River Valleys Committee

Principles and Design Considerations for Watercourse Crossings

for the Calgary Transportation Plan and Municipal Development Plan

On 20 February 2008, at a special meeting of the River Valleys Committee (RVC) Land Use & Development Subcommittee, the Plan-It-Calgary Team invited members of the RVC and the Bow River Basin Council (BRBC) to prepare a set of criteria that would make potential river crossings more acceptable (or less objectionable) to the local environmental community. The information in this document is based on experience in Calgary and elsewhere, provided by numerous members and partners of the RVC and BRBC, and includes ideas from *Green Streets: Innovative Solutions for Stormwater and Stream Crossings* (ca. 2002).

During the next 30 years, components of Calgary's road, transit and pathway systems may require new crossings of river or creek systems, or widening or modification of existing bridge structures. Watercourse[1] crossings may also be needed for electrical transmission, telecommunications, water or wastewater lines. In such projects, it is essential to balance the need for expanded infrastructure with the significance of the environmental areas and communities that may have to be crossed. When a crossing is deemed necessary, these facilities must be designed and constructed to protect the rivers, creeks, and other natural ecosystems that will be affected.

When a new bridge is constructed, the landscape will be profoundly changed over a very long time frame. A bridge in the wrong place will probably be there for one to two hundred years. The planning rationale leading to the bridge will probably change beyond recognition (or simply cease to exist) in a fraction of that time. Therefore, the imperative must be to obey the Precautionary Principle.

The fragility and vulnerability of Calgary's watershed(s) are already clearly recognized in legislation, in the *South Saskatchewan River Basin Water Management Plan* and others. In particular, the Bow and Elbow Rivers have been impacted by human development and activities beyond their capacity to maintain their own natural functions and integrity. Surface- and groundwater are increasingly coming under pressure due to human development, both as resources in their own right and from intrusions and degradation from multiple sectors. Cumulatively, we do not have sufficient knowledge of our impacts to justify anything but a precautionary approach when it comes to our environment.

The following discussion describes **six essential principles** that The City of Calgary should adhere to if and whenever a new or expanded river or stream crossing is contemplated. Some examples of river valley protection and management in Calgary and elsewhere are presented in Table 1 at the end of this document.

[1] Definition: "A water body with defined bed and banks, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood and includes but is not limited to rivers, creeks, and wetlands." Adapted from *Water Act*, RSA 2000, c. W-3, s. 1(1)(ggg) and *Code of Practice for Watercourse Crossings*, s. 1(2)(bb).

Principle 1:	**Persuasive and demonstrated need for the crossing.**
Principle 2:	**Advanced planning for appropriate siting based on all relevant factors.**
Principle 3:	**Adherence to the recommendations of comprehensive Biophysical and Social Impact Assessments.**
Principle 4:	**Successful minimization of impacts from construction, rehabilitation and ongoing operation and maintenance.**
Principle 5:	**Cooperation between multiple jurisdictions based on long-term planning and mutual agreement on objectives and uses.**
Principle 6:	**Effective policies, regulations, guidelines and enforcement.**

Principle 1: Persuasive and demonstrated need for the crossing.

Crossings of rivers, creeks, wetlands and other water bodies must always be seen in the context of the full costs of social, environmental, and economic impacts. Planning and design should not proceed nor will plans or designs be considered for approval until the need for the crossing has been accepted by City Council and a program developed for having the full costs of the crossing calculated and included in City budgets.

Previous public concerns regarding watercourse crossings focused on the need for new road bridges through communities and environmentally sensitive areas, particularly crossings of the Bow River at Shaganappi Trail (through Edworthy Park) and Sarcee Trail (Bowmont Park), and the Elbow River at 50th Avenue SW (River Park/Sandy Beach/Britannia Escarpment). The 1995 *Calgary Transportation Plan* sought to avoid or delay the need for new watercourse crossings and to protect our river valleys and other environmentally sensitive areas by encouraging more compact, mixed use communities that would support greater walking, cycling and transit use and reduce the number and length of auto trips. The Plan-It-Calgary *Key Directions for Land Use and Mobility* represent a continued commitment to these planning objectives and policies to preserve community and environmental values while enabling an efficient transportation and utilities network.

To meet that commitment, the need for a crossing must be firmly established…

- Use balanced triple-bottom-line and full-cost accounting to assess the crossing and the corridor it serves and all alternatives, including the option of doing nothing.
    - What are the benefits and costs (advantages and disadvantages) of the proposed crossing, corridor and alternatives?
        - Will travel time via transit decrease enough to disadvantage private vehicles and warrant the crossing?

        - Will the cost of moving goods decrease?
        - What will be the social advantages and disadvantages, including consideration of accidents, noise, visual impacts, health impacts from pollution, reduced population in developed areas, shifts in employment centre locations, reduced intensification of existing corridors and activity centres, impacts on vulnerable populations, increased reliance on lower-priority travel modes (in the Transportation Hierarchy), and reduced diversity of choice within communities?
        - What are the direct costs, including construction, maintenance and operation (including policing and enforcement)?
        - What are the future costs of maintenance, operation and decommissioning?
        - What will be the impacts on the airshed and terrestrial and aquatic ecosystems, including the gain or loss to society as measured by people's willingness to be compensated for environmental damages?
- How and to what extent do the proposed crossing, corridor and alternatives satisfy each of the *Key Directions for Land Use and Mobility*?
    - Will the crossing meet the City's need to stimulate intensification of existing corridors and activity centres, or instead encourage the expansion of the city at its periphery?
    - It must be demonstrated that travel demand cannot be managed to eliminate the need for the crossing, and that travel demand cannot be met sufficiently by expanding or modifying current routes or infrastructure.
    - Will the crossing and the transportation corridor it serves:
        - Be a complete street?
        - Serve travel to work and services that are (or would be without the crossing) available in the travelers' communities of origin?
- Identify who benefits.
    - Develop a program for paying the full costs of the crossing and the corridor it serves.
        - Which method or methods of raising revenue will be used (e.g., property taxes, user fees, license fees, provincial or federal grants, etc)?
- Prepare a comprehensive report for public review and presentation to City Council, on the need for and impacts of the proposed crossing on the corridor and all alternatives.

<u>Principle 2:</u> Advanced planning for appropriate siting based on all relevant factors.

Watercourse crossings must be treated with the utmost awareness of the environmental sensitivity of aquatic and riparian areas. By looking at the "big picture," better choices can be made for locating a watercourse crossing. Several factors play significant roles when planning, designing, constructing, maintaining and using a crossing and the transportation utility corridor(s) it serves. These factors include:

- City-wide street, transit and utility connectivity to promote compact growth and public transit while reducing car dependence.
- Use of river and stream corridors by people, fish, migratory birds and other wildlife and the sensitive integration of human development within riverine ecosystems.
- Waterway constraints, such as hydrology (e.g., volume of water from droughts to floods), hydraulics (e.g., erosive power of moving water and ice) and channel morphology (meandering, braiding, entrenchment, etc).
- Location and design of watercourse crossings.
- Bridge design principles (e.g., structural, aesthetic, etc).

Within the Calgary Region, there are many crossings of river, creek and ravine systems by transportation infrastructure, including railways, roads, light rail transit lines and pathways. Utility crossings include electrical, communication, hydrocarbon, potable water and sewage lines. This infrastructure has been provided to enhance mobility and connectivity between communities and to assist economic development and social interactions by reducing the costs to individuals and businesses of moving people and goods to and from external destinations.

All crossings (including facilities adjacent to waterbodies) have the potential to affect aquatic and riparian habitats and the land that drains directly into them. Advanced planning is required and cost effective; crossing sites should only be chosen after careful determination of the least damaging crossing location—before the crossing and associated infrastructure leading to it are designed. The City has numerous “priority” sites in need of retrofit due to erosion of unstable banks; retrofitting at many of these individual sites is estimated at over $1,000,000.

Advanced planning will minimally include the following considerations:

- Locating a watercourse crossing involves an initial broad view of the watershed and street system.
- All options should be explored and assessed before a crossing is proposed, including the following:
  - Engineering design can only mitigate damage to a limited extent once the location has been chosen. There may be viable sites, routes or alignments that would create fewer or less intense impacts.
  - Screening of possible sites to find the location with the least environmental impact should precede the final selection of the crossing location.
  - There are often opportunities to combine other facilities or utilities into a single corridor to minimize future environmental impacts.
  - There are often opportunities to compensate for past or existing deficiencies by incorporating upgrades or enhancements in the proposed infrastructure.
  - When developing potential infrastructure through or over a riparian or aquatic corridor, use existing alignments if they minimize additional construction activity.

- The potential for existing crossings and associated facilities to be closed and reclaimed as the result of the new project should be evaluated.
  - There may be opportunities for mitigation of or compensation for existing deleterious conditions by enhancing or augmenting local natural functions, amenities, values, etc.
  - Bridges can be an opportunity to enhance (or impair) recreational values. The height of a bridge can define a park-like setting and create (or deny) a visual corridor along the watercourse.
- Crossings where the watercourse is most hydraulically "stable" will reduce the detrimental impacts of channelization.
  - Once a bridge is in place, the watercourse will be constrained at that location due to the permanence of the associated supporting structures and the costs of changing them.
  - Typically, straight and relatively narrow sections of a watercourse are preferred. However, the term "stable" can be misleading when dealing with watercourses, so great care must be taken during pre-design analysis and assessment.
  - The orientation of the watercourse crossing should generally be perpendicular to the anticipated flood flow direction in the existing flood plain, but should also consider historic and potential future channel changes.
  - Embankments, culverts, piers, footings and other components of a crossing can narrow or obstruct the flood plain and trap flood debris. These obstructions can cause changes in surface water elevations and flow velocities during seasonal high flows and flood events. These impacts may be lessened by locating crossings in areas where the flood plain does not extend much further than the bank-full channel width.
  - To prevent "induced" channel erosion and meandering, crossings should be located where watercourses are naturally confined by bedrock and show little evidence of meandering over time.
- Plans may need to be changed as a project proceeds, including such components as the shape and size of piers, work schedules, berm design and layout. Much of this work often focuses on the construction phase, as the physical footprint after completion can be relatively small (e.g., piers). However, careful consideration needs to be given to potential changes in long-term impacts that may result. If the projected impacts change, then any associated mitigation or compensation costs must be factored in and provided as well.
- Maintaining biodiversity and hydraulics are critical factors. Crossings should not be located in a meander belt, where a valley is wide, with oxbows or wetlands, or where approaches for the crossing traverse down a coulee. These are likely to be the most significant habitat and wildlife corridors in the region.
- Crossings and approaches should be located to minimize construction impacts to riparian corridors.
- Long-range planning for all types of river crossings requires inter-jurisdictional cooperation. While this may require time and other resources in the short term, it will

save significantly (economically, socially and environmentally) over the medium to long term (see *Principle 5* below).

Principle 3: Adherence to the recommendations of comprehensive Biophysical and Social Impact Assessments.

A comprehensive Biophysical Impact Assessment (BIA) with clear recommendations will be prepared early in the planning process. Species richness, ecosystem complexity and functional sensitivity (i.e., susceptibility to change due to external influences) tend to be far greater in and adjacent to watercourses than in other habitat zones, particularly in semi-arid climates like southern Alberta.

The BIA must consider numerous specific elements:

- Plants and animals: terrestrial, avian, aquatic, insects, amphibians.
- Permanent and seasonal migration routes and movement corridors.
- Impacts on flight patterns of migrating and local birds (e.g., wires parallel to crossing structures increase bird kills).
- Conditions and functionalities before and after construction.
- Seasonal and climate-related hydrological changes (e.g., droughts, floods, ice conditions, temperatures, etc).
- Hydraulic conditions and functions (e.g., erosion, scouring and deposition; the creation of channels, oxbows or side channels; flood plain and floodway dimensions and characteristics; etc).
- Alluvial aquifer functions or capacities, which are critical to biodiversity, water quantity and quality, and flood and drought attenuation.
- Wildlife corridors—to minimize conflicts, wildlife and human corridors should not be mixed.
- Potential for and value from permeable or soft surfacing—most animals (and humans) prefer it.
- Connectivity of viable wildlife habitats, as an essential part of comprehensive network planning. The potential for restoring connectivity lost through fragmentation from existing infrastructure should also be considered.
- Fish passage: on larger rivers this is usually not an issue beyond the construction stage, however, on smaller systems (e.g., Forest Lawn Creek, West Nose Creek) where culverts are contemplated, upstream connectivity is a major concern. Proper culvert design is critical and must consider these factors: length, width, shape, substrate type and embeddedness of the slope. A culvert must not be used if any of its environmental impacts are greater than would occur if a bridge were used instead.
- "Collateral damage" and cumulative effects on the escarpment from back sloping, fill, etc; the bridge span itself may cause relatively little impact.

- Wildlife passage design that is effective and sensitive to key target species and surrounding land uses, including projected changes in land use or activities.
- Long-term impacts from operations (e.g., die-back of Douglas Fir from salt spray off the bridge deck, sedimentation, air pollution, lack of sunshine underneath a bridge, etc).

Social and economic values of water bodies and riparian areas should be protected, including the following:

- In-river recreational pursuits such as canoeing, kayaking, rafting and fly-fishing.
- Tourism and revenue-producing activities such as river guiding and bird watching.
- "Quality of life" enhancements derived from access to nature within an urban setting, especially in areas experiencing or expected to experience a significant intensification of human population or activities.
- Reduced impact on wilderness recreational areas outside the city (e.g., National and Provincial Parks), as people tend to seek natural experiences close to home.
- Allocation of sufficient resources for park and pathway design, to keep people and their pets out of rivers, streams, oxbows, wetlands and other sensitive areas.
- River pathways are required to be a minimum of 3.5 m in width and other regional pathways are minimum 2.5 m in width, plus 1 m clearance on each side. For recreational pathways associated with either dedicated or multi-use crossings, the following guidelines should be incorporated:
    - Pathways on river crossings should be a minimum of 5.5 m in width.
    - Viewing bays should be added if the pathway is not significantly greater than 5.5 m, to ensure that people can stop safely to enjoy the river view without obstructing through-passage over the bridge.
    - The sides of the crossing (beside pathways) should be open, to prevent snow from drifting and to allow ice to melt. Open sides will also assist in clearing snow off the pathways rather than building up along the edges, thereby reducing their effective width.
    - The City of Calgary has standard railing heights and a maximum slope of 3 % for wheelchair accessibility.

A comprehensive Social Impact Assessment[2] (SIA) must also be prepared early in the planning process. The SIA will build on the needs assessment (see *Principle 1* above) and cover all relevant issues related to how the crossing, corridor and related infrastructure will affect people, their quality of life, their behaviour and the communities in which they live.

The terms of reference for BIAs and SIAs should be developed in consultation with key stakeholders. BIAs and SIAs should undergo stakeholder and peer review.

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[2] For an introduction to SIAs, see Interorganizational Committee on Principles and Guidelines for Social Impact Assessment, "Principles and guidelines for social impact assessment in the USA," *Impact Assessment and Project Appraisal*, v. 21, no. 3 (September 2003) pp. 231-250; and Frank Vanday, *Social Impact Assessment: International Principles*, International Association for Impact Assessment, Special Publication Series, no. 2 (May 2003). SIAs include all relevant economic issues.

Principle 4: Successful minimization of impacts from construction, rehabilitation and ongoing operation and maintenance through engineering design and rehabilitation requirements.

In a highly developed area like Calgary, it is unlikely that there will be no impacts on the environment or society when physical infrastructure is built. Neither is it always appropriate to use mitigation measures such as "no net loss" which try to offset environmental or social damage by providing compensation elsewhere that does not benefit the communities and ecosystems that have been affected. Every effort should be made to avoid potential adverse impacts, and such efforts must be demonstrated prior to accepting mitigation as an option.

The construction and operational footprint of watercourse crossings and associated facilities must be no more than the minimum required to ensure that increased mobility, communication or delivery of power or pipelined materials achieves the *Key Directions for Land Use and Mobility* and the objectives of the *Municipal Development Plan*. This goal will be achieved best through demand management including price signals, better technology, balanced triple-bottom-line evaluations, and community-approved design standards.

The economic, social and environmental impacts from a watercourse crossing and associated facilities must be limited to direct effects on the right-of-way and other impacts that are deemed unavoidable by local residents and City Council. Ideally, all impacts will be fully compensated through financial, social and/or economic measures that benefit the communities and ecosystems adjacent to the watercourse crossing and associated facilities.

To minimize the impacts of river crossings, the following standards shall be implemented:

- Engineering design will follow best management practices (BMPs), including but not necessarily limited to the following:
    - Provide the minimum road width necessary to serve intended needs and adjacent land uses. An effect of a highly connected street system is an increase in impervious surfaces. Therefore, it is beneficial to narrow streets, which can decrease the amount of impervious paving.
    - Wide streets and sloped embankments can result in the need to disturb a significant length of the watercourse. By narrowing street and shoulder widths at watercourse crossings and by considering steeper embankments or clear span bridges, the total length of disturbed channel may be reduced. Steeper embankments may, however, inhibit or eliminate wildlife movements and recreational access.
    - Narrower streets (within "standard" rights-of-ways), there may be opportunity for additional street trees and/or swales to treat stormwater runoff.
    - Use more habitat-friendly forms of river training such as bio-engineering to mimic natural armouring, instead of riprap and concrete. Replicate historical natural bank stabilization, rather than hard surfaces. This can be most effectively applied if the crossing is established at a hydraulically stable section of the watercourse (i.e., not in an active meander belt).

- A clear span bridge is usually the preferred type of crossing because it typically causes less impact to watercourse and flood plain functions.
- When combining utility crossings with bridges, any corrosion problems due to leaks or electric currents should be anticipated and prevented. Risk assessments should be done by an expert team.
- Bridge spans that either eliminate or minimize the disturbance of the watercourse bed and shore are preferable.
- Recreational access to the watercourse and approach ramps should be included, as appropriate (consult with user groups regarding best placement for access and egress points).
- Where significant conflicts are expected, priority shall be given to the protection of wildlife habitat and corridors (ecologically sensitive areas) over all other uses.

- Adverse biophysical impacts shall be avoided if possible, or minimized if unavoidable:
  - Vegetation impacts should be minimized by crossing the stream corridor at a right angle and keeping the right-of-way as narrow as possible.
  - Designing for acoustic, visual and safety factors is important.
    - Sound barriers block the view and turn crossings into visual canyons; however they may be needed to reduce salt spray and/or disruptions to wildlife habitat and corridors.
    - Concrete is very noisy but physical buffers and rubberized surfaces help.
    - Wet surfaces increase traffic noise, especially with low clouds that reflect sound back to the ground.
  - Watercourse crossings often represent the low point in a street alignment and occur at the location where storm drainage collects and is discharged into the watercourse. Water quality is negatively impacted by untreated runoff from bridges, ramps and approaches. Water from bridge and approach runoff needs primary and secondary treatment, as well as the following considerations:
    - The risk of contaminated spills requires a high level of protection to be built in.
    - BMPs such as stormwater ponds, storm receptors, and constructed wetlands must be used in the vicinity of the crossing to treat street drainage and runoff from bridge decks to meet federal, provincial and municipal requirements as well as the objectives and criteria in water and watershed management plans.
    - Storm receptors are good for grit and oil in surface runoff but are not effective with salt runoff or spray.
    - Stormwater ponds and constructed wetland forebays must be dredged regularly.
  - Shadowing from crossings can alter the seasonal and daily sunlight patterns on water and land and change biological functions, structure and viability. These impacts may be addressed by narrowing the right-of-way, using grated bridge decking where appropriate, or dividing the road into two with an open segment in between.

- The natural hydraulics of the watercourse must be respected and accommodated:
    - Crossings that are restrictive to flow can confine the watercourse and increase flow velocities. Higher velocities can impact instream habitat by scouring gravel or by changing the size and distribution of material transported and deposited after flood events.
    - Bridge openings should be sized to convey the probable maximum flood flow, without increasing flow velocities. Some bridges can be designed to be over-topped during a flood.
    - Adequate clearance must be provided between the high-water flood level and the lowest part of the bridge structure, to allow unobstructed passage of debris.
    - The placement of and hydraulic impacts due to bridge abutments must consider existing impediments and recreational river traffic because of the danger to boaters during different water levels, including emergency/rescue services.
    - Bridge abutments, piers and footings should be located outside the bank-full channel. An arched construction that spans the channel may be preferable. For bridge elements located in the flood plain, the orientation and surfaces of the structures must be hydraulically smooth and designed in a manner to allow a gradual contraction of flow from the natural channel and flood plain through the crossing, and expansion of the flow downstream of the crossing.
    - Bridge length should be established to allow proper conveyance of the probable maximum flood flow. The length of the bridge must be increased to eliminate the potential for scour of the abutments and piers, to provide access under the crossing for pedestrian paths, and to preserve wildlife migration corridors and riparian vegetation.
    - The footprint of crossings and their associated facilities must be minimized to reduce impacts or interruptions to natural groundwater flows within the alluvial aquifer.
    - Pedestrian bridges at creek level can be designed to be washed out during a flood (the owner is responsible for retrieving the bridge after the flood recedes). The experience with foot bridges in Fish Creek Provincial Park during and after the 2005 floods is worth revisiting.
- Rehabilitation targets shall include the following:
    - If a project's costs escalate beyond its approved budget prior to completion, the environmental enhancements and mitigation measures are often the first things to be deleted. In public-private-partnership (P3) projects, this may be seen as a significant cost-cutting measure, but these tend to be short-term savings only. Such measures often result in a reduction in overall project performance and could be resolved by administering mitigation components through a separate fund or contract.
        - Construction designs and contracts must be extremely detailed and specific regarding environmental components and requirements.
    - Cigar-shaped piers are often preferable as they tend to have fish spawning associated with them. This is likely the result of the piers simulating the

channelized habitat that fish key into for spawning. These areas may produce the proper substrate size and water velocity to attract fish for spawning.

- Fish migration and spawning must be able to continue throughout the construction period, even if this means expanding the time frame of construction. Mitigation targets should consider species, size, life cycles, and the ability to monitor these factors.
- Native vegetation cover shall be used exclusively to re-naturalize the slope, which can take time to become established or may be out-competed by weeds if special care is not taken.
- Indigenous plants typically have deep roots so they may need one or more metres of depth for successful transplanting. With adequate care in the first few years, native seeds work better, however native plants may need irrigation for a few years. Disturbances should be prohibited for at least five years.
- Rehabilitation should be done in as little time as possible.
- To some degree, a flood can enable the watercourse to “fix itself” after construction is finished.
- Wildlife fences must be placed appropriately to avoid a mortality trap.

Principle 5: Cooperation between multiple jurisdictions based on long term planning and mutual agreement on objectives and uses.

Ideally, the number and frequency of watercourse crossings will be minimized. Each crossing represents a stationary impediment across a dynamic natural system. Strategically locating crossings is essential for reducing potential short- and long-term impacts to the watercourse and surrounding ecosystems. In addition to the immediate cost savings that can be achieved by reducing the number of crossings, maintenance costs will be reduced proportionately.

While it may appear prudent to some to expedite the planning process by limiting design considerations, this reverse logic is beneficial in the short term only. Any cost savings from “not over-designing” in the first place are superseded by long-term maintenance obligations and disruptions to ecological services. The following suggestions should help to guide early planning efforts:

- Integrate proposed watercourse crossings with relevant plans and policies such as local water or watershed management plans (e.g., Bow River, Elbow River, Nose Creek), the Provincial *Water for Life* Strategy and *Land-use Framework*, the *Calgary Metropolitan Plan*, and the City’s *Wetland Conservation Plan*.
- Aim to exceed the current minimum requirements established by regulatory agencies, in anticipation of more stringent regulations as our increasing population puts more pressure on shared resources and natural capital.
- Contact agencies responsible for fisheries, terrestrial species, hydraulics, alluvial aquifers, flood plain management, wetlands, etc, to ensure that all requirements and initiatives will be coordinated.

- Single-use crossings (including foot-bridges, transit, electrical, water or road) can be a waste of resources and opportunity. Even a pedestrian bridge has a “footprint.”
- Pre-screening of locations should include long-term goals of multiple jurisdictions (municipal, regional, provincial, federal) to optimize each individual crossing and minimize the number of crossings.
- New bridges should be over-designed to allow for future contingencies and unknowns.
- Bridge and utility crossings will enjoy long lives (e.g., 50 to 100 to 200 years or more) and must be planned and designed accordingly, to reduce future intrusions into natural areas and adjacent communities.

Principle 6: Effective policies, regulations, guidelines and enforcement.

Proper planning and design of watercourse crossings must be governed and supported by environmentally responsible legislation. Some relevant examples of local regulations, guidelines, policies, etc are listed here:

- The Department of Fisheries and Oceans Canada (DFO) typically requires a site-specific analysis for major watercourse crossings, which would, at a minimum, include the following details: fish habitat, hydraulics, timing of the project (for spawning and migration), construction activities and sequencing.
- City of Calgary BIA components include flora, fauna, terrestrial, avian, amphibians, insects and hydrology.
- The City of Calgary is registered under ISO 14001 and there is also an ISO 14001 standard for bridges.[3]
- Alberta’s Wetland Policy and Calgary’s Wetland Conservation Plan include a “no net loss” principle, with a prioritized approach: avoid; mitigate; compensate.
- Ducks Unlimited Canada (DUC) has set a price on the value of ducks and other wildlife; this sort of information is valuable for full-cost accounting.
- The City has a valuation process and provides protection for trees.
- The City of Calgary’s Wetland Conservation Plan includes a minimum 3:1 replacement ratio on the basis of affected wildlife habitat and other functionalities. Watercourse crossings that avoid wetlands and oxbows will have less to replace.
- Enforcement should be done by the appropriate level of government (federal Acts, provincial Acts, regional plans, municipal plans and bylaws, etc). Adherence to the recommendations of the BIA should minimize the need for active enforcement.
- Fish and other aquatic species are critical to river crossing design. Existing DFO regulations require that impacts (e.g., spawning windows, avoidance of siltation, protection of dikes) must be considered during construction and, where there is potential for rehabilitation, use of big rocks on the bottom of caissons and berms will

[3] Calgary Transit is ISO 14001 accredited: http://www.calgarytransit.com/environment/iso_14001.html.
Example: Massachusetts Port Authority's (Massport's) Tobin Memorial Bridge received ISO 14000 certification in 2006.

avoid disruptions to and from up-welling water. For example, the *Alberta Operational Statement Habitat Management Program for Clear Span Bridges* applies to small-scale bridge structures that completely span a watercourse. It includes the following recommendations to avoid negative impacts to fish habitat:

- The project is not located on a Class A stream according to the Alberta *Water Act—Codes of Practice*;
- The bridge is placed entirely above the high water mark (HWM);
- The bridge is not located on meander bends, braided streams, alluvial fans, active flood plains, or any other area that is inherently unstable and may result in the alteration of natural steam functions or erosion and scouring of the bridge structure;
- The bridge is no greater than two lanes in width and does not encroach on the natural channel width by the placement of abutments, footings or rock armouring below the HWM;
- The work does not include realigning the watercourse;
- There is no alteration of the bed or banks or infilling of the watercourse; and
- DFO's "Measures to Protect Fish and Fish Habitat when Constructing Clear-Span Bridges" must be consulted.

- The Alberta *Water Act* has also established codes of practice for crossings of water bodies. The codes of practice provide general criteria for maintaining existing aquatic conditions based on protection of fish that are considered valuable for human use or of special concern. The codes of practice generally do not govern impacts on riparian areas and have no requirements for compensating damage that occurs.[4]

[4] Waxwing Synthesis and Resolution, *Issues and Policy Recommendations: Nose Creek Watershed*, 2005, pp. 5-6 and Appendix B, pp. 16-17.

Table 1: Examples of River Valley Protection and Management

Example	*Principle 2*: Location	*Principle 3*: Impact Assessment	*Principle 4*: Construction, Rehabilitation and Ongoing Operation	*Principle 5*: Cooperation, Long-Term Planning and Agreement	*Principle 6*: Regulations, Policies and Guidelines	Comments
Alberta Children's Hospital			G			Hillside incorporates native vegetation.
Carburn Park			G			Foot-bridge abutments are in the flood plain, set back from the floodway.
Centre Street			G			Bridge has "iconic" value.
Crowchild Trail over the Bow River				G		Traffic bridge has a pedestrian bridge slung under it.
Deerfoot Trail Extension over the Bow River	G					The bridge location was changed (downstream) due to sensitive fisheries considerations at the location originally proposed.
	B			B		Large sanitary siphon across the Bow River to the Pine Creek Wastewater Treatment Plant, forecast long ago, was not incorporated into the Deerfoot Trail extension bridge.
			G			Spawning is happening near the bridge, as the 2005 floods removed silt that had accumulated over the years and through construction.
Deerfoot Trail Between Peigan Trail and Country Hills Blvd			G			This part of the highway has a new surface that is quieter.
Elbow River inside Calgary			F			Some areas along Elbow River are "hard" on one side and "soft" on the other.
Graves Bridge over the Bow River	B			B		Twinning failed to clip or incorporate the adjacent (parallel) power lines onto the new bridge deck, exacerbating bird kills due to their attempts to avoid flying into the bridge structures.
			G			Glenmore Reservoir overpass and the new bridge span have runoff protection.
			B			Opportunity to upgrade the new span to compensate for the inadequacies of the old span were omitted from the Terms of Reference (the Old Graves Bridge has no runoff protection).
				G		Includes capacity for a future water line.
				B		Currently there is a pedestrian/bicycle lane but when traffic increases this lane will be converted for vehicles. Either a new bridge will be required or pedestrian and bicycle traffic will be eliminated from the corridor.
Macleod Trail over Fish Creek		F				The crossing is terraced with vegetation in the middle, but is too narrow.
Macleod Trail over the Elbow River			G			This bridge near Stampede Park was designed to over-top during a flood.

National Parks		G			G	*National Parks Act* looks for the best alternative for development sites, where impacts on wildlife will be minimized.
Paskapoo Slopes		G				Biophysical Impact Assessment included winter and summer assessments.
Sarcee Trail at Trans Canada Highway			G			On top of the hill there are major ravines with dense growth that has spilled over into the valley.
Sarcee Trail At Patterson Heights			G			Natural re-vegetation provides small bird habitat.
Stoney Trail Bow River bridge:		B				A lack of sunshine underneath has led to die-back of Douglas Firs.
37th Street Bridge over Fish Creek		F				The City's bridge is higher and wider (with better wildlife corridors) than the proposed provincial ring road bridges in the same locations.
			G			The bridge has recreational values as well as pedestrian and wildlife corridors.
Calgary Zoo bridge 31i6			G			The main vehicular and pedestrian service access bridge to the Calgary Zoo has two span support piers that are poured in place concrete via cofferdams and/or caissons and are semicircular on the upstream side.
Whitemud Freeway (Edmonton)			G			There is a variety of native grasses and shrubs on the embankments.

G	Good Example.	F	Fair Example.	B	Bad example.