Stantec

North Highway Connector

City of Red Deer | Red Deer, Alberta

Canadian Consulting Engineering Awards 2014 • Category B - Transportation

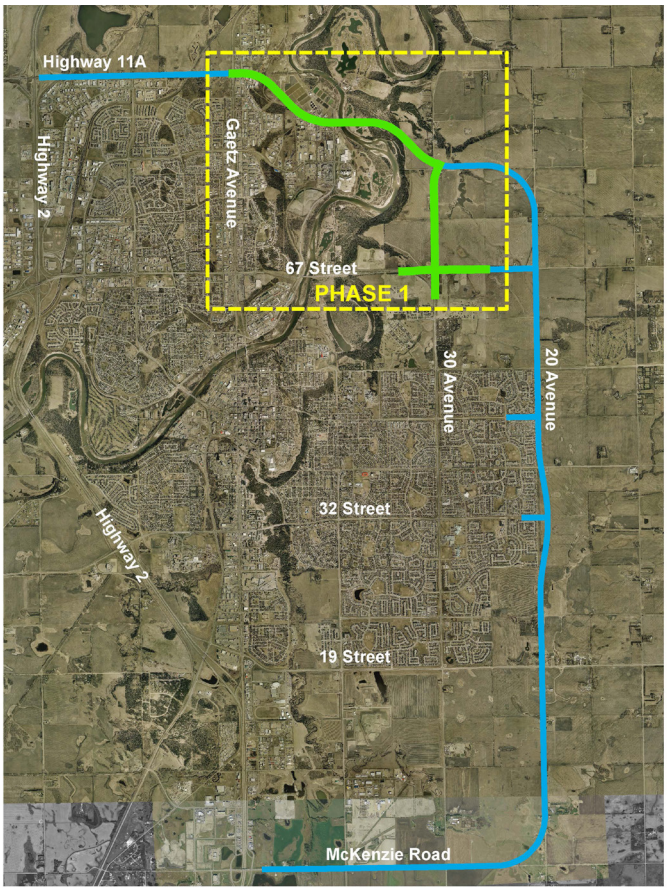
Design with community in mind

Project Background

In May of 2008 the City of Red Deer retained Stantec Consulting (along with subcontractors ISL Engineering, Parkland Geotechnical and Thurber Engineering) to undertake the preliminary design, detailed design and construction management of the North Highway Connector (NHC) project. The NHC project is the first phase of a future expressway "Ring Road" known as Northland Drive to be constructed around the City of Red Deer which will connect Highway 11A west of the City with Highway 11 East of the City.

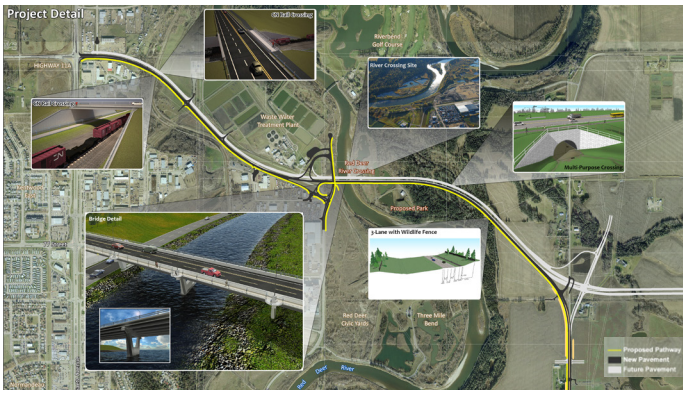
The preconstruction site conditions included steep forested river valley escarpment slopes, the Deer River, rural roadways, the City waste water treatment plant, an industrial subdivision and undeveloped agricultural land.

This project included a number of major challenges including staged roadway design for 8.5 km of expressway/ arterial roadways, embankment fill up to 18m high, a CN overpass, a river bridge, a wildlife underpass structure, a landfill removal, construction of stormwater treatment systems, a storm lift station, environmental considerations and pedestrian/cyclist accommodation.



Preliminary design of this project was completed as a single package however due to the magnitude of the project the detailed design and construction was divided into a number of contracts which are currently in varying phases as outlined below:

- Riverside Sanitary Landfill Removal (Construction Completed 2009)
- Contract A1 & A2 – Tree clearing, 40 Avenue realignment, earthworks, storm sewer, fencing and landscaping throughout the Red Deer River Valley (Construction 2011 to 2013)
- Contract B – CN Rail Overpass (Detailed Design Completed 2012)
- Contract C – Red Deer River Bridge(Detailed Design Completed 2012)
- Contract D – Wildlife Underpass Structure (Construction Completed 2012)
- Contract E & F– Roadway Surface Construction (Detailed Design Completed 2012)



Project Management

Extensive project management was required for this project which included managing sub consultants and internal multidiscipline specialists in the fields of transportation, deep utilities, geotechnical, bridges, structures, electrical, controls, instrumentation, process, wildlife, environment, archeology and construction.

Studies & Assessments

In addition to the standard preliminary design report prepared for this project, a number of site assessments and studies were conducted including:

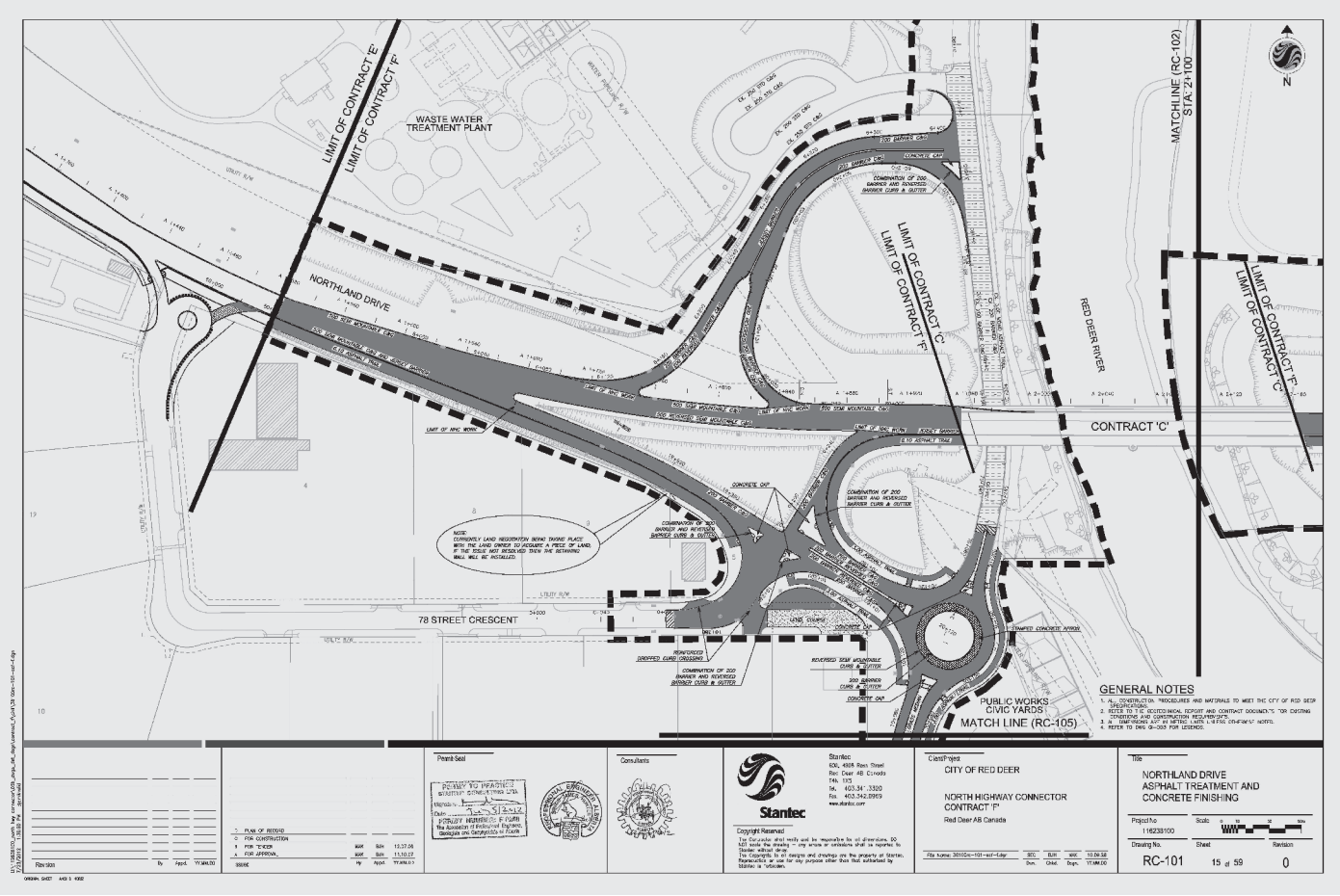
- Geotechnical assessment/reports for the roadway and embankment construction;
- Geotechnical assessment/report for the river bridge;
- A fish habitat assessment and compensation plan;
- A Historical resource impact assessment;
- A borrow management plan;
- A terrestrial assessment; and
- Multi phase environmental site assessments.

The studies illustrate the comprehensive approach to the project as well as help illustrate the management demands required to coordinate these efforts.

Roadway Design

The general roadway alignment was selected prior to preliminary design but included a number of challenges to overcome include traversing through the forested river valley escapement where steep unstable slopes presented major challenges. The roadway design also included special considerations as the initial construction for the expressway was an undivided two-lane roadway that will be expanded in the future to a 6 lane expressway.

A particularly challenging area was directly west of the Red Deer River where the Northland Drive expressway will intersect with the existing 40 Avenue. This constrained location is the only access to the City Waste Water Treatment Plant and also provides access to a small industrial subdivision. At this location a unique parclo interchange has been designed which incorporates a three legged roundabout which will connect the Northland Drive off ramp with 40 Avenue while helping provide access to the surrounding facilities.



Pedestrian & Cyclist Accommodation

The City of Red Deer, and many other communities throughout Alberta, have been striving to provide upgraded accommodation for pedestrians, commuter cyclists and other active modes of transportation. With the design of Red Deer's first expressway a new City standard cross section had to be developed for this roadway classification. The project team looked at this situation as an opportunity to provide superior pedestrian and cyclist accommodation throughout the expressway corridor. The resulting design was a facility separated from vehicular traffic which included a 2.0m pedestrian walkway as well as two directional dedicated commuter cyclists lanes through the entire expressway corridor. This facility is intended to help promote greener transportation alternatives and active lifestyles. The design intent is that this enhanced pedestrian and cyclist facility will form a model that will be replicated as the expressway is extended and will eventually encircle the entire city.

Riverside Sanitary Landfill Removal

Completion of multiple environmental site assessment phases helped identify the presences of a small historic landfill that was located directly below the proposed bridge abutment and interchange location west of the river. The former landfill was in operation from 1968 to 1969 when standard practice included utilization of gravel excavations as landfills for common household waste which also included a number of hydrocarbon rich items and other pollutants. The methodology with which the landfill was constructed, operated and capped did not include construction of an impermeable liner and the location was capped with less than 1 metre of common granular material. The landfill was located just 20 metres west of the river and the groundwater flow through the area moved northeast indicating that any contamination from the landfill had been migrating through the granular subgrade, towards the river, for 40 years.

Costs and benefits for removal of the landfill were reviewed and ultimately the environmental benefits coupled with proposed infrastructure considerations resulted with the recommendation to remove the landfill prior to construction of the proposed roadway. The removal of the landfill was completed with stick compliance to environmental regulations and best practices including full time onsite inspection and testing completed by environmental specialist.

The waste that was removed had varying levels of contamination which had to tested sorted and ultimately disposed of at a number of disposal facilities. The more heavily contained waste was had to be shipped longer distances to facilities that had capacity to properly treat and/or dispose of the contaminated material while the standard waste was hauled to City of Red Deer active Waste Management Facility. As the landfill site was being excavated the void created needed to be backfilled with clean material suitable for the foundation of the proposed interchange and bridge abutment. A number of backfill material sources were evaluated, during which time the team identified that the Waste Management Facility was planning to dig new landfill cells. This provided a cost saving opportunity for two way haul which allowed for the truck hauling waste to the Waste Management Facility to backhaul clean backfill while excavating the material from a future landfill cell.

The removal of the old riverside sanitary landfill was completed in 2009 prior to roadway embankment grading as was a recognizably successful first phase of the project with a substantial environmental benefit that was completed very cost effectively.

Embankment Grading

In order to complete this project embankment design and extensive grading was required to connect the surrounding uplands with the base of the Red Deer River Valley which included an existing CN Rail spur line on the west river valley slope. Special geotechnical considerations were required as fill areas of up to 18m high were required through an areas which included historical slope failures. During construction slope indicators and pour pressure monitors in the subgrade were closely monitored to ensure slope stability. Horizontal and vertical wick drains were also constructed into the west escarpment slope to help provide slope stability during and after construction.

East of the river, the floodplain required construction of a causeway to situate the future expressway above the 1:100 flood elevation as this flood plain area was complete inundated with water during a major flood in 2005. This included constructing the lower portion of the causeway exclusively with free draining granular material which will help promote stability of the causeway during future flood events. As an additional challenge, the floodplain area had previously been mined for gravel and was partially backfilled with reclamation material that did not constitute a foundation suitable for the causeway. Diligent geotechnical investigation was completed to determine where in-situ granular material was still available and the workplan included utilizing the existing granular material on site to construct the foundation of the causeway, helping to limit the need to import costly granular material.

In total this project required grading of approximately 1.5 million cubic meters of material, of which nearly one third had to be provided from off-site borrow sources. To help minimize project costs Stantec complete a City wide Borrow Management Plan which identified and qualified borrow sources throughout the City including newly proposed subdivisions, storm ponds and existing stockpile of excess material. Each site was reviewed with respect to material suitability, location and cost to secure. As a result, the project was tendered with four off-site locations where economic sources of fill were available for embankment construction.

Storm Water Infrastructure Design

In total approximately 4 km of storm sewer main was installed as part of this project, with the major components east and west of the river outlined below.

Prior to this project much of the area east of the river was undeveloped, however the north east sector of the City was beginning to expand and it was recognized that the proposed roadway storm system could also be utilized to provide storm water conveyance from a future development are (covering over 1000 ha) to the River. A storm report was completed to determine the storm water conveyance requirements and the storm system was designed to meet the requirements of this large future development area. This upsized design resulted with storm main construction of up to 2.7m diameter trunk mains and due to the steep river valley slope the storm design included such special design considerations as pipe anchors, energy dissipaters and air vents. At the base of the storm system east of the river the area that was mined for gravel to construct the causeway, was constructed into a storm pond complete with forebay to allow for storm water treatment prior to being released into the river. The storm pond design included a submerged outlet therefore any potential contamination spills onto the expressway would be trapped in the storm pond thereby protecting the river.

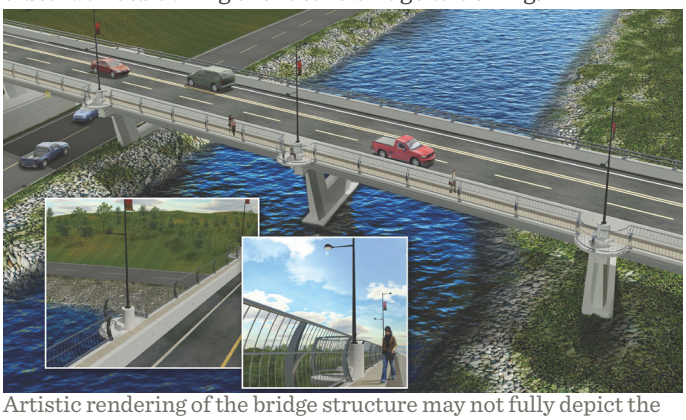
Prior to construction the area west of the river was home to an industrial subdivision with rural roadways and no distinguishable runoff treatment. Storm design for the proposed expressway included installation of two storm water treatment units which will provide treatment prior to runoff releasing into the river. A portion of the design required the existing 40 Avenue to be realigned to pass under the future Northland Drive Expressway River Bridge. In this underpass area the roadway was constructed at an elevation below the 1:100 year River flood elevation therefore the gravity storm system could only drain during time of low river flow, and a storm lift station complete with backup generator was constructed to provide trapped low area drainage, allowing the roadway to be passable at all times.

Red Deer River Bridge Design

The Northland Drive Red Deer River Bridge was a first of its kind design, within the City of Red Deer. Past bridge design within the City included utilitarian vehicular considerations with little attention given to aesthetics, architecture or multi-modal users. The design of this 195m long bridge is a blend of functionality and aesthetics with architectural enhancements including "V" shaped piers which were designed with consideration to help mitigate impacts of high water flow and debris jamming. Three unique pedestrian outlook platforms will be installed on the south side of the bridge adjacent to the pedestrian pathway complete with built in seating. This will provide users with rest opportunities and nodes to stop and view the surrounding natural beauty of the Red Deer River valley. A one of a kind design was prepared for the stainless steel, concave hand/safety railing to further enhance the bridge aesthetics and pedestrian environment. Dedicated two way cycle lanes will also be provided between the vehicular traffic and the pedestrian walkway, which will help promote alternative transportation options, healthy life styles and green commuting.

During design a cost benefit analysis was completed for several components including reinforcing types and surface treatments. The design process also included extensive input from the City's bridge maintenance department to help minimize future maintenance and operation costs.

The first phase of construction comprises of three traffic lanes with one west bound though lane, an east bound through lane, and a second eastbound acceleration lane provided due to the close proximity of the interchange. In the future traffic volumes will result with requirement to twin the bridge followed by widening each bridge from three to four lanes. Costs and benefits were evaluate for future bridge widening options which lead to the selection of carefully chosen girder materials as well as the decision to construct the bridge piers to the ultimate 4-lane width during the first phase of construction. These carefully evaluated considerations will help minimize future costs, reduce complexities and mitigate environmental disturbances during the future bridge widening.



Artistic rendering of the bridge structure may not fully depict the proposed design dimensions.

Riverbank Armoring and Floodway Protection

Throughout the City, the meandering Red Deer River has carved the valley landscape into twists and turns with extensive ongoing riverbank erosion, unstable slopes and extensive flood plain areas. During 2005 the City was subjected to flood conditions near the 1:100 year level and the proposed bridge location was heavily impacted with the surrounding area inundated by water.

As the bridge location is on bend the west bank is exposed to continuous higher velocity currents which were eroding the riverbank. The proposed interchange directly west of the river included realigning 40 Avenue to pass under the proposed bridge at an elevation below the 1:100 year river flood elevation with little room between the roadway and the river. The design team prepared a solution that included a retaining wall and riprap armoring combination that will mitigate erosion, protect the bridge abutment location and accommodate the 40 Ave underpass through this constrained area.

Under normal conditions the meandering river will flow around the bend and under the proposed bridge location. However, during flood events the east riverbank is overtopped with water flowing directly north, perpendicular to the east bridge approach, rather than flowing around the bend. This site condition required not only traditional river bank armoring at the east abutment location but also considerations up stream where the flood flow direction would impact the proposed approach and causeway through the flood plain. Simply raising the ground elevation and armouring the upstream east river bank was evaluated with results indicating that would more than double the bank armouring costs for this project. An alternative design was then prepared which included three flood plan spurs to be constructed primarily from on-site materials, which allowed the flooding waters to be channelized along the newly constructed causeway embankment while providing diversion away from the causeway a key locations and mitigating flood water impacts.

CN Rail Overpass Design

An existing CN Rail spur line is precariously perched part way up the west river valley escarpment in north Red Deer, which needed to be crossed with the proposed expressway. The crossing design was prepared in conjunction with the embankment grading design through the steep, unstable river valley escarpment requiring up to 18m of fill to provide the required vertical clearance above the railway. The horizontal span requirements for the bridge included considerations for the railway as well as provision for a future pedestrian pathway and wildlife accommodation. After evaluating a number of options a clear span design was selected which comprised of bridge girders mounted on mechanically stabilized earth walls constructed as part of the embankment on either side of the railway.

The first phase of construction comprises of three traffic lanes with one east bound though lane, an west bound through lane, and a second eastbound climbing lane provided as the expressway rises up out of the river valley. The future expansion of the expressway will require this crossing to be twinned. To mitigate staging compilation and minimize whole life capital costs the MSE wall and embankment grading was constructed for both crossings during the first phase of construction.

Artistic rendering of the bridge structure may not fully depict the proposed design dimensions.

Multi-User Crossing Structure, Wildlife Accommodation & Landscaping

The project area is located in the northern limits of Red Deer where there is limited development and major forested areas paralleling each side of the Red Deer River. Early assessments of the project area identified that these forested areas where major wildlife corridors along the river valley, and home to active deer and moose populations. The wildlife presence immediately raised concerns regarding disruption to wildlife habitat as well as concerns about potential for the wildlife impacting traffic safety. Through careful deliberation the project team developed strategically located wildlife crossing locations that would allow animals to pass under the expressway. These locations included wildlife corridors provided under the river bridge (on each side of the river) and under the CN Rail crossing on the west river valley escarpment.

The most heavily forested area within the project is on the east valley escarpment and at this location the project team designed an 5m high x 10m wide x 60m long animal underpass which would also form part of the future City park trail network. The indented dual purpose utilization for both park tails and wildlife resulted with the structure being dubbed a "Multi-User Crossing". With major wildlife considerations required the project team had many challenges. A cost benefit analysis was completed when selecting the material to be used for this structure as both steel and precast concrete structures are viable options. Ultimately a concrete arch structure with MSE walls was selected with key considerations being cost, constructability and wildlife utilization. The nose generated by the traffic on the expressway above the may deter animals from approaching and utilizing the underpass. It is anticipated that the concrete structure will dampen the noise more than a comparable steel structure. The length of the structure was also a key consideration as long dark tunnels will not be readily utilized by wildlife and the future 6 lane expressway crossing over the structure limited options to reduce the crossing length. To mitigate the impacts of the length a unique 5m x 10m "sky light" feature was designed near the centre of the arch which extends up to the surface of the expressway embankment in the future roadway median. This skylight allow light to shine into the centre of the tunnel providing daylight conditions throughout the entire underpass. This unique and successful design was published immediately after it construction, in Imagineering magazine (First Issue – 2013).

For wildlife accommodation it is not enough to simply provide alternative crossing locations as animals still prefer to walk directly across the roadway. To funnel the wildlife into the provided crossing location and minimize the wildlife / vehicle conflicts over 3km of wildlife fence was designed surrounding the entire expressway through the river valley.

Multi-User Crossing Structure.

Project Funding

This project was awarded in 2008 which was followed by a nationwide recession that peaked in the middle of the design process. Construction was originally planned to start in 2009 however funding sources had already disappeared before the first contacts could be tendered. Although the budget was not available for construction the City still badly needed this proposed infrastructure and the project team was not content to see their prize project be put on the self indefinably. Working hand in hand with the City of Red Deer, Stantec rallied a team of specialists and began pursuing stimulus funding (for qualifying a portion of the project) which was being administered by the federal government. To qualify for this funding the City needed a shelf ready project (which the team had) and also had to meet extensive reporting requirements to confirm environmental and social stipulation had been met. Many of these requirements were already met with the extensive log of background studies and site assessments completed by the project team, but there was more work to do in order to meet the stringent federal requirements for the large multidiscipline project. The outcome of a concentrated team effort provided positive results the project funding was attained.

Conclusion

The North Highway Connector is a large project which has included work from dozens of multi-discipline engineers and specialist from 2008 to present. The project team was comprised of the City of Red Deer, Stantec Consultants and sub consultants (ISL Engineering, Parkland GEO, Thruber Engineering) who faced countless challenges throughout the course of the project. Each challenge provided the opportunity to develop unique and creative solutions which were assembled to provide a highly successful project. This report is a sample of the work completed but no length of report could properly credit all the tireless work that has been put into this project over the past 5 years. In conclusion Stantec respectfully submits this project to the CEA for award considerations.