargent and Associates to conduct in-plant QA of the steel fabrication, but this began several months after steel fabrication began. Sargent and Associates and Geocon appear to have conducted their duties reasonably well, but their scope did not include the early fabrication of steel. Phase 2 now has a comprehensive QA process in place.

Serial	Item	Description	Action Required	Remarks
03	Engineer of Record and Design Responsibility.	Lack of clear and continuous EoR chain of responsibility for Phase 1 of the Project. Spronken and Jivko are identified as EoR for the design and construction phases, respectively.	<p>A concise letter is to be provided by the GNWT clearly articulating who is the EoR for the various components of the structure.</p> <p>GNWT should review whether modifications to the Spronken design have extinguished Spronken's responsibility.</p> <p>S&A/Infinity should confirm that design issues raised in Design Report No. 3 have been addressed.</p>	Consideration should be given to expanding Infinity's scope to include design review of the substructure to ensure continuity and compatibility with the superstructure design.
04	Compliance of the Pier Bents to the fracture-critical requirements of CSA S6-00.	Evidence shows there was not sufficient detail to qualify the plate used in the pier bent fabrication for fracture-critical elements. This issue is under review as part of the Phase 2 scope.	<p>Further tests and/or reviews of the documentation are required in order to ensure the fracture-critical elements meet the code. Levelton recommends this issue be covered by Sargent and Infinity as part of the Phase 2 work.</p> <p>BPTEC/TY Lin to review piers after redesign and modification.</p>	
05	Footing Bearing Surface Approval for South Piers.	<p>1) South Pier footing bearing surfaces were not certified by the geotechnical engineer in accordance with the S6-00 and the specifications prior to pouring concrete.</p> <p>2) Raising of Pier 2S footing elevation during construction.</p>	<p>EBA has approved the south pier bearing surfaces, letters of October 30, 2008 and April, 2010.</p> <p>Change in bearing surface elevation should be reviewed by the Territorial Advisors, S&A, Infinity and EBA as to the impact of the higher elevation of Pier 2S bearing surface.</p>	

Serial	Item	Description	Action Required	Remarks
06	Allnorth certifications of concrete elements of Piers 1-4S are incomplete.	<p>No evidence of rebar inspection reports. Further review has established adequate inspection, but documentation is lacking.</p> <p>As-built surveys showed deficiencies in tolerances with respect to pier alignment.</p>	Alignment deficiencies to be dealt with as part of the Phase 2 work.	
07	Unrepaired concrete in the Piers 3S footing surface.	A possible depression in the concrete surface may have left rebar exposed over an area of <1 m ² .	Exposure of the pier footing and visual inspection of the suspected depressed area to be undertaken and corrective action to be taken if required. GNWT/Associated Engineering to arrange this with Ruskin.	
08	North Piers (concrete).	Levelton recommends acceptance of the concrete works on the basis of Allnorth certifications.	Formal acceptance by GNWT required.	
09	Turnover Packages of steel fabrication prepared by AIS have not been submitted to Jivko and thence to GNWT.		GNWT to make arrangements with Atcon and/or S&A to formally submit the documents.	

Serial	Item	Description	Action Required	Remarks
10	Steel Elements: Lack of QA and deficiencies in QC of steel fabrication prior to S&A involvement.	The overall QC for the fabrication in the AIS plant prior to Sargent and Associates' involvement in late 2008 was uncoordinated and disjointed resulting in a lack of confidence that the components were fabricated to the specifications.	Atcon to identify the P.Eng. responsible for QC of steel fabrication, and provide Turnover Packages with completed certifications. Expand S&A scope to include review and testing of fabrication work completed prior to their involvement. S&A to confirm acceptance of all steel fabrication. S&A to address issues remaining in Geocon Report No. 55.	This will likely require additional review and testing of completed steel on site. S&A to recommend scope and related requirements.
11	Scour Protection Rock: Records do not establish appropriate approvals for the type, gradation or placement of the protective scour rock.	Available records from EBA contain evidence of deficient material. There is no confirmation in the records of placement of scour rock to the specified dimensions. The basis for source approval is uncertain.	Review of the as-placed material and a full survey of the scour rock placement should be conducted by a qualified consultant to confirm type of rock, gradation, and placement are done to specifications and meet the needs of the project.	This issue will require further discussion among the Phase 2 design/management team to develop a complete action plan.
12	Steel Erection.	There are outstanding issues regarding dimensional tolerances, plumbness and alignment.	Levelton recommends this be dealt with as part of the Phase 2 work.	
13	Earthworks.	Inadequate documentation of source approval and compaction. Evidence of construction deficiencies.	Work is under way in Phase 2 to resolve the outstanding issues. EBA to provide certification of the work on satisfactory completion.	

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