Retention of an Existing Wetland for Stormwater Management: A New Approach for Calgary, Alberta

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The future Rocky Ridge Subdivision is located in northwest Calgary, Alberta. The area for the new subdivision is considered prime real estate as most of it has unobstructed views over the foothills to the peaks of the Rocky Mountains to the west. The area also has excellent access to the downtown area via Crowchild Trail, one of the main traffic corridors in Calgary, and to the Trans Canada Highway that runs west to Banff and Lake Louise.

The Rocky Ridge area is characterized by a steep, rolling topography with valleys and numerous depressions, many of which hold water most of the time. These wet depressions, or wetlands, provide important wildlife habitat in a regional context. Many of these wetland basins will be retained and incorporated into an integrated stormwater management system for the subdivision as a whole. As such, it is the first of its kind within Calgary to retain the natural features of the existing landscape.

The following sections describe the Stormwater Management concept for the Rocky Ridge Subdivision and how it is unique compared to most of the stormwater management facilities presently existing in Calgary. Also included is a brief discussion of the background, and some of the latest developments in Stormwater Management in the Calgary area.

In addition, a description is presented of a wetland that has been incorporated in the development of the first phase of the subdivision. Subsequent

Van Duin, B., J. Gareau, P. Jalkotzy and J. McAuley. 1996. "Retention of an Existing Wetland for Stormwater Management - A New Approach for Calgary Alberta." *Journal of Water Management Modeling* R191-15. doi: 10.14796/JWMM.R191-15.

© CHI 1996 www.chijournal.org ISSN: 2292-6062 (Formerly in *Advances in Modeling the Management of Stormwater Impacts*. ISBN: 0-9697422-5-8)

sections describe the measures taken to protect the integrity of the wetland during and after construction of the subdivision including a multi-year monitoring program which also addresses the benefits for designing and monitoring future stormwater management facilities in the Calgary area. A summary of the benefits to the developer and community at large concludes this chapter.

15.1 Rocky Ridge Subdivision Stormwater Management Concept

Developers today face many pressures including zoning regulations and above all the demands from their shareholders. Land use policies specify what percentage of developable land needs to be set aside for other 'no income producing' usages such as schools, community facilities, green zones, play areas, etc. Stormwater management is one of many issues in the planning and design of new subdivisions, albeit an increasingly important one, as it can directly affect the layout of new subdivisions. Land set aside for stormwater management facilities in principle reduces the financial return for the developer unless these facilities have a multi-purpose use or enhance the adjacent properties so that the developer can receive a premium for the lots. The latter is the case for the first phase of Rocky Ridge where the potential exists to incorporate the wetlands to make the subdivision more attractive.

The existing drainage in the Rocky Ridge area is from the north to the south towards the Bow River. Crowchild Trail, on the south side forms a physical boundary as it is elevated with respect to the surrounding area. Similarly, the right-of-way of the future Stoney Trail will become a physical boundary on the southeast side. The total area of the Rocky Ridge watershed is about 736 ha which includes 187 ha to the west and north of the subdivision.

Numerous deep depressions are scattered throughout the area, especially in the northeastern part. Most of these depressions are self-contained resulting in the relatively low total (pre-development) unit flow rate of $6.7 \text{ L s}^{-1} \text{ ha}^{-1}$ from the entire area. The Master Drainage Plan for the Rocky Ridge area specifies that the flow rate after development is not to exceed the even lower unit flow rate of $2.6 \text{ L s}^{-1} \text{ ha}^{-1}$ for the 1:100 year design storm event. This permissible unit flow rate is based on a comprehensive, basin-wide cost-benefit analysis which compared pipe conveyance and stormwater retention costs. Minor and major system flows in excess of this flow rate have to be retained in stormwater management facilities and released at the controlled unit flow rate.

Logically, the existing depressions or wetlands in the Rocky Ridge area are ideal locations for stormwater storage purposes after development of the area. The development plan for the first phase proposes to retain a local wetland and incorporate it into the subdivision as an environmental enhancement feature that

serves as a 'natural' stormwater storage facility servicing an area of 15 ha. The facility would be a first of its kind within Calgary with the main objective of satisfying the stormwater storage requirements; however, secondary objectives are water quality improvements as well as retaining a more natural environment.

The developer of the Rocky Ridge subdivision, Marquis Scenic Acres Development Co. of Calgary, recognized at an early stage that a reputation as a "green" developer produced distinct benefits from a marketing point of view. The wetland could become an essential component of the subdivision and be incorporated into the regional pathway system. As such Marquis developed innovative land development strategies in advance of environmental guidelines now being drawn up by a special city committee encouraging developers to become more environmentally sensitive and retain natural features where possible (Calgary Herald, 1994).

The two parties involved in the approval process within the City of Calgary are the Engineering and Environmental Services Department, and the Parks and Recreation Department. Although the proposed stormwater management system incorporating wetlands deviated from the common stormwater management policies, City staff were receptive to the project. The City viewed this as a small-scale pilot project providing an opportunity to gain a better level of understanding of the use of wetlands as stormwater storage facilities. In addition, the approval to proceed with the wetland was conditional on the wetland being converted into a standard dry or wet pond (at the developers' expense), if it does not operate satisfactorily. Particular issues of concern are potential odour and mosquito problems, Calgary's unique climate, and maintenance. The maintenance period was extended from the standard two years to five years and a monitoring program was required to assist in the evaluation of the operation of the wetland.

15.2 Developments in Stormwater Management in the Calgary Area

Over the last sixteen years stormwater storage requirements for new subdivisions in Calgary have been provided in dry and wet ponds. These stormwater storage facilities are built according to City of Calgary guidelines which include recommendations with respect to layout, shape and maximum depth of inundation. Although dry ponds were envisioned to serve as multi-purpose facilities incorporating soccer fields or baseball diamonds, their use has been restricted at times as a result of frequent inundations and consequently wet soils and grass during the summer months. Wet ponds often have the disadvantage of higher construction costs, raise concerns about safety issues and require good turn-over volumes to safeguard water quality.

Stormwater management in the Calgary area however has progressively changed over the last ten years. More changes can be expected when experiences gained from current projects like Rocky Ridge are interpreted and incorporated as alternative stormwater management practices. Careful evaluation of this wetland approach is needed to ensure that these type of stormwater storage facilities are acceptable to the general public and a cost-effective alternative. It is recognized that experiences gained in Ontario or the United States with wetlands as stormwater storage facilities cannot necessarily be made applicable to Southern Alberta, in particular since the climate in the Calgary area is much harsher with lower temperatures, low total precipitation (less than 400 mm/year) and high evaporation.

The City of Calgary Sewer Division is currently evaluating a pond system in the Edgemont subdivision in North Calgary for potential use as a 'natural' facility while a pilot study is underway for a constructed wetland in Southwest Calgary.

15.3 Description of the Wetland

The wetlands of the Rocky Ridge development area are located within the aspen parkland ecoregion of Alberta. This ecoregion is characterized by a mosaic of rough fescue grassland and aspen forest. Shrub communities are also common (Strong and Leggat, 1992). The wetlands form an environmentally sensitive area within the Rocky Ridge Area Structure Plan and are considered *...natural features that may be worthy of preservation...* (City of Calgary, 1992).

The use of natural wetlands for stormwater management is generally discouraged (Schueler, 1992) since the resulting changes to the hydrology of the basin will likely reduce the biological diversity of the water body. However, preservation of the wetland in a completely natural state was not considered practical in light of the development plans for the area. Subsequently, incorporation of the wetland into the stormwater system for the subdivision became an option preferable to removing the wetland completely in order to construct a conventional dry or wet pond.

During the summer of 1993, a cursory baseline biophysical survey was undertaken of the wetland which is incorporated in the first phase of the Rocky Ridge development area. Based on this survey (W-E-R AGRA Ltd., 1993), the wetland was classified as transitional between a seasonal marsh (normally flooded until late June/early July) and a semi-permanent marsh (normally flooded until late in the growing season). The survey also determined that the wetland functioned as part of a wetland complex that provided important wildlife habitat in the region, particularly for waterfowl. In combination with relatively undisturbed uplands, it provided important nesting areas, and during the 1993

survey the number of duck broods (at least three) utilizing the wetland was high relative to its size of approximately 1.25 ha. Other types of wildlife that have been known to, or are expected to, inhabit the wetland and surrounding uplands include deer, weasels, coyotes, herons, hawks, song birds, frogs, salamanders, etc. The wet conditions in summer 1993 were ideal for the development of a diverse wetland vegetation community, characterized by a good mix of emergent plants (e.g. sedge, spike rush) and open water (and associated submergent plants, e.g. pondweed).

Wildlife habitat was affected by construction activities during the summer of 1994 which included stripping and grading of the uplands to the south, west and immediate north of the wetland. However, despite the loss of nesting habitat, several (at least four) duck broods were again raised on the wetland. The high number of duck broods raised on the wetland in 1994 probably reflected the relatively undisturbed upland nesting habitat present to the north and east.

The continued use of the general area by wildlife will depend on the extent of development that occurs. The biological diversity in the wetland is expected to be reduced as the hydrologic regime of the drainage basin will change as a result of the development. Consequently, the wetland will not have the wildlife habitat value that existed prior to development, but it will provide considerably more habitat than if a dry pond were constructed in its place.

15.4 Methods Used for Evaluating Stormwater Storage Requirements

The Master Drainage Plan for the Rocky Ridge subdivision is based on the premise that post-development flows will not exceed the permissible unit release rate of $2.6 \text{ L s}^{-1} \text{ ha}^{-1}$ for the 1:100 year design event. Major and minor system flows in excess of this release rate have to be retained in stormwater management facilities distributed over the new subdivision.

Storage volume requirements in Calgary are generally evaluated with the help of both single event and continuous simulation. Single event analysis is usually conducted with models such as INTERHYMO or MIDUSS for a 24 hour, 1:100 year design storm. For continuous simulation analysis AGRA Earth & Environmental (AEE) has developed its own 'pond routing' program that uses runoff hydrographs generated by QUALHYMO. This routing program allows an annual variation in evaporation rates which can be considerable in the Calgary area. Continuous simulation is typically carried out for the period 1960 through 1992, which is the period of record for which continuous rainfall, snowfall, and temperature records are available from the Calgary International Airport. Results from the continuous simulation routing routine are subsequently processed to determine the annual maximum volumes in the pond. These maximum volumes

are further evaluated with the help of frequency analysis packages such as the Consolidated Frequency Analysis package CFA. Another program developed in-house is used to determine the frequency of inundation in the pond, which is important for assessing the potential for multi-purpose use of the facility.

15.5 Pre- and Post-Development Runoff Rates and Volumes

Figure 15.1 shows the variation of water level in the wetland for a typical wet year (1965) under both pre-development and post-development conditions as determined by means of QUALHYMO and AEE's in-house routing program. (Note that the normal operating level shown in Figure 15.1 for post-development conditions is for illustration purposes only). The actual recommended level, which likely will be closer to the minimum operating level of 1258.60 m, will be determined as part of the monitoring program). It shows that the levels under pre-development conditions varied gradually during the course of the year. Under post-development conditions, levels would have risen rapidly during and after a storm event but would also have returned quickly to the operating level. The change in pattern is caused by the urbanization of the watershed which results in

Figure 15.1 Pre- versus post-development water levels in wetland for typical wet year.

a much quicker response and higher peak flows. The quick recession is due to the outflow at the outlet control structure and is required to restore the storage capacity of the wetland.

Biologists on the project team recognized that the rapid fluctuations in water level could prove to be beneficial in the control of mosquitoes. However, water level fluctuations in the wetland should resemble the original growing conditions as much as possible, particularly in spring. It is anticipated that the plant diversity is likely to be reduced as a result of the altered hydrology of the watershed.

15.6 Protecting the Integrity of the Wetland

Unfortunately, it was not possible to eliminate impacts on the wetland from the development. This would have meant that the watershed plus a buffer zone would have to been retained in its natural state. This however was impossible in view of the proposed development for the area. Isolation of the wetland solely was not practical either from a business point of view. The only remaining viable alternative was therefore the incorporation of the wetland into the stormwater management system as either a standard dry or wet pond, or as an enhanced ‘natural’ facility.

Various measures were developed to protect the integrity of the wetland, during both the construction phase and after completion of the subdivision. These measures include both structural works such as an operable outlet control structure, a sedimentation vault, and artificial nesting structures for waterfowl, and non-structural works such as sedimentation and erosion control, vegetation management and public education programs.

15.6.1 Sedimentation and Erosion Control Program

The City of Calgary has the policy, as do most municipalities in Canada and the United States, that the stripping and grading processes must adhere to a sedimentation and erosion control program. Recognizing that sediment inputs to the wetland could potentially adversely affect the wetland and its capabilities to improve the water quality, and since the buffer zones of the wetland were minimal, various measures were implemented to protect the wetland. These included silt fences, straw bale walls, diversion ditches, etc. In addition, the area was re-seeded after completion of the grading process.

The sedimentation and erosion control program included additional expenses to ensure protection of the wetland as even “small” quantities of sediment entering the wetland are potentially detrimental to the integrity of the wetland. Hence, recommendations were made to maintain the control program after the grading process is completed and underground utilities have been installed. Also,

silt fences and straw bale walls surrounding the wetland are to be kept in place and accumulated sediment is to be removed during construction of the homes and regional pathway around the wetland. In addition, and until the completion of the construction of the development phase, silt traps have been recommended around the catchbasins to minimize the amount of fine silt entering the wetland.

15.6.2 Water Level Control by the Outlet Control Structure

The outlet control structure (see Figure 15.2) is located at the east end of the wetland. The flow restriction is achieved by an orifice while stop logs can be used to regulate the operating level over a range of 1.40 metres. The elevation of the crest of the weir in the structure is set at the maximum 1:100 year level in the pond based on the maximum operating level. A sluice gate is provided to drain the wetland to the lowest operating level. Should it be necessary to drain the wetland completely, the remaining volume of water could be pumped out.

Figure 15.2 Outlet control structure (dimensions in mm).

Pumping will be used to regulate the levels in the wetland prior to construction of the outlet control structure. This is necessary since the stripping and grading activities in the adjacent areas have drastically changed the hydrological regime of the watershed. This has resulted in a substantial increase in

runoff volumes to and water levels in the wetland, and the inundation and drowning of the emergent vegetation. The drawing down of the water levels in the spring will help to rejuvenate the emergent plant growth.

The minimum operating level is based on the average water levels observed in the wetland in the summers of 1992 and 1993. The maximum level was selected such that the maximum 1:100 year level in the pond would not affect the adjacent residential development. As shown on Figure 15.1, the water levels in the wetland under pre-development conditions varied gradually during the course of the year as opposed to post-development conditions where the levels will rise rapidly during and after a storm event but will also return quickly again to the normal operating level. The insertion of stop logs at the control structure will allow for variations during the year. (The operating procedure will be evaluated continuously as part of the monitoring program).

15.6.3 Sedimentation Vault

Various configurations for a sediment intercepting facility were considered including a sedimentation forebay, 'Stormceptor' maintenance hatch, and standard rectangular vault or vault equipped with lamellae separators. In consultation with the planners and landscape architects for the Rocky Ridge subdivision, it was decided to dismiss the forebay concept because of space requirements and aesthetics. In addition, it would be difficult to retain floatable material. A 'Stormceptor' maintenance hatch was seriously considered, however the sediment load from the tributary area would require too frequent sediment removal based on the information provided by the manufacturer. A vault structure as shown in Figure 15.3 was chosen for its simplicity, easy access, and no need for specialized equipment for cleaning. A simple rectangular shaped vault structure was selected, the top of which is easily lifted to remove the floating material, retained by a skimming device, and to remove sediment using a back-hoe. The structure also serves as a viewing platform which the public could access via the regional pathway system.

The elevation of the discharge openings were set above the maximum operating level so that the wetland would not back up into the vault for minor events or the first flush phase of major events. The operation of the sedimentation vault is facilitated by a diversion weir at the upstream end of the structure. This weir directs the first flush through the structure while larger flows will by-pass the facility circumventing the potential for re-suspension of sediments. The structure was designed for a flow of about 150 L/s, (which covers most storm events), and for a removal ratio of over 95% for fine sand. The by-passed flow is directed to a riprap lined impact basin to reduce the energy of the incoming flow, which reduces the potential for disturbance of the wetland.

cutting of the plants and off-site disposal (Schueler, 1992). Drawbacks to this procedure include cost, lack of suitable disposal sites and loss of biomass to support the wetland food chain

Periodic drawdowns of water levels have been recommended as a means of managing aquatic vegetation growth in the wetland. Removal of the vegetative cover in the surrounding uplands during stripping and grading operations in 1993 reduced the capacity of the drainage basin to retain runoff during spring melt and storm events. As a result, water levels in the wetland in 1994 were considerably higher than in the previous year. This flooded condition led to the drowning of the emergent vegetation community. Drawdown will expose wetland substrates and enhance the germination of seeds and growth of new shoots from plant roots. The wetland will slowly be re-flooded to keep pace with the growth of new shoots.

Excessive plant growth in the wetland may eventually lead to the buildup of peat and the loss of the pond's storage capacity. Water level drawdown may also be used to encourage the aerobic degradation of the previously anaerobic peat. One potentially negative aspect of this practice is the resulting release of nutrients into the water column and eventually into the storm sewer.

In the event that the emergent vegetation community becomes dominated by a few aggressive species (e.g. cattails), it will be possible to temporarily increase water levels to create areas of open water where other plant species can become established. This will help to create a more diverse environment for water quality improvement and wildlife habitat.

15.6.6 Wildlife Habitat Mitigation

It has been recommended that the loss of upland duck nesting habitat in the immediate vicinity of the wetland, due to the subdivision development, be mitigated as much as possible by the placement of artificial nesting structures into the wetland. Either nesting cones or floating nesting platforms have been proposed. Nesting platforms are preferable since they will not be inundated by rising water levels during storm events.

15.6.7 Public Education - Participation

A significant public education effort has been expended to date by the developer, the project team, and the City of Calgary; however, it is recognized that the long term success of the wetland will depend on the attitudes and acceptance of the general public and the home owners in the subdivision. It is vital that the home owners have an appreciation and sense of ownership of the wetland. Practically, this means that home owners be made aware of the benefits to the wetland of minimizing, or becoming more discriminate in the use of

fertilizers and pesticides, and delaying of watering their lawns directly after fertilization. In addition, other contaminants such as paint thinners, or oil and antifreeze from cars should be prevented from entering any storm sewer system.

It is expected that the home owners directly adjacent to the wetland will probably be environmentally sensitive as they will have to pay a premium for their lots. However, in order to reach all home owners in the subdivision, the developer is planning to include a public education package along with other information. The owners of the surrounding acreages, the emerging community association of Rocky Ridge, and the Alderman for the area have been very appreciative and supportive of the efforts by the developer and project team in retaining the wetland.

15.7 Monitoring program

15.7.1 Description of the Program

During the cursory 1993 baseline biophysical assessment of the wetland it became clear that a monitoring program was essential to track the efficiency of the wetland in removing contaminants from stormwater and the changes to the biological integrity (and therefore treatment function) of the wetland as a result of the stormwater inputs. A monitoring program was particularly important in the case of the wetland, since it was essentially a pilot project in the Calgary area.

Any level of monitoring is better than no monitoring at all, at least as long as the limitations of the gathered information are understood by all stakeholders. In this case, it was recommended that the monitoring program be conducted for a minimum of five years and address four components of the wetland facility: water quality (inlet, outlet and in-pond), aquatic vegetation, aquatic invertebrates, and sediments. The first year was assigned to the collection of baseline information on in-pond water quality; aquatic vegetation composition, distribution and abundance; aquatic invertebrate diversity; and in-pond sediment quality. Initial estimates placed the cost (services and expenses) of the total program at approximately \$50,000 per year. Attempts to obtain financial support from government agencies, conservation organizations, etc. for the monitoring program were not successful. As a result the first baseline year of the monitoring effort (summer 1994) was reduced to in-pond water quality only and AEE agreed to cover the cost. The water quality parameters were selected on the basis of those currently monitored by the City of Calgary as part of their ongoing stormwater quality monitoring program. In-pond water quality sampling took place during ten non-storm events and included the following parameters:

- total suspended solids (TSS),
- chemical oxygen demand (COD),

- oil & grease,
- total ortho and dissolved phosphorus,
- ammonia nitrogen,
- nitrate and nitrite nitrogen,
- total Kjeldahl nitrogen (TKN),
- ICP total metals screen (includes total phosphorus),
- total hydrocarbons,
- biochemical oxygen demand (BOD),
- total organic carbon (TOC),
- dissolved oxygen (DO),
- pH,
- temperature,
- conductivity,
- salinity,
- turbidity, and
- total and fecal coliforms

For financial reasons the proposed monitoring effort for years two through five has been reduced to inlet and outlet water quality sampling (five storm events and three baseflow events) and in-pond water quality sampling (five baseflow events). Parameters analyzed will be limited to TSS, nitrate nitrogen, dissolved phosphorus, total metals scan, TKN and COD for both inlet and outlet, and in-pond sampling. In-pond sampling will also include the following parameters: fecal coliforms, TOC, BOD, pH, conductivity, salinity, DO, temperature and turbidity. This sampling effort was estimated to cost about \$20,000 per year. Inlet and outlet samples are to be collected with automated samplers installed within the structures. The cost of these items is to be covered by the developer.

During visits to the wetland to collect samples, written and photographic records will be made of general changes in vegetation composition and distribution, and other signs of altered wetland health (invertebrate/amphibian abundance, algal blooms, odours, mosquitoes, etc.)

A raingage and continuous water level gage are to be installed. Information gathered from these devices will assist in estimating the mass balance of contaminants entering and leaving the wetland in stormwater. As a result, it will be possible to assess the pollutant removal efficiency of the wetland.

15.7.2 Benefits of the Monitoring Program

The monitoring program will provide many benefits. These include:

- Most importantly, inlet and outlet monitoring, in combination with hydrologic information provided by the rain and water level gages, will allow for an assessment of contaminant mass balance and therefore the efficiency of the wetland in removing the pollutants

from stormwater. At the end of five years, this information will help to identify whether the condition of the City of Calgary's approval has been met (i.e., better outlet than inlet water quality).

- Although limited in quality, information will be gathered on the effects of stormwater inputs on natural wetlands.
- Information collected during the monitoring program and general observations will be used to assess whether other management strategies or additional structures are required for the wetland. For example, poorer water quality at the outlet compared to the inlet may indicate that flows are short-circuiting between the two structures. It may then be necessary to construct berms or a network of small islands near the inlet to redirect flows, reduce short-circuiting and increase the residence time. Decreases or increases in emergent vegetation density in the wetland may indicate the need for adjustment of water levels to rejuvenate or discourage plant growth as the case may be (see section 15.5 for details).
- Information gathered will be useful for public education, improving data bases on the technology and providing a case study (including do's and don't's) for similar projects elsewhere in Calgary and the region.
- Data obtained by the water level monitor at the control structure in combination with the raingage at the site can be used to establish a water balance. This in turn can be used to verify the subdivision runoff water quantity estimates as provided by the INTERHYMO and QUALHYMO models. In the Calgary area these estimates, at present, are often based on scarce local information or extrapolations from data sources in Eastern Canada or the United States. Unfortunately the conditions under which information was obtained for the latter generally do not apply to conditions in Calgary. The results obtained under the monitoring program may aid the City of Calgary and other organizations in selecting the proper parameters for design of facilities.

15.8 Evaluation of Benefits

The benefits of retaining the wetland in the first phase of the Rocky Ridge subdivision are many. For the developer the most important issues are economic ones. Also, retaining the wetland re-establishes the reputation as a "green" developer potentially resulting in a higher interest in the area.

Direct savings for the developer will include the substantial reduction of earthworks when compared to those of a dry or wet pond, and the elimination of

the in-pond piping. The cost of the control structure including required level monitoring system are similar, while extra costs are associated with the sedimentation vault and the monitoring program. Some extra income may be expected due to premiums on lot pricing. In general, the overall picture would definitely be positive if it were not for the cost of the monitoring program and the uncertainty of possibly having to convert the wetland into a standard dry or wet pond after the five-year extended maintenance period.

For the general public the result will be a more appealing subdivision which enhances property values when the subdivision is considered to be a better environment in which to live. For the City of Calgary enhanced property values mean higher revenues from property taxes. The type of maintenance compared to a dry pond will change: mowing of grass will be eliminated and clean-ups after storm events will be less. However, sediment in the vault will have to be removed on a one to five year basis, depending on the loadings, and vegetation may have to be harvested. The facility is expected to improve the water quality of the runoff which is a distinct advantage over a standard dry pond.

The monitoring program should provide the engineering and scientific community with invaluable information about water quantity and quality specific to the Calgary area. Results from the program can also be used for other future locations.

15.9 Conclusions

The incorporation of an existing wetland with its natural features into the stormwater management concept for the first phase of the Rocky Ridge subdivision is the first of its kind within Calgary. It is an example of a more environmentally sensitive approach in the land development industry. The City of Calgary has approved the project on the conditions that a monitoring program be implemented during a five year maintenance period. Also, should the operation be unsatisfactory as determined at the end of five years, the wetland should be converted into a standard dry or wet pond, at the cost of the developer.

The monitoring program will provide scientific information to refine the operation of this particular wetland and it should also be invaluable for any future similar developments in the Calgary area.

The process of planning for the incorporation of the wetland into the Rocky Ridge Subdivision stormwater system provided many challenges with respect to planning, timing and communication between stakeholders. It is extremely important in a project such as this that the concept of using a wetland for stormwater retention and treatment does not become simplified. Wetlands are complex biological systems that develop as result of interactions between several factors such as hydrology, landform, climate, soils, vegetation and wildlife.

Changes in one any of these factors (e.g. hydrology) can adversely affect the biological integrity of the wetland. It is therefore important to assemble an integrated team of professionals (engineers, planners and biologists) with expertise in wetlands science. As well, it is important for all stakeholders to understand the sensitivity of wetlands to disturbance and the need for special management strategies (e.g. erosion control). The experience shows that all stakeholders are encouraged to work as a team and be involved in the planning process from the beginning of the project.

Acknowledgements

Many individuals deserve credit for their efforts with respect to this innovative approach in the Rocky Ridge area including Marquis Scenic Acres Development Inc. of Calgary and their Development Manager Larry Israelson, and staff at the City of Calgary. At the IBI Group, the prime consultant, Steve Shawcross, Keith Schneider and Elvin Karpovitch. And at AGRA Earth and Environmental Limited, Les Panek, Rudy Wouts, current Senior Project Manager, and above all Dennis Westhoff, who was the original proponent of the concept.

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