DISRAELI BRIDGES PROJECT

1 Introduction and Background

The construction of the Disraeli freeway was completed in 1960, connecting Henderson Highway with the City's downtown via Main Street. The freeway provides a vital link of approximately 2 kilometres in length between the downtown and the northeastern quadrant of the City. This road system includes a bridge over the Red River and a CPR Overpass which were opened in 1959 and 1960, respectively. Figure 1 depicts the expanse of this freeway.

Condition Assessment of the facility in 2006 identified numerous deficiencies that required either rehabilitation or upgrading in order to achieve a further 75 year service life and to meet current design standards.

Based on the condition assessment report, the City identified that a major rehabilitation of the existing Disraeli Bridges (Red River Bridge and the CPR Overpass) and upgrading of the approach streets and traffic interchanges was required.

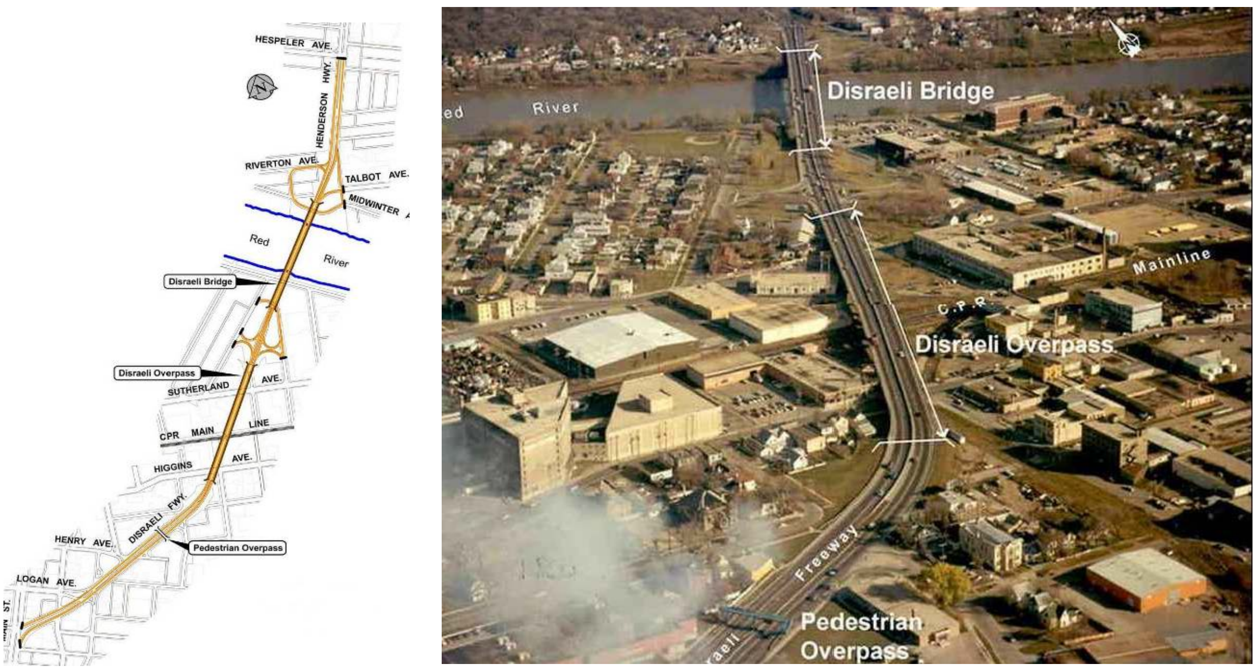

Figure 1 – Existing Disraeli Facility

2 Bridge Rehabilitation Needs

The City commissioned a consultant to undertake a detailed condition assessment of the entire Disraeli Facility from Main Street to Hespeler Avenue to identify material and performance deficiencies that needed to be incorporated into the rehabilitation works and to determine the remaining service life of the structure. A road safety review and an accessibility audit were also included in the assessment to identify works associated with road and structure safety as well as pedestrian safety and accessibility. In addition, a load rating of the existing structure was conducted in accordance with the CHBDC to determine strengthening requirements.

Significant issues respecting future traffic capacity, safety concerns for interchange access, barriers, vulnerability of pedestrians and cyclists, street lighting, narrow sidewalks, tripping hazards, lack of bicycle lanes, lack of separation between roadway and sidewalk, and poorly located crossings were identified.

Based on the rehabilitation needs, conceptual alternatives and preliminary designs for rehabilitation of the Bridges were prepared. The preferred concept provided a basic minimum rehabilitation alternative for the existing facility, which required no modification to the abutment and pier substructures. The steel superstructures required strengthening comprising of cover-plating the existing steel girders for the additional loads but no additional girder lines were required.

2.1 Community Profile Impact Study

A Community Profile Impact Study covering the adjacent neighbourhoods found that the Disraeli Freeway is viewed as a utilitarian bridge – a means for crossing over the rail line and Red River – but is not considered part of the adjacent communities. It was expressed by the stakeholders that the project contributes to the community by:

- Improving linkages with surrounding community amenities,
- Making pedestrian experiences more comfortable and safe,
- Reflecting the history of Point Douglas and Elmwood,
- Looking at ways to open up access within Point Douglas, and
- Considering how the Disraeli Freeway can serve as an opportunity for future land development and growth.

2.2 Request for Proposal

Advice and commentary received by the City from private sector participants involved in other Canadian Public-Private-Partnership (P3) projects encouraged the City to invite proposals for the Design, Build, Financing and Maintenance (DBFM) of new as well as rehabilitated Bridges in order to open competition to the best solutions that the private sector can offer by proposing either:

a) refurbishment,
b) new construction, or
c) a combination of refurbishment and new construction of the Disraeli Bridges Project.

The City conducted a value for money study over the proposed design life of the structure and determined that it was in the City's best interest to procure the work in the form of a Design Build Finance and Maintain (DBFM) agreement with a 30 year concession period.

The City had several objectives when issuing the Request for Proposals (RFP). These included:

- Engaging in a fair and competitive process,
- Encouraging innovative solutions to meet the needs of the project,
- Minimizing disruption to the general public and business during the construction period,
- Ensuring that the components of the project were maintained in a manner that ensured safety and convenience of the affected public,
- Ensuring that there was optimal value in undertaking the project in this manner,
- Ensuring that at the end of the concession period the components of the Project would be handed back in a manner such that the maintenance costs remain reasonable over the balance of the design life for the upgraded bridge structure, and
- Adding value to the Project by reducing out-of-service time, accelerating completion of the Works, appropriately sharing risks and providing for long-term maintenance for the upgraded Assets while meeting or exceeding the City's hand-back requirements.

The RFP also provided an opportunity for the shortlisted qualified teams to present proposals that would involve construction of either completely new structures or a combination of new and rehabilitated structures. In addition, the RFP was appended to include construction of a separate pedestrian/cycling corridor.

2.3 Project Scope

The private sector team to be selected after the RFP stage of this procurement process was required to, at minimum:

- Upgrade roadways, intersections, medians, signing, and lighting,
- Design and construct new and upgraded bus stops and rest areas,
- Design and construct aesthetic enhancements to improve and unify the pedestrian environment and feature the heritage of the neighbouring communities,
- Provide for pedestrian and cyclist accessibility and safety improvements,
- Rehabilitate concrete piers and abutments,
- Replace all bridge and overpass bearings,
- Blast and zinc coat all re-used bridge, overpass and pedestrian overpass structural steel,
- Replace bridges decks, including sidewalks, expansion joints, and barriers,
- Strengthen or replace steel girders to maintain the currently posted load capacity of 36.5 tonnes or to meet the CL-625 loading as defined by the Canadian Highway Bridge Design Code (CHBDC),
- Rehabilitate roadways, and
- Implement all required riverbank protection measures.

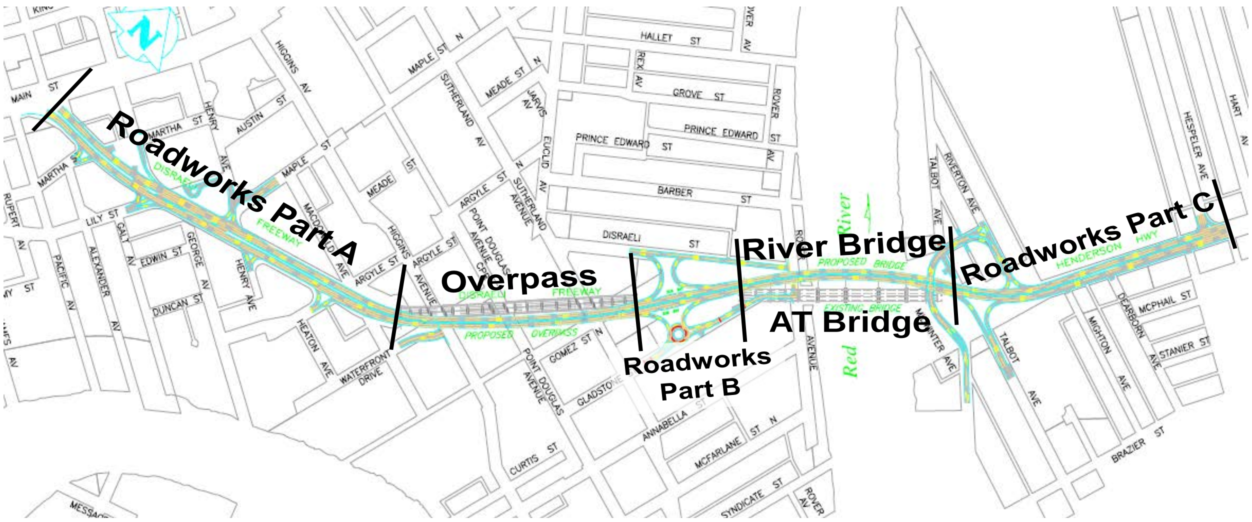

Figure 2 – Scope of Work

3 Project Team

Tetra Tech, as primary consultant and design team lead, partnered with PCL Constructors Canada Ltd. as part of the Plenary Roads Winnipeg team (PRW) to pursue this opportunity. Other partners in the design team included Stantec Consulting, TREK Geotechnical, Dyregrov Robinson Consultants, Bruce Harding Consulting, Scatliff+Miller+Murray, and McGowan Russell Group. Speco Engineering and GCS Technologies partnered with PCL Constructors to provide independent design review.

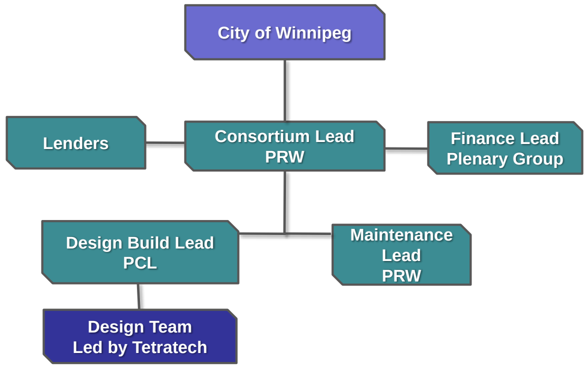

Figure 3 – Project Team

The project was represented by three distinct Phases – Pursuit; Design; and Construction – which are described in the following sections.

4 Phase 1 – Pursuit

During the Pursuit phase, the evaluation criteria to select the most optimum solution became the primary focus for the project team. All ideas and options were benchmarked against the minimum requirements as identified in the project scope in order to ensure that the solution provided by the PRW team would optimize the points scored per invested dollar. The investment included the capital cost, engineering costs, and maintenance costs during the concession period. Furthermore, it was realized that community tolerance for full closure of the Disraeli Bridges was limited and that there will be pressure to minimize any such requirement. This issue was critical and therefore managing this public expectation would have ensured success for the Project. The main items that the project team focused on were:

- Increasing the capacity of the bridges to 62.5 tonnes,
- Providing a minimal or zero lane closure plan on the Disraeli Bridges,
- Implementing a traffic management plan that would provide similar operation during a typical "Business Day" as it existed prior to construction, and
- Including enhancements to the design that exceed the minimum technical requirements of the project.

To develop the ideas and options to proceed forward with, several team information gathering and brainstorming sessions were held in a collaborative manner with all members of the project team. This collective approach allowed the PRW team to provide the best solution to the City for the DBFM agreement that not only achieved but exceeded all of the project objectives.

5 Phase 2 – Design

The Design for the project began after notification of project award. A fast-tracked design schedule was finalized with the entire team so that the design could be implemented while meeting all review and input requirements, without impeding the construction process. The analysis was completed first for procurement of delivery items requiring a long lead time to ensure smooth progression of the construction phase. To effectively manage the project schedule, the design was split into 56 discreet deliverable packages that were reviewed at the 60, 90, and 100% stages by independent, regulatory, and City reviewers. In total, during the course of the project, 396 submissions were made and over 1000 drawings were produced.

Because the operation and maintenance of the project during the concession period will be the responsibility of Plenary Group, significant effort was placed during the design phase to clarify the expected performance of the structural components and roadway during the 30 year period. Furthermore, consideration was given in determining the expected hand-back conditions. Combining these two prerequisites together required that the design be entirely focused on life cycle performance exceeding the minimum technical requirements of the project. The design team led the maintenance team through a review of similar bridges and roadways within the City of Winnipeg. Understanding of the construction, operations, and maintenance history was compiled for each component to develop performance expectations. Several performance scenarios were developed and then evaluated in a life cycle cost analysis to determine the most optimum choice. This allowed the construction and maintenance teams to review the cost of the structure and compare it to the expected impact on the annuity. Based upon this process, the team selected certain design enhancements for the facility.

Understanding the constructability of all aspects of the project was increased by the direct involvement of the construction team during the design process. Methods of forming, accessing, and selecting materials were all reviewed together. The design-build team developed the design that provided the most cost-effective construction. This process greatly enhanced the team's innovative design for a project of this nature. The key features of the design phase are described hereafter.

5.1 Design Enhancements

Enhancements to the design were implemented that not only met but exceeded the minimum technical requirements of the Project. Some of the major enhancements included:

- Selection of the curved alignment for the River Bridge and the CPR Overpass; allowed the two bridges to be constructed with the least interruption to traffic. Two lanes of traffic each direction was operational during week days; bridge closures were limited to weekends during the construction of the tie-ins to the existing road alignment at the bridge abutments. The original RFP provided an allowance for full road closure of 18 months; the selection of curved bridges was more appealing to the City of Winnipeg, and the residents of the northeastern quadrant of the City, specifically.
- MMFX Reinforcing steel in the bridge superstructure. Although significantly more expensive than conventional reinforcing, MMFX provides greater durability for the bridge deck due to its corrosion resistance properties over the life span of the structures, thereby minimizing expected maintenance costs during the concession period and the remaining service life after hand-back.
- Use of Fibre Reinforced Concrete (FRC) to provide excellent cracking control during curing for shrinkage as well as to provide abrasion resistance. The use of FRC will also ensure minimal cracking that should exceed the minimum cracking performance and hand-back requirements.
- Upgrading the design capacity of the structures to 62.5 tonnes from the minimum specified 46.5 tonnes;
- Increased quality control and assurance testing to ensure that all materials placed for the project will provide the maintenance team a detailed record of the construction quality.
- Use of Weathering steel in lieu of coated plain steel girders to provide an expected lower maintenance girder over the 75 year design life of the bridge structures.

5.2 Geotechnical Investigation and River Bank Slope Stability

It was recommended in the Preliminary Design Report that protection of the river banks in the near vicinity of the bridge structure included a rock fill rip rap blanket extending 50m upstream and 50m downstream of the bridge to provide the necessary protection from erosion. The PRW team had conducted a supplementary geotechnical field investigation in order to gain a clearer understanding of the subsurface conditions and to confirm the conclusions of the Preliminary Design Report. PRW's investigation consisted of the installation of piezometers to monitor the pore pressure in the till layer, drilling to bedrock and obtaining samples for rock quality, and obtaining samples to confirm foundation design criteria for the Overpass and Bridge structures. The analysis of the data gained from the geotechnical investigation indicated the following:

- The riverbank on the River Bridge North side did not meet the accepted standard for both short term and long term safety factors in its existing configuration. This was further confirmed by the obvious slope failure that cut through Midwinter Avenue just to the east of the existing bridge.
- Bedrock quality appeared to be very good, except that it was very deep compared to other bridges. Thus the foundation system would have to consider of the lengths of the piles and methods for construction.

PRW team had compared the proposed design of a new structure adjacent to the minimum rehabilitation option as per the Preliminary Design Report and had determined that the north bank would need to be stabilized, regardless of the design strategy (new or refurbished bridge). The increase in area of stabilization for the PRW proposal was nominally greater than that required for the minimum rehabilitation option. PRW team proposed that two rows of 2.1m diameter rock columns socketed 1m into the till would provide the necessary stabilization to the north bank to meet the requirements of the Waterways permit. In total, 102 rock columns river bank contour, were used. This protects the riverbank in the vicinity of the new bridge. In addition rip rap was placed as shown on the Figure on the river bank on both sides of the river. PRW team installed permanent slope inclinometers and piezometers on the Midwinter side of the river to monitor long term behavior of the intended stabilization.

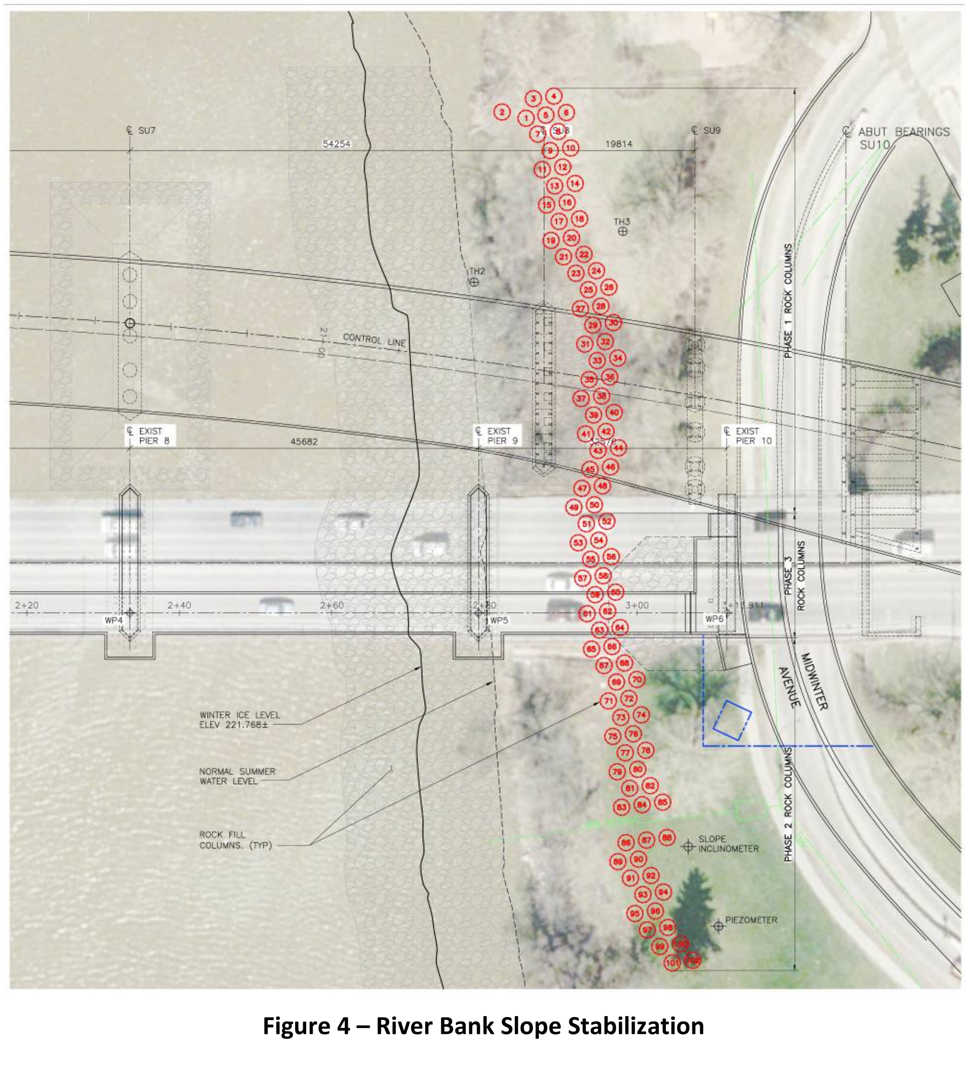

Figure 4 – River Bank Slope Stabilization

5.3 Regulatory Requirements

The Project was subject to all statutes, regulations, codes and by-laws of general application including permits or approvals from Navigable Waters Protection Act, Fisheries Act, Canadian Environmental Assessment Act, Canada

Transportation Act, Railway Safety Act, The Dangerous Goods Handling and Transportation Act, The Contaminated Sites Remediation Act, and The Workplace Safety and Health Act.

Obtaining all of the project's Environmental permits was the responsibility of the design team. The City would have been responsible in the event of changes to the regulatory environment. Due to the presence of site contamination and the requirement to follow the Canadian Environmental Assessment Act, there was a significant risk to obtain the required permits so that it did not impact the construction schedule. The design team was responsible to identify all the significant impacts that the project may cause, develop mitigation strategies to contain and control the impacts, and then work with the regulators to gage the level of concern and improve the mitigation strategies, if necessary.

Immediately after notification of project award, it was discovered that the regulatory environment for obtaining the necessary permits had changed. Typically, projects of this nature could be divided such that only the components causing the particular impacts would need to be evaluated and assessed. The supreme court of Canada ruling on another environmental process was that the entire project needed to be assessed so that the full impact of the project could be reviewed for any potential impacts. Due to this, the regulatory climate changed and the design team was now required to prepare the assessment not just for the river crossing but of all components, thus significantly increasing the amount of time and effort required to complete the task. Working with the City, the design team negotiated an early works scope to advance the start of the environmental impact statement and to allow PRW to fully engage the regulatory authorities with respect to this project. The goal of the design team was to prepare a comprehensive assessment of high quality that CEAA and the other responsible authorities could use as the basis for the preparation of the environmental impact statement with minimal effort on their part.

5.4 Project Risks

One of the most significant challenges for the design team on this project involved construction of the river bridge through a designated contaminated site. The impacted soil extended into the river precisely where construction of the new structure was planned. Working with the Federal authorities, Manitoba Conservation, Manitoba Hydro, and the construction team, the design team developed methods for encapsulation and containment of construction activities so that the impact and amount of disturbed impacted soils requiring treatment was minimized. The end result was that the designs and construction methodologies were approved by all regulatory agencies. These methodologies were innovative for design and construction of bridge substructure units within contaminated soils.

Other major risks that were encountered during the course of the project were either mitigated or minimized. These risks included:

- Land acquisition,
- Designated contaminated site,
- Disposal of contaminated materials,
- Environmental permitting,
- Changes to standards/environmental requirements,
- High water levels on the Red River,
- Quantities for construction, and
- Timely delivery of materials.

6 Phase 3 – Construction

In order to eliminate or reduce risk during Construction, the project team developed a construction management plan to oversee and manage the construction effort which was then communicated to the City. Through implementation of this plan, issues were detected early, monitored closely and elevated to the appropriate level for resolution, involving the City as required.

The construction management plan ensured:

- Proper flow of information and communication among all parties,
- Effective management of all parties on site as well as the progress of the construction schedule, and
- Timely and effective management and resolution of issues, claims and incidents related to or affecting construction.

The construction team wanted to provide evidence of the quality of the final product to be transferred to the maintenance team. Tetra Tech was instrumental in the development of the construction quality management system (QMS). It was recommended that the construction team enhance the amount of testing on the project to ensure that compliance was 100% in line with the project specifications.

6.1 River Piers – Segmental Precast Concrete Construction

During the first season of construction, the Red River was experiencing a winter flood event. High water elevations during the winter of 2010/2011 did not permit foundation investigations, which were required to confirm bedrock elevations for construction of rock caissons. The high water elevations also jeopardized the intended plan to install a temporary rock bridge to be used for construction of the river piers and girder erection. After much deliberation, it was determined by the construction team that the risk and probability of such an event would have a significant impact on their ability to achieve substantial performance of the project within the Contract dates. The design team began to work with the construction team to alter the design so that the construction of the river piers and girder erection could be completed using barges. Caisson foundations were changed to steel HP piles and were driven from the floating barges.

The monolithic cast-in-place concrete piers originally designed were modified to a series of modular precast concrete pier segments, formed using match casting techniques, which would be filled with concrete and post-tensioned together. The design of concrete pier segments was optimized to maximize the available cranes on site and to suit site constraints. The lower pier shaft consistent of a series of three match-cast precast concrete segments that were dropped to the river bottom and positioned into place, connected and secured together with a steel hanger support system mounted to the driven steel piles, and then connected using a foundation tremie concrete pour. An intermediate locking concrete pour was then used to provide a bearing surface for the subsequent precast concrete segments. The use of precast concrete piers and construction of a foundation system using a floating barge was the first of its kind in the City of Winnipeg.

Figure 5 - Construction of River Piers

6.2 Disraeli CPR Overpass Land Piers – Post-Tensioned Pier Cap with Caissons

The land pier at SU.2 of the CPR Overpass was relocated from its original location to limit the extent of property acquisition required, accommodate construction staging, and to avoid a number of underground utilities. The preliminary design consisted of a foundation of hammer head pier shaft on precast concrete piles. The substructure was redesigned with only two 1500 mm diameter steel jacketed caissons, allowing for the passage of traffic beneath the bridge between the two caissons. A cast-in-place concrete pier cap, complete with two post tensioned ducts of 15 mm multi-strand diameter tendons was used to transfer imposed loads of the revised substructure location.

Figure 6 – Post-Tensioned Pier Cap

7 Conclusion

The P3 project selected by the City of Winnipeg to pursue the Disraeli Bridge Project succeeded in delivering the project with the least interruption in traffic during construction. The project was completed on budget. The River Bridge and CPR Overpass (Figure 7) were open for traffic on October 2012; ahead of schedule. Construction of the Active Transportation Bridge is currently underway (at the time of writing this paper).

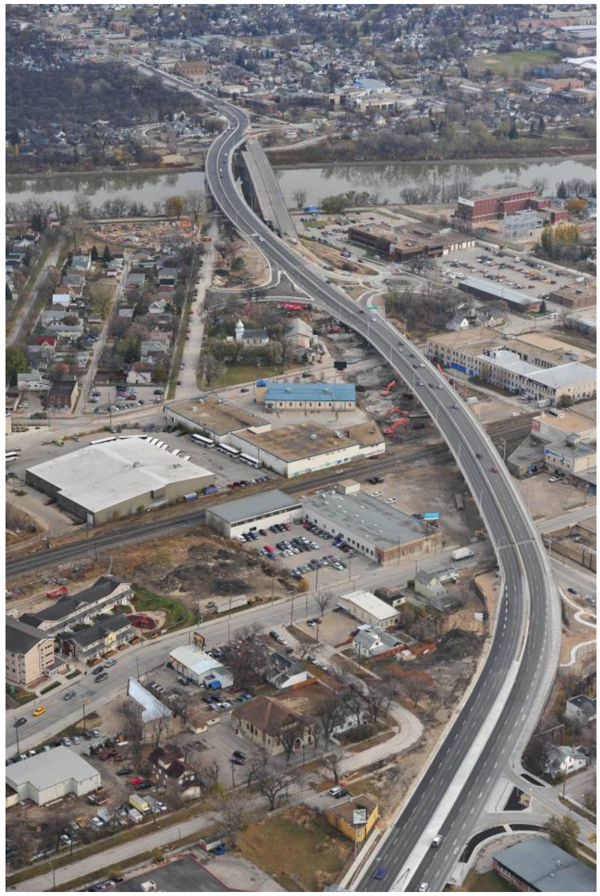

Figure 7 – Completed Disraeli River Bridge and CPR Overpass