Appendix I

Riparian Policy

APPENDIX I

RIPARIAN POLICY FOR THE MUNICIPAL DISTRICT OF ROCKY VIEW NO. 44

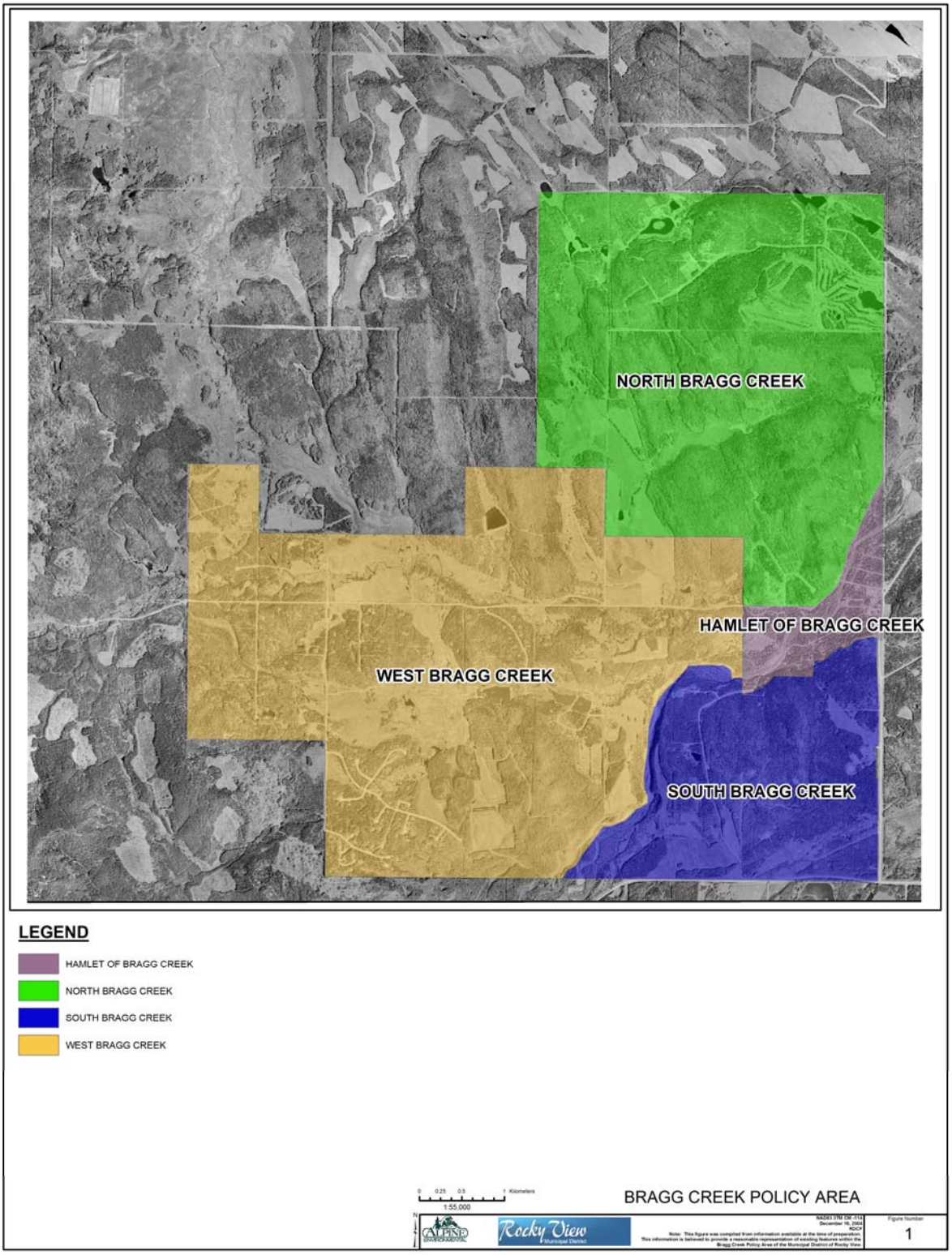
BACKGROUND

The Greater Bragg Creek Area Structure Plan (GBCASP) covers the policy areas described and shown in Figure 1. Within the boundaries of the four policy areas that make up the Greater Bragg Creek area, there are several streams, the most notable of which are the Elbow River and Bragg Creek. Tributaries are also present that flow into these two major streams. The Municipal District of Rocky View (MD) currently has a policy that governs lands adjacent to these streams, which are referred to as riparian lands in the following discussion. The current land use policy, which mirrors Alberta Environment's policy within the White Zone (Developed Lands) of the Province of Alberta, requires that a 6 m development-free zone be in place adjacent to and on both sides of any stream channel. The stream channel is defined as being measured from the high water mark or top of bank.

While the current MD policy provides some protection to riparian lands, it does not encompass enough of the riparian lands to effectively protect water quality within and downstream of the GBCASP policy area. Since the protection of water quality within the Bragg Creek area and in the Elbow River, which is source water for the City of Calgary, is a key issue in the area, an evaluation of the current riparian policy was undertaken to determine whether or not it could be improved upon. Improvements in the policy were sought to meet many ecological objectives such as improvements in water quality, runoff control, protection of wildlife corridors, erosion protection and others, which will be discussed below.

During the development of the suggested riparian policy, attempts were also made to allow the policy directive to be consistent with the directions being taken by other jurisdictions; but most importantly the policy had to be cognizant of and consistent with the Federal Fisheries Act and the Department of Fisheries and Oceans mandates. Specifically, all water bodies which contain fish or join water bodies that are known to support various life stages of fish are considered by the Act to be fish bearing. This means that the Elbow River, Bragg Creek and all tributaries to these two streams are considered to be, in fact, fish bearing whether they are permanent or seasonal streams. Using this definition as a basis, the riparian policy was extended to cover all streams within the policy area.

In West Bragg Creek in particular, there are a number of wetland complexes, including fens that do not have a defined bank and channel but are none-the-less important discharge and recharge areas that contribute to, and help maintain, base flow conditions in the more defined tributaries and streams. The riparian policy, as it applies to these areas, would initially be a 30 m set back.


NORTH BRAGG CREEK
HAMLET OF BRAGG CREEK
WEST BRAGG CREEK
SOUTH BRAGG CREEK
LEGEND
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1:55,000
BRAGG CREEK POLICY AREA
Rocky View
1

INTRODUCTION

The proposed riparian policy as detailed here has been developed based on a review and adaptation from:

- The scientific literature;
- The existing policies in the Province of British Columbia (BC) (BC Riparian Areas Regulations, 2004);
- The existing planning policy (County of Strathcona, *Municipal Development Plan Bylaw 38-98*, 2002, and the Natural Resources Conservation Board, Application to Construct a Recreational and Tourism Project in the Town of Canmore, Alberta 1992);
- Assessment of Forest Management Effects on Nitract Removal by Riparian Buffer Systems by Hubbard and Lowrance (1997); and
- Riparian Area Functions and Management Goals for Fish, (Alberta Fish and Wildlife Division, 2001).

The merits of a non-linear buffer width based on site specific conditions and goals are many. The variety of approaches used to establish these non-linear buffers however, makes them difficult to administer, cost prohibitive to set, and too open to interpretation and challenge, depending on who sets them and what goals are sought to be achieved. While it is clear from a review of the documents cited above, and their supporting literature, from both the planning and scientific perspective a standard and more uniform approach to the establishment of riparian areas is the preferred methodology to meet the administrative purposes and the goals wishing to be met by the establishment of such zones.

The rationale suggested by the literature for a uniform buffer width can be summarized as follows: uniform buffers are more easily enforced, do not require personnel with specialized knowledge of ecological principals to determine them, allow for greater regulatory predictability, and require smaller expenditures of both time and money to administer. Fixed buffer widths do not generally consider site specific conditions and therefore, may not fully or adequately buffer aquatic resources. As a result, it is recommended that a fixed buffer width be prescribed as a minimum set back distance from the stream bank as defined in the definitions, which follow. This width can then be amended based on site specific investigations designed to ensure that adequate protection to the natural resources of this ecological zone are accounted for and protected. It is unlikely that the buffer width would be reduced by such investigations except in instances where 1st Order streams were involved, at boundaries of wetland areas or where bedrock outcrops preclude the usefulness of a full riparian area. However, it is anticipated that in the policy area described by the GBCASP the majority of riparian buffers would be at least 30 m in width from the top of bank. This buffer width would hold true for all streams and tributaries within the GBCASP except for the banks of the Elbow River. On the Elbow River which is a 2nd or 3rd Order stream, the buffer width would be set at 50 m from the high water mark or top of bank in all instances.

The literature provides three basic methods for determining buffer width requirements, they are:

- Application of a constant buffer width for the entire area under consideration;
- Determination of a minimum buffer width based on soil capability, extent of the source area or slope; and
- Spatial modeling which takes into consideration the regional variations in physical, ecological and socio-economic conditions.

We are recommending that Option 1, a uniform buffer width, form the basis of the proposed MD policy for the GBCASP.

WHAT IS A RIPARIAN BUFFER DESIGNED TO PROVIDE?

Riparian buffers are functional, natural transition areas between upland and wetland areas. Historically, these natural areas have been degraded by a variety of land use practices such as agricultural practices for crop and forage production, cattle watering, and both rural and urban development. The mismanagement of these areas threatens their functionality. Now riparian buffer areas are being promoted by many jurisdictions throughout North America as a protective system to effectively reduce pollution in runoff waters from agricultural practices, to reduce erosion and soil loss, to protect water quality and fish habitat and, if they are functional, to increase overall bio-diversity levels.

Specifically, properly established riparian buffer zones can:

- greatly enhance pollution removal through the uptake of nutrients in runoff;
- retain sediment loss to the watershed;
- stabilize stream banks, prevent erosion, decrease stream runoff and runoff energy;
- promote water storage in a system by slowing runoff and acting as an attenuating system for storm events;
- control overall water temperatures in a stream thereby enhancing aquatic capabilities;
- provide a source of organic detritus to the aquatic system thereby providing food for the base aquatic ecosystem and fish;
- through it's vegetative diversity, enhance overall species diversity in birds, small mammals and amphibians; and,
- provide safe habitat for the transitional movement of larger wildlife through an area by providing connectivity.

These are some of the main properties of a properly designed and ecologically robust riparian buffer zone although there are many other functions that the system can and does perform. A detailed accounting of functions and the rationale for the establishment and maintenance of riparian buffers and how they can assist in obtaining the stated goals can be provided at a later date based on a more thorough review of the available literature on the topic. This review would include methods for the determination of riparian health, which reply on information pertaining to

the use of fish and wildlife as indicators of its health, determinations of the sensitivity of a particular riparian zone and a determination of the natural processes taking place in a riparian zone. All of these are important considerations to determine if a riparian buffer is functioning appropriately to meet the objectives of its establishment.

To provide some guidance at the level of consideration of this proposed policy change, the broad goals sought for riparian zones and why they are established are presented in Table 1. Table 1 was adapted from Alberta Fish and Wildlife Division (2001) documentation and is being presented to provide information that is not considered new to Alberta and forms the basis of the scientific objectives desired for such buffers. In Table 2, specific buffer widths as determined from the scientific literature to meet the broad objectives are outlined to indicate that, on a goal by goal basis, buffer width requirements may vary widely. Mean riparian widths that are suggested by the scientific literature to maintain specific ecological functions are also shown in Table 3. If all of the suggestions and functions are to be somewhat accounted for, Table 3 would suggest that a mean width of all values, somewhere in the range of 47 m, would mitigate the riparian area against loss of functionality for the majority of the specified goals. In an area that is already developed, such as the GBCASP, this goal is not likely achievable. However, the literature clearly shows that for the majority of water issues such as protection of fish habitat, water quality, removal of sediment and water soluble pollutants a buffer width of 30 m is considered sufficient to address and control these concern. While the 30 m buffer width may not address all concerns, it is felt that it will provide some level of protection to all areas that are identified as being of concern in Table 1.

Not all buffers, regardless of their width, are equal and much of their overall efficacy is dictated by the type of vegetation present within the buffer. Table 4 indicates the effectiveness of different types of vegetative cover within the riparian area on achieving protection for each of the ecological functions that the riparian area is expected to perform. As indicated in Table 4, a compromise in buffer composition and its vegetative cover types is required to achieve even partial protection for some of the desired outcomes. It is precisely for this reason that minimum width can be expanded if necessary or in some instances contracted, depending on site specific conditions and needs, and is recommended.

DEFINITIONS USED TO DESCRIBE AND DEFINE A RIPARIAN BUFFER AREA (as described in and adapted from BC Riparian Area Regulations, Province of British Columbia (2004)

It should be noted that the main definitions outlined below have been extracted verbatim from the Province of British Columbia *Riparian Area Regulations* (2004), except where specific changes to reflect the Alberta condition or conditions in the GBCASP area were required or where such changes were warranted. The BC regulations were developed in a consultative manner between British Columbia Ministry of Water, Land and Air Protection (BC MWLAP) and the Department of Fisheries and Oceans Canada and are now in effect throughout that province. As such, these regulations provide a sound indication of the direction that such policies will take across Canada. In addition, the policy directives provided by this regulation are quite consistent with other policies already in place in Alberta.

Active floodplain - an area of land that supports floodplain plant species and is:

a) adjacent to a stream that may be subject to temporary, frequent or seasonal inundation, or

b) within a boundary that is indicated by the visible high water mark.

Assessment Report - a report prepared in accordance with the assessment methods to assess the potential impact of a proposed development in a riparian assessment area and which is certified for the purposes of this regulation by a qualified environmental professional.

Development - any of the following associated with, or resulting from, local government regulation or approval for residential, commercial or industrial activities or ancillary activities to the extent that they are subject to local government powers i.e. the Municipal Governance Act:

a) removal, alteration, disruption or destruction of vegetation;

b) disturbance of soils;

c) construction or erection of buildings and structures;

d) creation of non-structural impervious or semi-impervious surfaces;

e) flood protection works;

f) construction of roads, trails, docks, and bridges;

g) provision and maintenance of sewer and water services; and,

h) development of utility corridors; subdivisions as defined by the MD.

Development proposal - any development that is proposed in a riparian assessment area that is within, or partly within, the boundaries of an area administered by local government.

Fish - all life stages of:

a) salmonids;

b) game fish; and,

c) regionally significant fish.

Floodplain plant species - plant species that are typical of an area of inundated or saturated soil conditions and that are distinct from plant species on freely drained adjacent upland sites.

High water mark - the visible high water mark of a stream where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark the soil and the bed of the stream with a character distinct from that of it's banks, in vegetation, as well as in the nature of the soil itself, and includes the active flood plain.

Natural features, functions and conditions - include but are not limited to the following:

a) logs, snags, and root wads;

b) areas for channel migration, including the active floodplains;

c) side channels, intermittent streams, seasonally wetted contiguous areas and floodplains;

d) the multicanopied forest and ground cover adjacent to the streams that:

i. moderate water temperatures;

ii. provides a source of food, nutrients and organic matter to streams;

iii. establishes root matrices that stabilize soils and stream banks, thereby minimizing erosion; and,

iv. buffers streams from sedimentation and pollution in surface water runoff.

e) a natural source of stream bed substrates; and,

f) permeable surfaces that permit infiltration to moderate water volume, timing and velocity and maintain sustained water flows in streams, especially during low flow periods.

Permanent structure - any building or structure that was lawfully constructed, placed or erected on a secure and long lasting foundation on land in accordance with any local government bylaw or approval condition in effect at the time of construction, placement or erection.

Qualified Environmental Professional (QUES) - an applied scientist or technologist, acting alone or together with another qualified environmental professional, where:

a) the individual is registered and in good standing in Alberta with an appropriate professional organization constituted under an Act, acting under that association's code of ethics and subject to disciplinary action by that association e.g. ASPB, ASET, AIA or similar body;

b) the individuals area of expertise is recognized in the assessment methods as one that is acceptable for the purpose of providing all or part of an assessment report in respect to that development proposal; and,

c) the individual is acting within that individual's area of expertise.

Ravine - a narrow, steep sided valley that is commonly eroded by running water and has a slope grade greater than 3:1.

Riparian area - a streamside protection and enhancement area.

Riparian assessment area:

a) for a steam of 2nd or lower Order i.e. Bragg Creek, and its tributaries, the 30 m strip on both sides of the stream, measured from the high water mark;

b) for a 3rd Order stream i.e., Elbow River, a 50 m strip that extends outside of the active flood plain;

c) for a ravine less than 60 m wide, a strip on both sides of the stream measured from the high water mark to a point 30 m beyond the top of the ravine bank; and,

d) for a ravine 60 m wide or greater, a strip on both sides of the stream measured from the high water mark to a point that is 10 m beyond the top of the ravine bank.

Illustrations that provide further information on the meaning of stream order and how to determine a streams status and for providing further clarity on the meaning of the ravine riparian set back requirements are shown in Figures 2 and 3. The high water mark is determined by the bankfull level of the water body. As shown in Figure 4, bankfull width is measured at the top of the roots of terrestrial vegetation along the edge of water bodies.

Stream - includes any of the following that provides fish habitat:

a) a watercourse, whether it usually contains water or not;

b) a pond lake, river, creek or brook;

c) a ditch, spring or wetland that is connected by surface water flow to something referred to in **a) or b).**

Streamside protection and enhancement area - an area:

a) adjacent to a stream that links aquatic to terrestrial ecosystems and includes both existing and potential riparian vegetation and existing and potential upland vegetation that exerts an influence on the stream; and,

b) the size of which is determined according to this regulation on the basis of the minimum regulated width as amended by an assessment report provided by a qualified environmental professional in respect to a development proposal.

For the purposes of the definition of ***streamside protection and enhancement area***, vegetation must be considered to be "potential", if there is a reasonable ability for regeneration either with assistance through enhancement or naturally, but an area covered by a permanent structure must be considered to be incapable of supporting potential vegetation.

Top of the ravine bank - the first significant break in a ravine slope where the break occurs such that the grade beyond the break is flatter than 3:1 for a minimum distance of 15 m measured perpendicularly from the break, and the break does not include a bench within the ravine that could be developed.

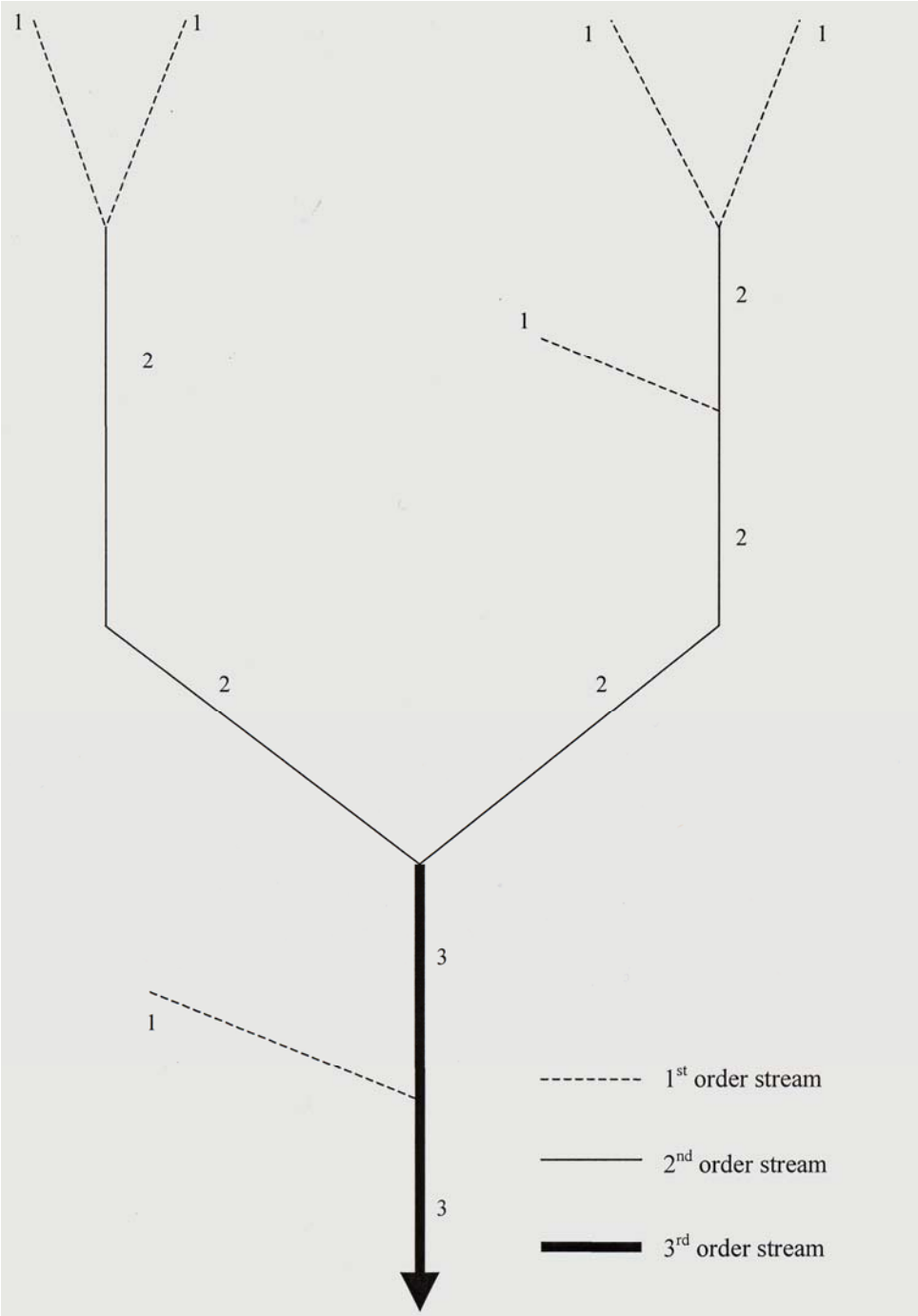

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Figure 2: Schematic diagram of Stream Order (New South Wales Government, 2004)

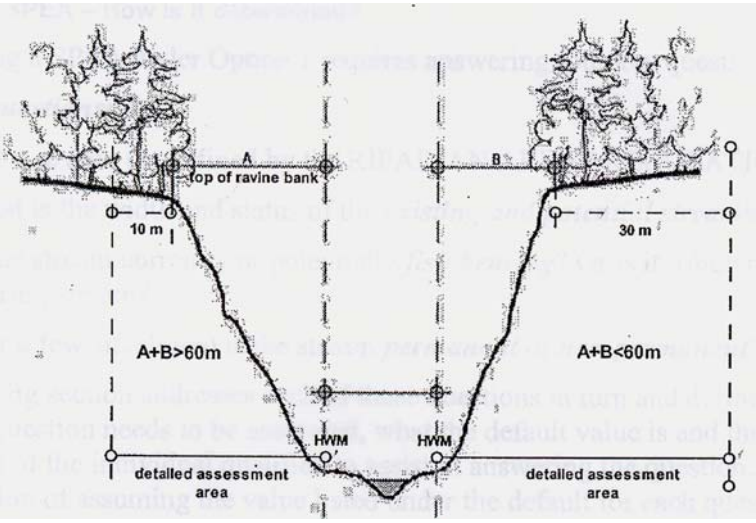

Figure 3: Assessment area for ravines (from Province of British Columbia, 2004)

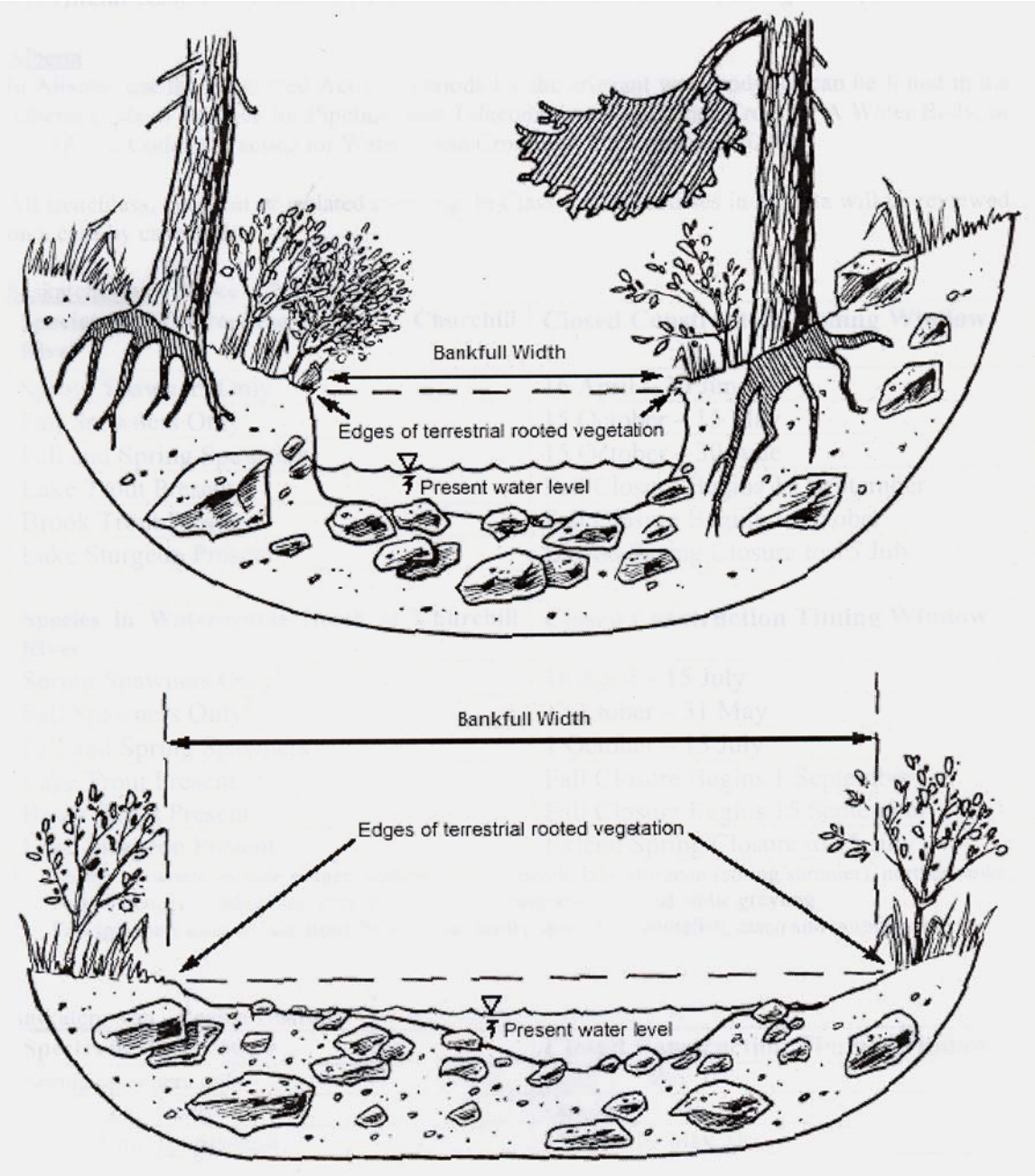

Figure 4: Diagram of bankfull width. Note that bankfull width is not measured at the water line. It is measured at the top of the roots of terrestrial vegetation closest to the water. (from, Fisheries and Oceans Canada, 2005)

Wetland - land that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal conditions does support, vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, fens, and similar areas that are not part of the active flood plain.

PROPOSED RIPARIAN POLICY FOR THE GREATER BRAGG CREEK AREA STRUCTURE PLAN

It is proposed that a riparian buffer area that is a minimum of 30 m wide, as defined in the definitions provided, be applied to all 2nd Order and lower streams and tributaries within the GBCASP. This would include Bragg Creek itself and its tributaries. Further, the riparian buffer area concept and regulation should be applied to the non-developed portions of the Elbow River but should extend to a minimum width of 50 m beyond the active flood plain along this river.

For permanent water bodies and wetlands within the area covered by the GBCASP, whether natural or man made, an extension of a similar riparian buffer area of a minimum of 30 m around its perimeter as measured from the normal high water mark for the water body or the outer edge of a wetland, as defined below, should be applied. Should the area already contain development, the policy cannot be applied retro-actively but should remain a long term objective of the MD should circumstances change in the future.

During the assessment process for a new development proposal within the area covered by the GBCASP, a full assessment report that specifically covers any riparian assessment area within its plan area must be assessed by a qualified environmental professional (QUES) to determine what the optimum riparian buffer width should be prior to receiving development approval. An example of the format for the riparian assessment area report can be found in the Alberta Riparian Habitat Management Society *Cows and Fish* program . These assessment reports can be tailored to suit the specific needs of the MD at a later date. Following review of this report the ultimate riparian buffer width can then be set however; it will not be less than the specified 30 and 50 m width as stated. Changes above this standard width will be determined on a site specific basis. The riparian width could require widening where for example the high water mark extends beyond the 30 m buffer width. Where this could occur would be in natural embayment areas that are normally not part of the main stream course, along natural but ephemeral or seasonal drainages courses, draws or coulees, where wetland areas connect directly into a stream course or similar types of site specific instances.

The determination of where the high water mark is in respect to the water course is the first step in setting the optimum width of the riparian zone which is generally termed to be the boundary of the Sensitive Protected Environmental Area (SPEA). On-site determinations of where the high water mark occurs are typically based on the following site characteristics. For flowing water courses, the high water mark is indicated by a distinct change in both vegetation and sediment texture. Above the high water mark, the soils and terrestrial plants appear undisturbed by erosion events. Bank areas below the top of bank typically have freshly moved sediments such as clean sands, gravels and cobbles depending on the energy of the stream being investigated. These areas will also show signs of sediment transport such as deposition and scour zones. Where stream channels and their banks are distinct, this type of determination may be a fairly easy process, however, in flatter areas such as occur in many areas of West Bragg Creek, identifying where the high water mark should be can be more challenging. In these types of situations, the high water mark should be identified and flagged by a QUES before being surveyed by a qualified land surveyor or GPS technician to delineate the actual required extent of the riparian buffer.

Wherever possible and practical, this riparian area policy should extend into those areas that contribute to the base flow in Bragg Creek and should include adjacent wet land areas, such as fens, ephemeral and seasonal streams. This will provide the connectivity of habitat type and function throughout the area covered by GBCASP.

The outer edge of wetlands can be determined from site specific ground surveys and by mapping the upslope extent of the following combinations of conditions:

- Predominance of plant species that normally grow in water or water saturated soils or in peat soils (plant communities that indicate sub-hydric or hydric ecological moisture regimes).
- Soils that are water saturated or show evidence of prolonged water saturation (gleying) within 30 cm of the surface or are peat soils.
- For shrub areas, the transition between shrub dominated and tree dominated plant communities.

The above wetland descriptors were adapted from those provided in the *BC Riparian Area Regulations* (Province of British Columbia, 2004).

Riparian areas once established could possibly be protected by restrictive covenants, or be stipulated and placed into an environmental land trust or could possibly form a part of the Municipal Controlled Environmental Reserve. Negotiations between a developer and the MD to establish the exact mechanism to provide these types of land protections would have to take place at the concept plan level of development. These levels of permanent protection are considered necessary and would afford such areas a defense against future encroachment and allow the riparian zone the opportunity to remain functional. The high diversity and interface between terrestrial and aquatic habitats will provide a high aesthetic value for the protected areas within the riparian area will likely increase the value of adjacent lands and could provide a living educational landscape feature that should be protected.

Riparian area protection policies should include provisions to exclude livestock and horse use in close proximity to stream banks wherever possible. Cattle watering directly from creeks and rivers may be an issue in this respect that must be recognized and may require working with local landowners to assist them with off-stream watering and appropriate crossing design. The effects of livestock use on the health and functionality of riparian zones has been the focus of a considerable amount of research in Alberta (Lorne Fitch of Alberta Sustainable Resource Development, personal communication, December 2004). Apart from physical damage to banks and streamside vegetation as a result of livestock use, the input of nutrients, sediment and fecal matter directly to receiving waters are all factors of concern that can and do impact aquatic ecosystems and downstream water quality. Therefore, wherever practical and possible, restrictions on livestock use and egress into and through riparian zones should be enacted. Similarly, restrictions on the use of these areas for motorized off-road vehicles, if applicable, should also be imposed.

In an attempt to make the proposed riparian policy consistent throughout the GBCASP area, some level of control over developments in and around streams and wetlands that would cause the riparian zones to be compromised should be put in place at the MD level. For example, on private lands through which a stream flows were a landowner to decide to channelize a portion of a stream the effects of this on both up and downstream riparian areas could be environmentally detrimental. Channelization would increase the stream velocity in the area being altered which would likely increase the potential for downstream erosion to occur and may also have the overall effect of negating efforts to maintain habitat. Upstream areas could also be negatively affected by such actions. It is suggested that any developments or changes that are proposed on any public or private lands within the GBCASP area that would or potentially could affect riparian areas be required to first obtain approvals from the MD (and other appropriate jurisdictions) before being allowed to proceed.

Similarly, the connectivity between upland forested areas and the down slope catchment area should also be afforded some level of protection. Protection is required to ensure that the up slope areas maintain their ability to retain and control precipitation and prevent rapid runoff to receiving water courses. Excessive clearing of these types of lands will increase storm runoff potential and could lead to an increase in erosion potential. Additionally, maintaining a level of connectivity, particularly between wetland areas and the up slope plant communities, is considered necessary to allow wildlife to use and move between both types of ecosystems and will go a long way towards maintaining some ecological integrity within the GBCASP area.

Some discussion of trail network design and incorporation within the GBCASP has been brought forward during the RISA process. Some general conceptual ideas that could utilize the connectivity provided by the riparian buffer to assist in future trail development will be briefly discussed here.

While trails for pedestrian use should not be incorporated directly into the riparian area, it should be possible to construct trail networks along the periphery (outer edge) of the riparian zone. As noted throughout the RISA documentation, the riparian areas extend up to and incorporate many of the wetland complexes throughout the GBCASP area. By their very nature and location the suggested stream riparian areas connect to and through the majority of these complexes and as such offer a unique opportunity to provide the needed connectivity of habitat not only for wildlife and vegetation but for pedestrian types of human use throughout the GBCASP area. These areas which, if maintained, will have extremely high bio-diversity and range of topography would make any trail system passing though them of high value from both recreational and educational perspectives. By locating such trails at the periphery of the riparian zone they should not impede the functionality of the buffer zone itself but because these lands would be public lands, in a sense, they could also assist in the accommodation of public-private access rights and trespass. Whether or not these public access issues can be addressed effectively, while still allowing a trail network through the area by utilizing the designated buffers will require further investigation and discussion by others outside of the RISA group and are merely being offered as a possible opportunity.

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Appendix II

Forest Composition:

ALCES Range of Natural Variability

APPENDIX II

EVALUATION OF "RANGE OF NATURAL VARIABILITY" OF MAJOR PLANT COMMUNITIES IN THE GREATER BRAGG CREEK REGION

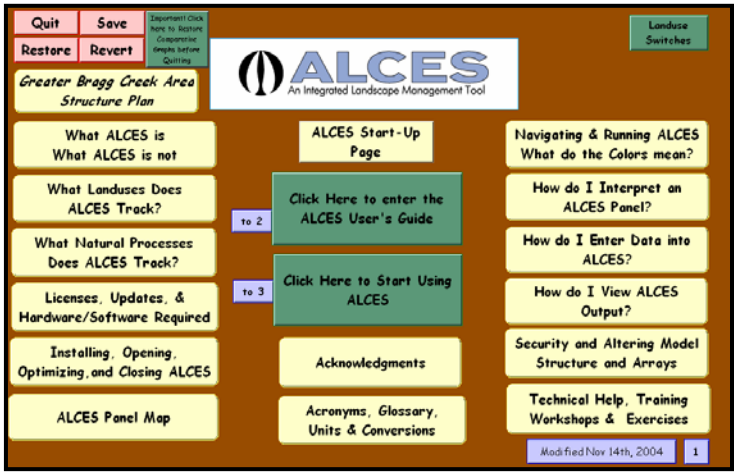
INTRODUCTION

The Greater Bragg Creek Region (GBCR) (~47.6 km^2) is well known throughout Alberta for its impressive natural beauty – a reflection of the diverse suite of natural plant communities that comprise the region. Plant communities that currently exist in the region include aspen forests, mixed wood forests, pine forests, white spruce forests, lowland shrub/muskeg complexes, native grasslands, and riparian assemblages.

Against this backdrop, of the region's natural plant communities, has emerged a set of land use footprints during the past several decades. The conversion of some natural grasslands and forests into pasturelands represented the first wave of human land uses in the region, which was subsequently followed by the establishment of a settlement (Bragg Creek), a transportation network (primary and secondary roads), and the arrival of an expanding wave of acreage complexes (with accompanying access roads and utilities).

To encourage the maintenance of ecological sustainability in the region, it is important for planners to recognize the importance of maintaining both the amount (area) and composition (%) of the major plant communities within the region. From the standpoint of landscape ecology, however, there is no single value that represents the "proper" amount of area for any single plant community. Plant communities are not generally constant in area, but rather vary in area based on the disturbance history (fires, insect outbreaks) of the region. Since the retreat of glacial ice sheets from the GBCR 10,000 years ago, periodic fires, floods, and insect outbreaks have caused significant variation in both the area and age structure of each plant community.

To establish a strategic level basis for estimating the "range of natural variability" for each major plant community, the landscape simulation model ALCES (www.foremtech.com) was deployed for the GBCR.



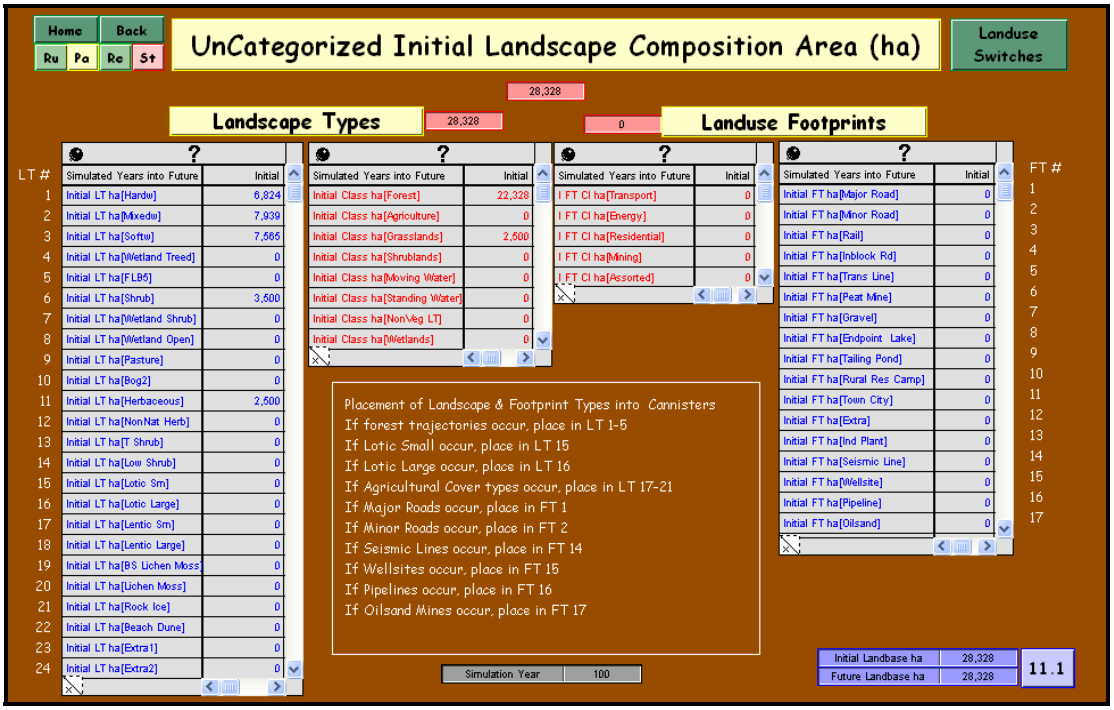
METHODOLOGIES

The initial composition of the GBCR+ was based on GIS theme layers assembled by Alpine Environmental Ltd. (Alpine). The dominant layer for attributing the plant communities was an Alberta Vegetation Inventory (AVI) based on photo-interpretation of 2001 aerial photography at a scale of 1:20,000.

The AVI inventory was used to compute area and age class structure (forest strata) for several dominant plant communities including:

- Hardwood;
- Mixedwood;
- Softwood;
- Shrubland; and,
- Native Herbaceous.

To properly assess the initial composition of native plant communities, it was also necessary to dissolve off the agricultural rangelands, and replace these areas with those forest types present in the pre-agricultural era (these corrections based on consulting aerial photography in the 1940's). The initial aerial extent of these communities is shown below.

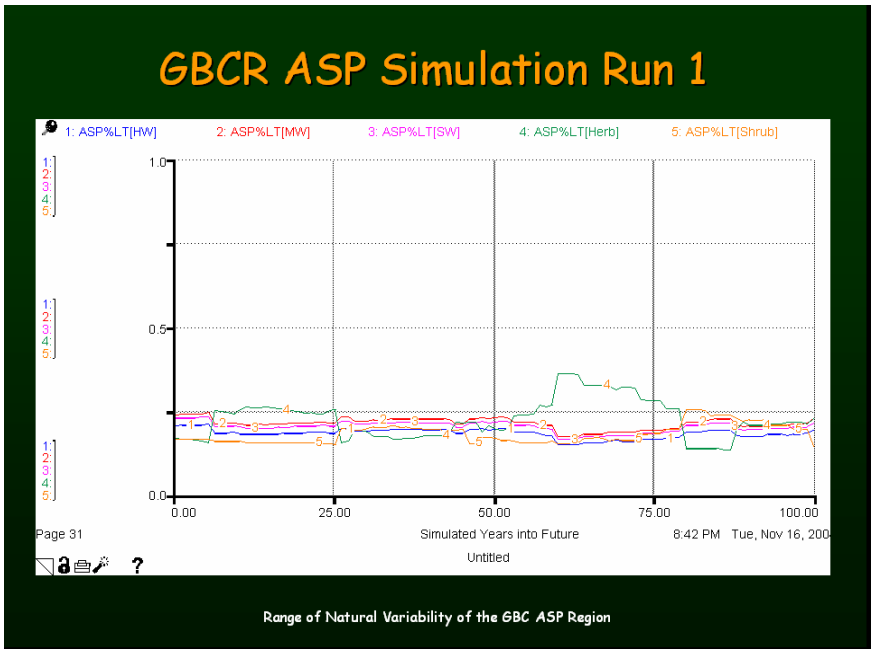


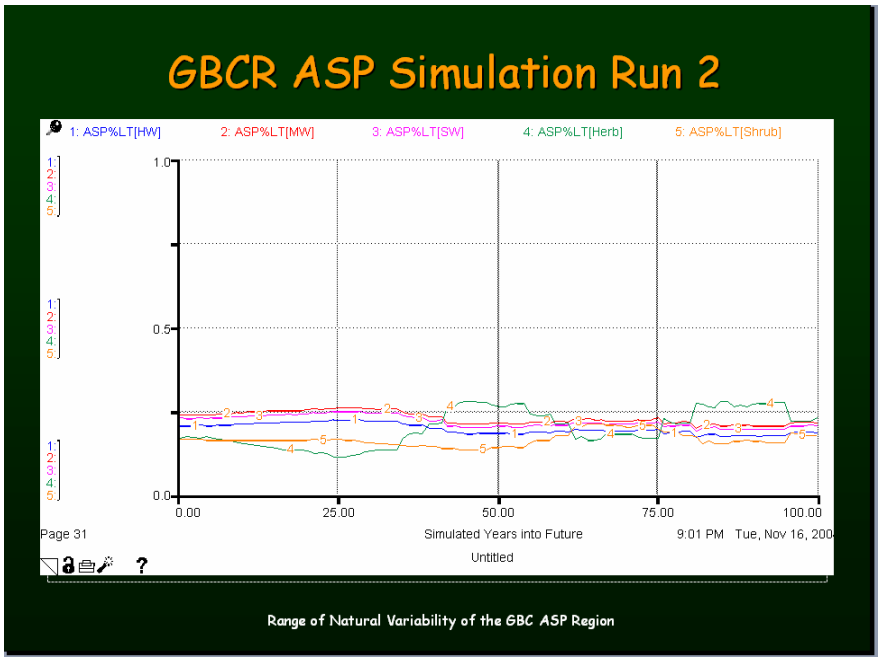
These values were entered into the ALCES model and subjected to stochastic fire regimes (lognormal distribution) based on a 100 year fire cycle (equivalent to a 0.01 annual fire rate). A successional dynamics model was used to track the arrival of herbaceous communities following fire events, and their eventual succession into shrub-dominated communities. In addition, the age class structure of each forest's strata was monitored.

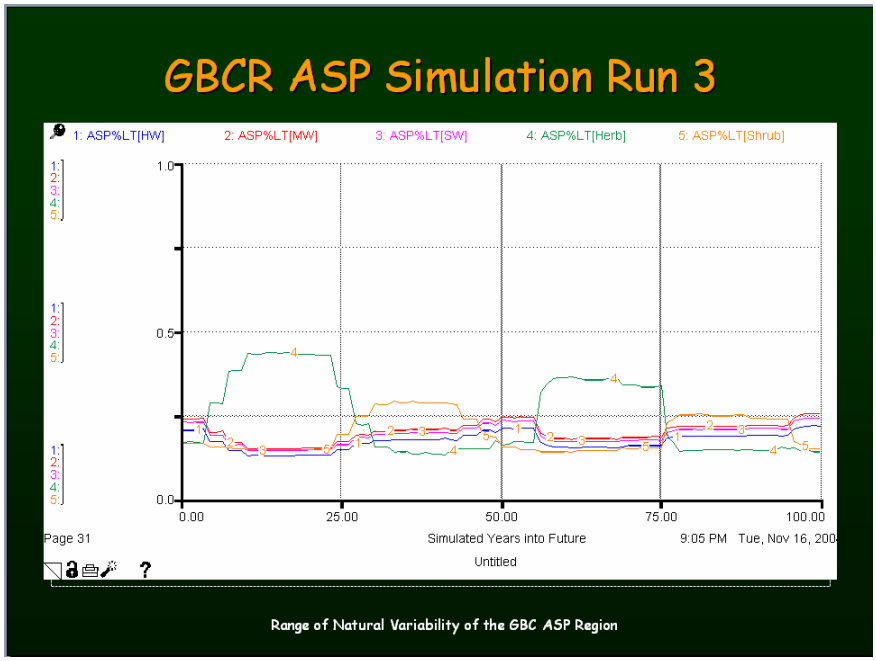
A total of ten (10) stochastic runs were conducted, with each run consisting of 100 years. The results from ALCES were then used to present the % of the landscape found within each plant community.

RESULTS

The graphs below indicate the temporal change in the proportional contribution of each plant community to the GBCR during each year of ten (10) different 100 year simulations. These results profile the significant changes in plant communities that can occur following fire events and subsequent succession.



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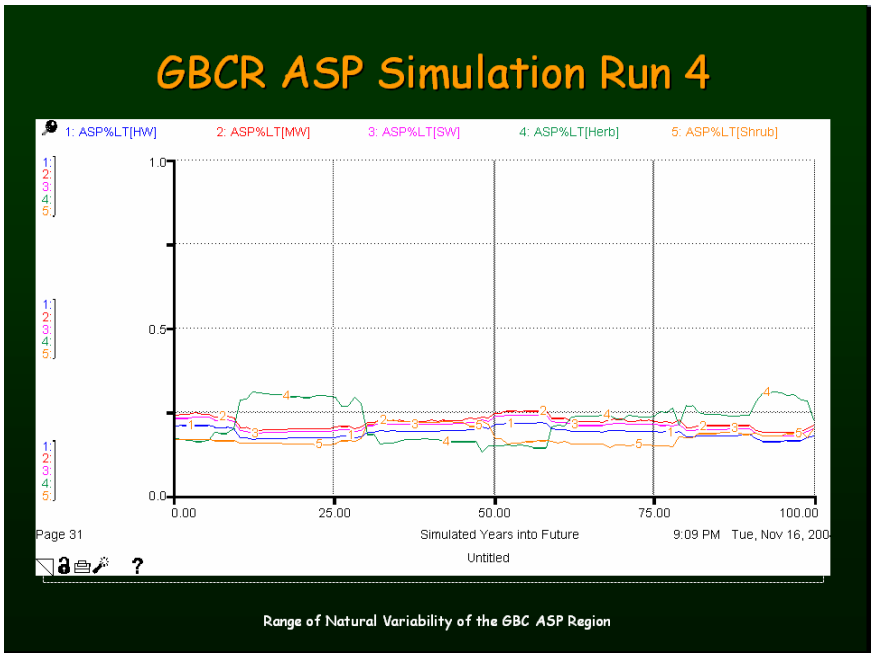
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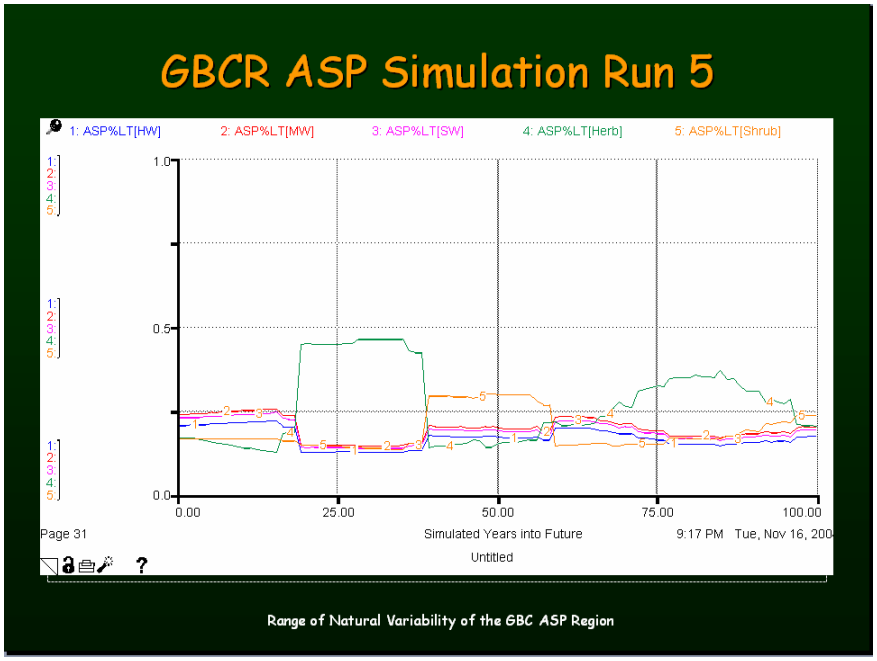
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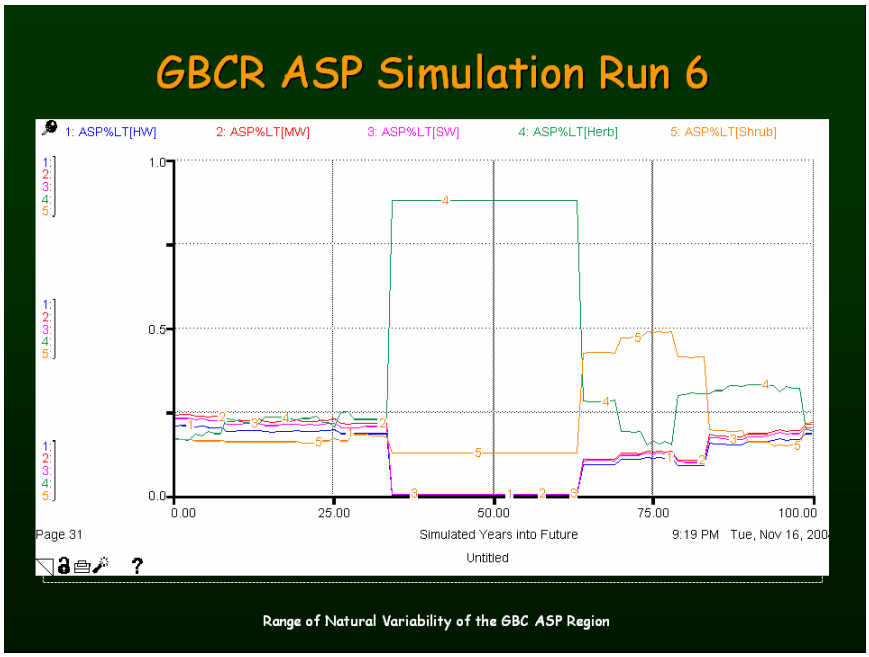
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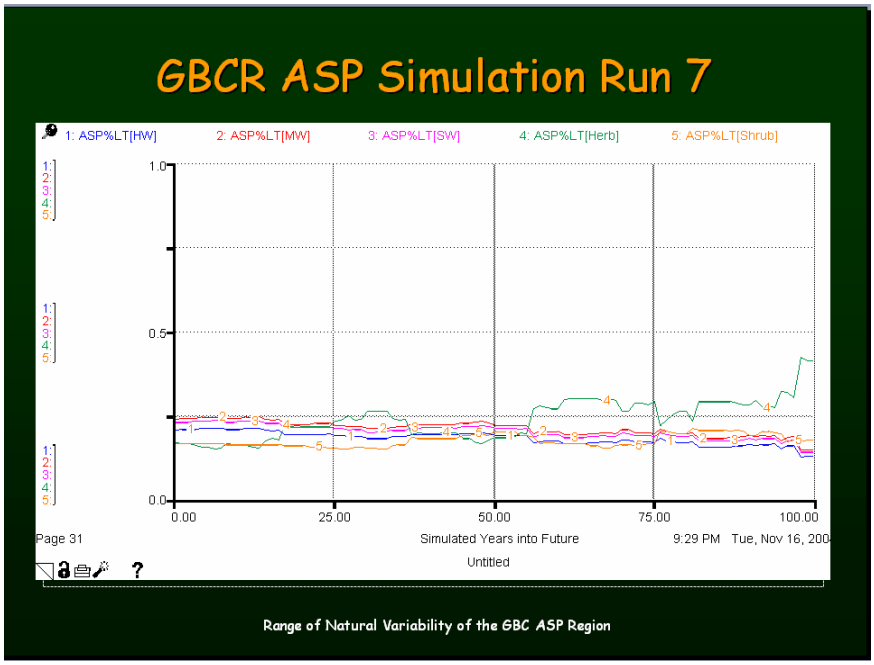
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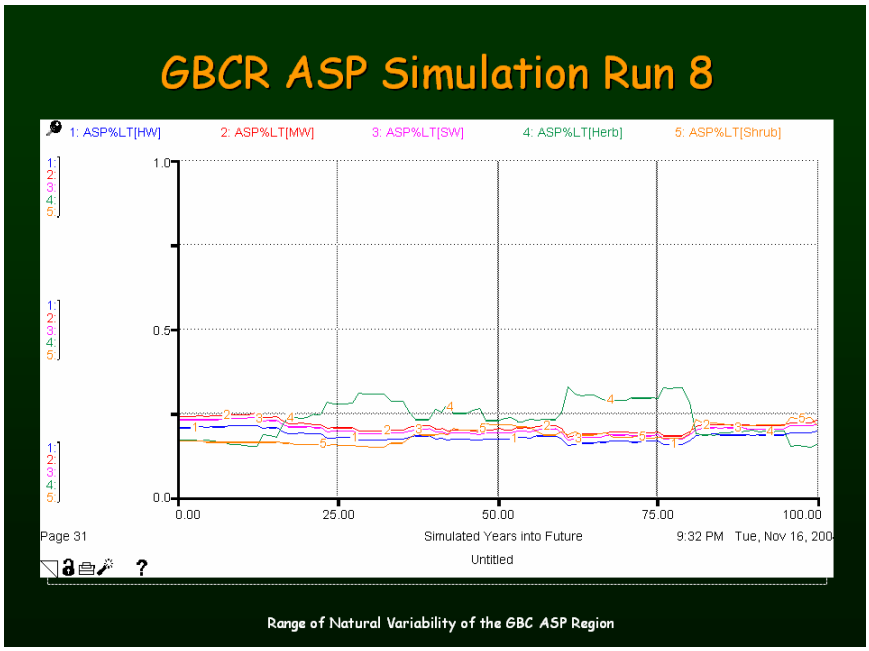
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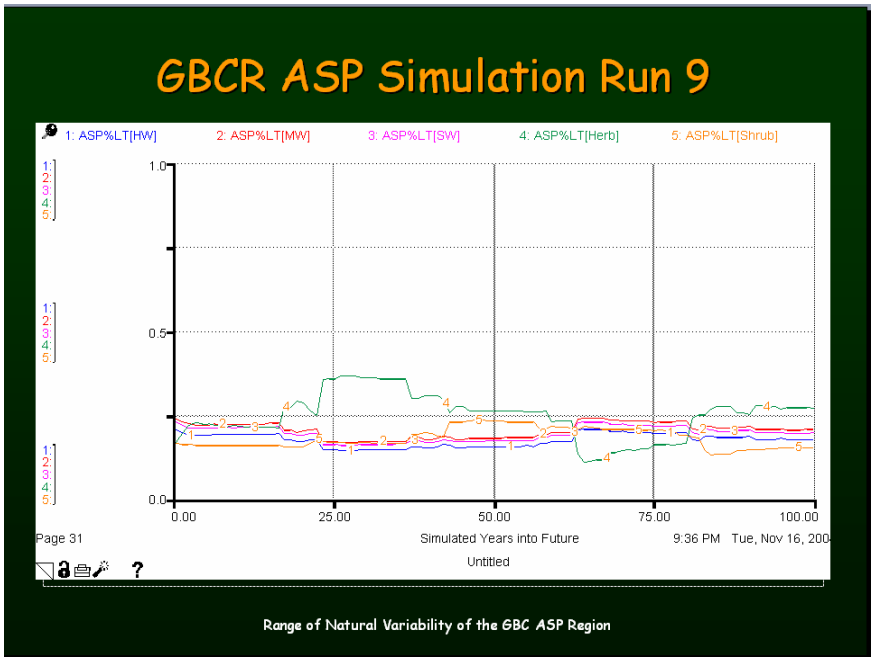
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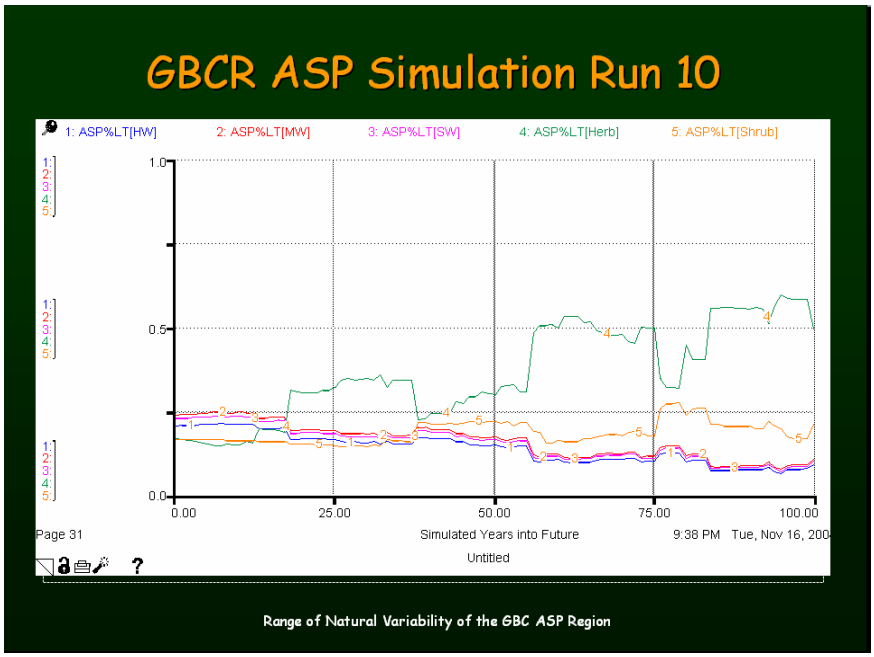
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CONCLUSIONS AND RECOMMENDATIONS

These strategic level simulations emphasize the dynamic nature of abundance of major plant communities in the GBCR. The total amount of area of any given plant community can vary significantly through time.

From a planning perspective, these results emphasize the importance of planners striving to maintain plant communities within their "range of natural variability". Although fire regimes, and other natural disturbance regimes, have been primarily responsible for the maintenance of this diversity in past centuries, their prevalence may be changing with human management decisions. Management decisions that result in plant communities being more abundant, or less abundant, than this natural range of variation, will presumably lead to some level of ecological risk.

In the absence of more precise information or modeling of plant community dynamics, these results can be used to guide managers toward management decisions that minimize ecological risk. The results presented above indicate that each of the dominant plant communities in the GBCR generally vary through time between half (0.5x) and twice (2x) of their current proportion of the GBCR. As such, a "range of natural variability" between 0.5 and 2.0 of current levels provides a benchmark for planning the persistence of these important plant communities.

Prepared by: Brad Stelfox, Forem Technologies
Rebecca Frostad, Alpine Environmental Ltd.

Appendix III

Environmental Reserve (ER) -

Minimum Setbacks from Waterbodies, Presented to the City of Calgary Council by Chris Manderson, January 19, 2005

ENVIRONMENTAL RESERVE SETBACKS

SUMMARY/ISSUE

This report investigates and reports on the feasibility of using Environmental Reserve setbacks greater than six metres as a means of preventing pollution of a waterbody.

PREVIOUS COUNCIL DIRECTION

UE2004-25 Wetland Conservation Plan: Direct the Administration to investigate the issue of utilizing appropriate tools for upland protection, including environmental reserve designation, as a means of preventing pollution to a waterbody and incorporate any such tools into the wetland functional assessment and report back to the S.P.C. on Utilities and Environment.

RECOMMENDATIONS:

That the S.P.C on Utilities and Environment recommends that Council direct the Administration to:

1. Develop Environmental Reserve setback guidelines for land abutting the bed and shore of any lake, river, stream or other body of water in accordance the Municipal Government Act after consultation with City Business Units and other stakeholders.
2. Integrate any recommendations for setbacks into the *Calgary Plan* and other appropriate policy documents.

INVESTIGATION

Background

Recent events have drawn considerable attention towards the protection of wetlands in the city of Calgary. Protection of wetlands and ensuring adequate buffering and setbacks of Radio Tower Creek and the Priddis Slough were identified as a concern in the Southwest Community 'A' and Employment Centre Area Structure Plan.

There are other significant environmental benefits of protecting larger riparian areas adjacent to wetlands and watercourses. A summary of these benefits is provided in Attachment 1.

The recently approved *Wetland Conservation Plan* identified a need to develop appropriate mechanisms to ensure that upland habitat adjacent to significant wetlands be protected. Healthy, functional uplands are a critical component of ensuring the long-term viability and sustainability of wetland habitats and riparian areas. The plan recommends the use of a variety of tools to acquire and protect upland habitat. These are summarized in Attachment 2.

Taking of Environmental Reserve as per the Municipal Government Act (MGA) can help protect some riparian areas, wildlife habitat and other areas adjacent to a waterbody, although such benefits are incidental.

Municipal Government Act (MGA)

The Municipal Government Act defines Environmental Reserve as follows:

> *664(1) Subject to section 663, a subdivision authority may require the owner of a parcel of land that is the subject of a proposed subdivision to provide part of that parcel of land as environmental reserve if it consists of*
> *(a) a swamp, gully, ravine, coulee or natural drainage course,*
> *(b) land that is subject to flooding or is, in the opinion of the subdivision authority, unstable, or*
> ***(c) a strip of land, not less than 6 metres in width, abutting the bed and shore of any lake, river, stream or other body of water for the purpose of***
> ***(i) preventing pollution, or***
> ***(ii) providing public access to and beside the bed and shore.***

The definition of Environmental Reserve allows for a fairly narrow interpretation of the conditions under which a setback of six metres or more would be permitted. Specifically, it would be necessary to

ENVIRONMENTAL RESERVE SETBACKS

demonstrate that such a setback will prevent pollution or is needed to ensure public access. Additional setback widths to provide for buffering, habitat protection, wildlife corridors, general open space or other potentially desirable attributes cannot be provided by means of Environmental Reserve.

a) Prevention of Pollution
For the purposes of this discussion, 'pollution' will refer to non-point source impacts from substances such as sediments, nutrients, and pesticides that typically reach a waterbody by surface or subsurface flows through adjacent lands.

There is a considerable body of evidence that riparian buffers of sufficient width can protect and improve water quality by intercepting non-point-source pollutants in surface and shallow subsurface flows. A review of the literature shows a wide variation in buffer width recommendations, ranging from four metres to over 60 metres (Attachment 3). This range is indicative of the great variation in the effectiveness of natural buffer strips to intercept pollutants. This variation is dependent upon a number of factors, including:

- Cover type (e.g. grass, shrubs, forest)
- Topography (e.g. steep slopes vs. flat)
- Soil type and permeability
- Adjacent landuse

Some studies recommend a riparian buffer of between five and 30 metres is appropriate for water quality protection as a general practice. However, there is a need to review the scientific literature to determine the extent to which these guidelines would apply in the Calgary region.

b) Public Access
There are comparatively few situations where a setback of greater than six metres would be required to ensure public access. It could be argued that if a six metre setback was located on a steep slope that would otherwise not qualify as ER, that it would be difficult to provide public access due to the severity of the slope. There would need to be clear evidence for this to warrant any additional taking.

Current Practice

In some cases it may be possible to take wetlands or riparian areas through an environmental reserve dedication. There are some exceptions:

- The bed and shore of permanent, naturally occurring waterbodies belong to the Crown, as defined by section 3 of the *Public Lands Act*.
- The 1:100-year floodway may be protected from development in rivers, streams and other watercourses

A 6-metre wide ER strip may be taken abutting these lands subject to the requirements of section 664 of the Municipal Government Act. This provision is not always used.

The *Land Use Bylaw* Floodplain Regulations and the *Calgary Plan* identify building setbacks that may apply in some circumstances along the Bow River (60 metres) and the Elbow River and Nose Creek (30 metres). These setbacks are not necessarily entirely dedicated as ER. Six metres of ER may be dedicated for public access and prevention of pollution, along with any available Municipal Reserve to provide additional setback distances. The remainder will often remain in private hands. Landscaping requirements and other controls may be placed on these lands through an Area Structure Plan and *Land Use Bylaw*.

The *Wetland Conservation Plan* identifies which wetlands are considered to be Environmentally Significant on the basis of a wetland classification. The *Plan* recommends the use of all available tools (including ER) to

ENVIRONMENTAL RESERVE SETBACKS

protect and buffer significant wetlands and other waterbodies.

Practices in other Jurisdictions
There are no clear and consistent guidelines for the taking of ER strips in other jurisdictions in Alberta. The City of Edmonton determines ER strips along waterbodies on a case-by-case basis; usually claiming between 10 and 30 metres. Usually greater setbacks are required adjacent to rivers, lakes or other significant waterbodies. Example ER setbacks required by other jurisdictions are provided in Attachment 4.

Other Tools for protecting riparian habitat and water quality
Taking an ER strip is one way to ensure that an adequate environmental reserve buffer can be achieved to prevent pollution. However, other tools may be available to meet this and other goals such as habitat protection (summarized in Attachment 2) should be considered.

Recommended Process
Adoption of ER strips adjacent to waterbodies greater than 6 metres is a departure from the usual practice. ER dedication is very relevant to wetland protection, but also has implications for other lands, especially riparian zones adjacent to rivers and streams that may or may not have wetlands associated with them. As such, it may not be appropriate to incorporate any such evaluation directly into the Functional Assessment procedure for the *Wetland Conservation Plan*. Incorporation into other policy documents should be considered.

ER Setback guidelines should clearly reflect a need to prevent pollution in an adjacent waterbody and should be clearly defensible. Any recommendation to adopt this process should be done after consultation with the key stakeholders, including the public, City Business Units and others. The primary intent of taking greater ER setbacks will be to prevent water pollution, as such; Parks will work with Wastewater to develop these guidelines. It is Parks intention to retain a consulting firm to conduct a literature review and evaluate the feasibility of developing Calgary-specific setback guidelines.

IMPLICATIONS
The recommendations contained in this report are consistent with several themes identified in the *Triple Bottom Line Policy Framework*, particularly themes related to Protecting Water Resources and ensuring Land Stewardship and Protection.

A standard fixed-width setback of six metres of ER is a generally accepted practice in The City of Calgary. This is generally clearly understood and would be the easiest to apply of all the alternatives proposed. Moving away from a set guideline can potentially introduce conflict in the approvals process unless an agreed-upon standardised review procedure is developed. This approach may introduce additional complexity to development approvals.

General
None

Social
Where additional setbacks are warranted, there may be an incidental benefit of making more open space available to the community. Such takings cannot be the focus of any ER dedications.

Environmental
Determination of ER setbacks based upon Best Management Practices and guidelines specifically for water quality protection will have a cumulative benefit of reducing pollutant loading into waterbodies.

Riparian buffers (protected through ER setbacks or other appropriate mechanisms) can help reduce imperviousness, sediment loading in streams and contribute to overall water quality improvements.

ENVIRONMENTAL RESERVE SETBACKS

Appropriate setbacks for water quality protection could have a positive effect on The City's obligations to meeting Alberta Environment's Total Loading requirements for water quality.

Appropriate ER setbacks to meet pollution prevention requirements may have incidental benefits that could include more options to protect important riparian habitat, provide for habitat connections and streambank stabilisation

Economic
An incidental benefit of greater setbacks adjacent to streams and rivers will be the ability allow for stream movement and streambank erosion, reducing the need to undertake riverbank armouring projects to protect property and assets in or near watercourses such as pathways and utility infrastructure.

Restoration of disturbed, non-functional riparian buffers can be considerably more expensive than ensuring that appropriate setbacks are dedicated beforehand.

BUDGET IMPLICATIONS
None

RISKS
There is a potential for increased conflict with the development industry in land use approvals.

There will be more responsibility on behalf of The City to demonstrate a particular setback width is required.

Additional work will be required by CPAG and CPAG specialists (Parks, Wastewater) in reviewing and approving setbacks.

ATTACHMENTS
1. Summary of the benefits of protecting riparian buffers
2. Legal tools available for Municipalities to conserve environmentally significant areas
3. Recommended riparian buffers for water quality improvement
4. Examples of Environmental Reserve setbacks and other requirements adjacent to waterbodies in some Alberta Municipalities

SUMMARY OF THE BENEFITS OF PROTECTING RIPARIAN BUFFERS

Additional benefits of protecting riparian buffers

There are many additional benefits to be realised from protecting riparian buffers adjacent to streams, wetlands and other waterbodies. These benefits are outlined briefly below.

'Riparian' is generally defined as the land adjacent to streams, rivers, wetlands and other waterbodies where the vegetation and soils show evidence of being influenced by the presence of water. Riparian areas are a part of the transitional zone between land and water and play a vital role in the healthy functioning of both.

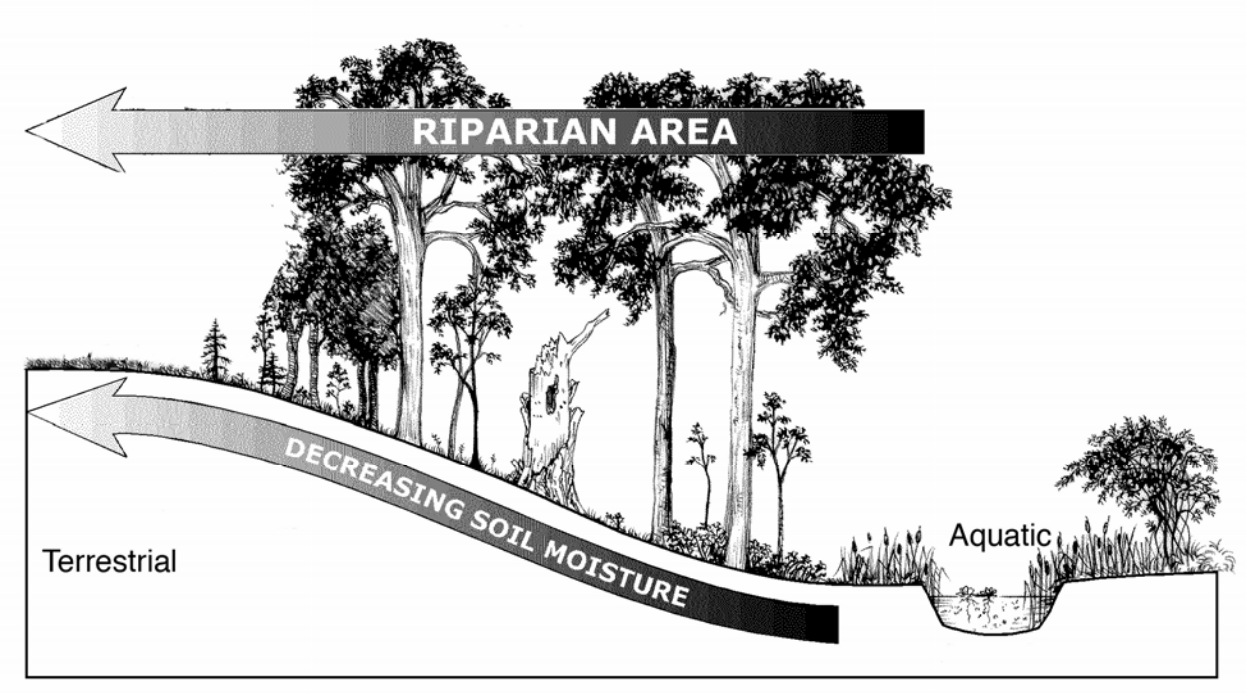

Figure 1. Cross-section of a typical riparian zone adjacent to a stream. Riparian vegetation shows a strong influence of higher soil moisture moisture, either from the stream itself or from subsurface flows[1].

Riparian areas are dynamic systems; the combination of natural disturbance and fluvial processes continually reshape the area to create distinctive ecosystems that play a critical role in habitat diversity in the landscape. Most stream systems move within a 'meander belt'.

Although riparian areas are usually a minor component of the landscape, their ecological significance can often outweigh their limited size. Abundant water and nutrient supplies

[1] Source: Minnesota Forest Resources Council. 1999. *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers.* St. Paul, Minnesota.

generally mean that these sites are highly productive and consequently they are important wildlife habitat for many species.

Riparian areas are generally in the lowest topographic position in the landscape and have natural connections throughout the watershed. As a result they are particularly sensitive to activities upstream and in adjacent lands.

They are often the only remaining native habitat in urbanised areas.

Riparian buffers are areas of land along streams and rivers that are left in a natural state to help maintain clean water and healthy aquatic communities. The benefits of riparian buffers are well known. They provide many useful functions, including:

- Filter sediment and pollutants from runoff;
- Reduce the impacts of floods;
- Stabilise stream banks;
- Provide habitat for wildlife;
- Provide shading to moderate temperature fluctuations in the water to maintain a healthy temperature for aquatic life;
- Provide leaves and woody debris that serve as energy sources and aquatic habitat;

Stream bank stabilisation and the 'meander belt'

There is ample evidence that stream banks with insufficient riparian vegetation are significantly more likely to collapse and erode. Although such erosion is a natural process, removal of riparian vegetation can accelerate this process significantly. This will lead to an increase in sedimentation in the stream, and also alter the dynamic of the streamcourse, making it wider, and shallower. Stream bank erosion and collapse is often the primary source of sediment pollution in watersheds and hastens the decline of the riparian land and the stream itself. As watersheds are developed, more and more water will be discharged into streams as stormwater, which can lead to changes in the hydrological regime of the stream.

While it is possible to restore natural, deep-rooted vegetation to previously eroded stream banks, it is difficult and expensive. Returning functionality to a restored riparian buffer also takes time. Trees take time to grow and compacted soils may take years take years to restore their naturally high infiltration rates. Artificial stabilisation of streambanks is costly[2], and unless carefully done, does not afford the habitat benefits of naturally vegetated riparian areas. Streambank restoration is often the only way to halt stream bank erosion once it has begun.

There has been renewed interest in protecting the "meander belt" of streams and rivers (the zone adjacent to a watercourse in which a stream will naturally move over time). Streams in urban environments can experience significantly different flow rates and regimes, resulting in elevated rates of erosion, bank failures and sediment transport, resulting in lowered water quality and potentially increased costs to protect and restore riverbanks. It is not uncommon for urbanised streams to double or triple in width due to flow regime changes.

[2] A recent study of the Ruhr river basin estimated that the total cost of restoring disturbed streams ranges from 200-1 billion Euros, with a median cost of 175 Euro/metre.

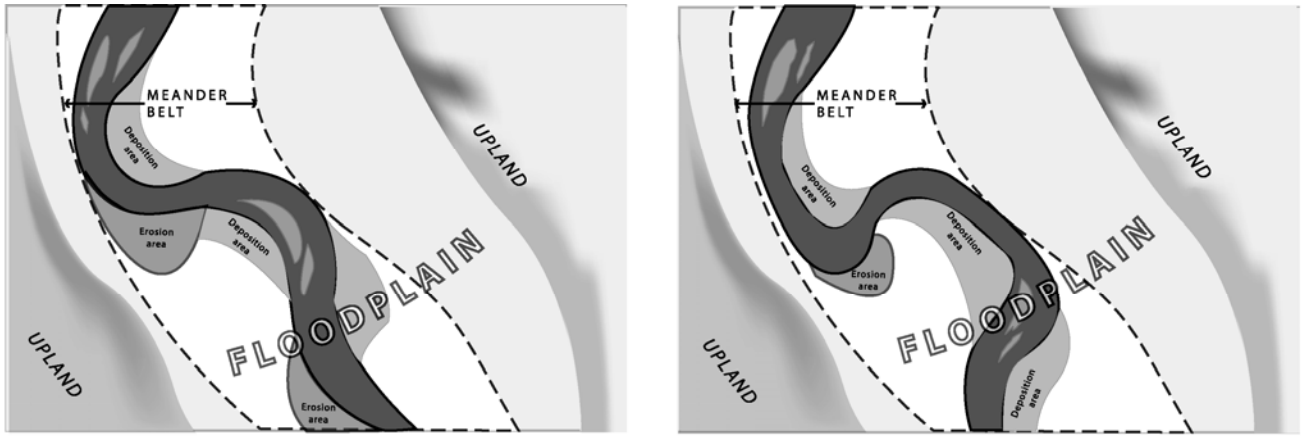

Figure 2. Example of stream movement over time in the meander belt

Water storage and flood control

All streams and wetlands have a natural flood regime. Healthy wetlands and riparian areas play an important role in moderating flooding, by slowing and storing floodwaters. This reduces the downstream impacts of floods, effectively reducing erosion and recharging groundwater.

As a watershed is urbanised, there is typically an increase in the amount of impervious surfaces and a reduction of vegetation cover. This can lead to an increase in the duration and amount flooding reaching a streamcourse. An intact riparian buffer can lessen the effects of upland development and diminish the downstream effects of flooding.

Aquatic and terrestrial habitat

Careful stewardship of riparian lands can protect habitat for numerous species. Water quality is itself a critical component of habitat, especially for many aquatic species which can be sensitive to water quality changes. Degradation of riparian zones is considered a major contributor to non-point source nutrient inputs to streams. A riparian zone with a healthy vegetation cover and soil microflora can play a role in reducing pollutant inputs to streams.

Retaining native vegetation in riparian areas is critical to stream dynamics and vitality. Riparian forests drop large, woody debris into streams and rivers, providing habitat for fish and invertebrates. Organic matter, like leaf litter and terrestrial invertebrates, adds food and energy to streams. Naturally vegetated riparian areas also are essential to many aquatic invertebrates that live a portion of their life and reproduce on land.

Small changes in water temperature or light can disrupt a stream’s natural balance. Riparian cover provides shade, moderating water temperatures for many species of fish and limiting light levels, which can stimulate excessive algae and macrophyte growth.

Riparian areas are important terrestrial habitats in themselves, often supporting higher levels of plant and animal diversity compared to adjacent uplands. Most habitat research on riparian areas has focused on animals, but some studies have documented the important role of riparian corridors for plant diversity and dispersal.

LEGAL TOOLS FOR MUNICIPALITIES TO CONSERVE ENVIRONMENTALLY SENSITIVE AREAS

(Adapted from: Kwasniak, A.2001. *Alberta Wetlands – A Legal & Policy Guide.* Environmental Law Centre and Ducks Unlimited Canada**.)**

Note: This is a general summary of some of the tools available for conservation. Not all of these mechanisms may be applicable or appropriate to the protection of riparian areas or other environmentally significant lands.

Tool	Advantages	Disadvantages	Notes
Administrative and Planning Tools			
Municipal Reserve	• May be required by the subdivision authority as a condition for subdivision • Simple • Not costly to municipality	• Is only triggered by an application for subdivision • Amount of land is limited by ss. 666 and 668 of *Municipal Government Act*	• Priority generally given school sites, neighbourhood parks and other open space needs (see *Open Space Plan*)
Environmental Reserve	• May be required by the subdivision authority as a condition for subdivision • High degree of protection • Simple, difficult to undo • Not costly to municipality	• Is only triggered by an application for subdivision • Must comply with s. 664(1) of MGA so does not apply to all environmentally sensitive land	•
Environmental Reserve Easement	• If the owner and city agree can replace the environmental reserve • High degree of protection • Simple • Flexible • Not costly to municipality	• Is only triggered by an application for subdivision • Costly to the proponent as the easement is granted without compensation • Must comply with s. 664 of MGA so does not apply to all environmentally sensitive land	• Environmental reserve easement is dedicated without compensation • Title stays in name of proponent
Natural Area Land Use Designation under Land Use Bylaw of City and other exercising of municipal authority involving down-zoning to regulate land use	• Uses the City Land Use Bylaw and zoning powers • Simple, flexible • Binds future owners unless changed by City • If a legitimate use of zoning powers no compensation is payable	• May be politically • Requires the definition of new land use category • Can be changed by City • Down-zoning must be in pursuit of long-term planning objectives	• See s. 640 of *Municipal Government Act* • Case law has shown that there is ample scope to down-zone land for protection of environment without having to pay any compensation. See F. Laux, *Planning Law and Practice in Alberta*, Second Edition, Chapter 8.

ATTACHMENT 2 UE2005-03

Tool	Advantages	Disadvantages	Notes
Conservation Easements			
Sale of Conservation Easement to City, other government, ENGO[1].	• Simple, Flexible protection • Binds future owners • Less costly than sale of land itself • City does not bear responsibility for management if Cons. Easement granted to a third party • Terms of the agreement can be modified by agreement	• Voluntary • Costly to recipient • Easement must fit within purpose set out in the *Environmental Protection and Enhancement Act* (EPEA) • Easement can be terminated by agreement or by the Minister of Environment	• The City, Alberta or government agencies qualify to accept a grant of a conservation easement. • ENGO must be a qualified organization as set out in the EPEA
Gift of Conservation Easement to City or other organisation	• Simple, flexible • High degree of protection • Binds future owners • Tax benefits, esp. if deemed an ecological gift • Less costly than sale of land itself • Terms can be modified by agreement • City does not bear responsibility for management if granted to a third party	• Voluntary • Easement must fit within a purpose set out in EPEA • For best tax benefits must qualify as an ecological gift • Costly to land owner	• An ecological gift can be an easement if certified by the Minister of the Environment to be ecologically sensitive • ENGO must be a qualified organization as set out in the EPEA
Donation/Sale of property for park establishment			
Sale to the City/ENGO	• Simple, flexible protection • High degree of protection possible • City does not bear responsibility for management if sold to a third party • Less costly to City and proponent	• Costly for the City/ENGO • Owner must be willing to sell • Does not bind future owners • Development still possible	
Gift to City/ENGO	• Simple, flexible protection • Tax benefits • Could be an ecological gift • City does not bear responsibility for management if donated to a third party • Less costly to City and proponent	• Potentially costly to Owner • Land owner must be willing to give the land • For best tax benefits must qualify as an ecological gift •	• An ecological gift must be land that is certified by the federal Minister of the Environment to be ecologically sensitive land. •
Personal, term and common law partial interests			
Voluntary action by owner to refrain from or limit development	• Simple	• Easy to undo owners • Expensive to land owner • Limited protection	

[1] Environmental Non-government Organisation

Tool	Advantages	Disadvantages	Notes
Lease to City, or other party	• Simple, flexible • Unlikely to be undone during term of lease • City carries out monitoring, upkeep and enforcement • City does not bear responsibility for management if leased to a third party • Less costly to City and proponent	• Could be costly to City, or third party • Leases usually must be of an entire parcel and not to part of a parcel • Land owner must be willing to lease land • No protection after term expires	• Must be registered at Land Titles if for over three years in order to bind future purchasers
License to City or ENGO	• Owner could give a license to enter onto land to carry out a conservation program	• Is not an interest in land, so does not bind future purchasers • Could be costly to City or ENGO • No protection after term expires	
Profit à Prendre to City or ENGO (right to enter onto land and take some "profit" of the soil)	• Owner could give City or ENGO exclusive right to trees or other vegetation—no one else may remove vegetation • City/ENGO carries out monitoring, upkeep and enforcement • High degree of protection if rights not exercised • Could be for a term or granted in perpetuity	• Could be costly to City/ENGO to purchase right • Conservation goal only realized if City/ENGO chooses not to exercise right • Land owner must be willing to sell a profit à prendre	• Profits à prendre are interests in land and bind subsequent purchasers if registered on title
Common law Easement from owner regarding neighbouring land	• Binds future owners • May contain positive or negative covenants • Less expensive than sale of land itself • Could be for a term or be granted in perpetuity	• Easement on a parcel (servient tenement) must benefit another land (dominant tenement) • Can be undone by owner of the dominant tenement	• See ss.71 & 72 of *Land Titles Act*
Restrictive Covenant regarding neighbouring land	• Binds future owners • Less expensive than sale of land itself • Could be for a term or granted in perpetuity	• Restriction on one parcel (servient tenement) must benefit another parcel (dominant tenement) • Covenants can only be negative and not positive • Can be undone by owner of dominant tenement • Can be removed by the Court in the public interest	• See s. 52 of *Land Titles Act*

Tool	Advantages	Disadvantages	Notes
Park Designation			
Sale to federal government for park dedication[2]	• High degree of protection • Difficult to undo • Flexible protection • Federal government responsible for monitoring, upkeep and enforcement • Tax benefits if a gift of capital property • Could be an ecological gift	• Dependent on action from the federal government • Provincial government must agree • Costly to the federal government • Difficult to meet criteria	• See the *Canada National Parks Act*, the *Migratory Birds Convention Act*, the *Canada Wildlife Act*
Sale to provincial government as a park[3]	• Varying degrees of protection depending on designation • Some designations are difficult to undo • Flexible protection • Provincial government carries out monitoring, upkeep and enforcement • less costly to City and proponent	• Dependent on action from the provincial government • Costly to the provincial government • Difficult to meet criteria	• See the *Wilderness Areas, Ecological Reserves and Natural Areas Act*, the *Provincial Parks Act* and the *Wildlife Act*

[2] Could be designated as a national park, park reserve, national historic site, migratory bird sanctuary or national wildlife area
[3] Could be designated as a provincial park, wildlands park, recreation area, ecological reserve, natural area, wilderness area or wildlife sanctuary

RECOMMENDED RIPARIAN BUFFERS FOR WATER QUALITY IMPROVEMENT

(after Fischer & Fischenich, 2000)

Source	Width	Buffer type	Benefit
Woodard & Rock 1995	≥ 15m	Hardwood forest	A 15m buffer was shown to reduce phosphorus concentrations adjacent to single family homes
Young et al. (1980)	≥ 25m	vegetated buffer	25m buffer reduced the suspended sediment in feedlot runoff by 92%
Horner & Mar (1982)	≥ 61m	grass filter strip, vegetated buffer strip	Removed 80% of suspended sediment in stormwater
Lynch, Corbelt and Mussalem (1985)	≥ 30m		30m buffer between clearcuts and streams and wetlands removed 75-80% of suspended sediments, reduced nutrient concentrations and helped maintain cooler water temperatures
Ghaffarzadeh, Robinson & Cruse (1992)	≥9m	grass filter strip	Removed 85% of sediments on 7% and 12% slopes
Madison *et al.* (1992)	≥5m	grass filter strip	Trapped approximately 90% of nitrates and phosphates
Lowrance *et al.* (1992)	≥7m		nitrate concentrations almost completely reduced due to microbial denitrification and plant uptake.
Nichols *et al.* (1998)	≥18m	grass filter strips	reduced estradiol concentrations in runoff into surface water by 98%
Doyle *et al.* (1977)	≥4m	grass filter strips and forested buffers	reduced nitrogen, phosphorus, potassium and fecal bacterial in runoff
Shisler, Jordan & Wargo (1987)	≥19m	forested and riparian buffers	removed as much as 80% of excess phosphorus and 89% of excess nitrogen

EXAMPLES OF ENVIRONMENTAL RESERVE SETBACKS AND OTHER REQUIREMENTS ADJACENT TO WATERBODIES IN SOME ALBERTA MUNICIPALITIES

Municipality	Setback	Source	Notes
City of Edmonton	10-30m		The City of Edmonton asks for up to a 30m Environmental Reserve setback adjacent to waterbodies. The actual setback width is determined on a case-by-case basis for through a biophysical inventory and assessment process. 10 metres is typically taken (Grant Pearsell, Conservation Co-ordinator, City of Edmonton, personal communication)
County of Grande Prairie	30m ER strip alongside Claire Lake	Municipal Development Plan	"…the County may require more than a 30 metre strip of land for environmental reserve for the purposes of ensuring public safety and reducing the risk of property damage (i.e. due to slope instability, high water table, or potential flooding). "
Red Deer County		Landuse bylaw	"Trees or vegetation shall not be cleared from any land within 20 meters (66') of any watercourse, water body, escarpment, or of the crest of a slope greater than 15%, where the removal could have a negative impact on the water body or bank stability."
Strathcona County	variable (50 metre setback from the top of the North Saskatchewan River bank and a 30 metre setback from the top of bank of other watercourses	Municipal Development Plan	Dedicate environmental reserve to protect the following areas: a) environmentally significant and sensitive areas and important wildlife habitat as identified in Prioritized Landscape Ecology Assessment of Strathcona County, 1997; b) shorelines of lakes to ensure public access; c) lands determined to be significant by a provincial water management committee; and d) a corridor along the top of bank of a drainage course. At the time of subdivision, the County shall determine the amount of land to be taken as environmental reserve.
Sturgeon County	30m along the N. Saskatchewan and Sturgeon rivers	Landuse bylaw	A minimum buffer strip of 30 m preserved for environmental reserve from the top of bank of the North Saskatchewan and Sturgeon Rivers. No permanent structures are permitted within the 1:100 year flood plain.
Yellowhead County		MDP (draft)	Engineering study required for all developments within 100m of a major river to determine the extent of active erosion