Nose Creek Basin Instream Flow Needs Study

FINAL REPORT

Prepared for:

The Nose Creek Watershed Partnership

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CORPORATE AUTHORIZATION

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EXECUTIVE SUMMARY

The Nose Creek Basin Instream Flow Needs Study is a second step in creating the Nose Creek Watershed Management Plan (NCWMP). The Instream Flow Needs (IFN) recommendations that are contained in this report are preliminary science-based quantities and qualities of water that sustain the integrity of aquatic environments. The corresponding flows are believed to preserve the natural flow regime, water quality, fish and fish habitat, and channel maintenance processes of riverine environments. As such, these recommendations are essential inputs to decision-making processes, and can be integrated with social, economic and environmental information to establish flow regimes for a stream reach.

These decision-making processes result in the generation of Water Conservation Objectives, which are the legislative tools used to establish flows in rivers and streams in Alberta. The generation of Water Conservation Objectives that are appropriate for the various reaches of Nose Creek and West Nose Creek was not part of the current study; these are to follow as part of the preparation of the NCWMP.

The IFN recommendations distinguish between rural reaches and urbanized reaches. The rural reaches are assumed to consist of Nose Creek and its tributaries upstream of Airdrie or Crossfield, and West Nose Creek and its tributaries upstream of Calgary. The urbanized reaches are assumed to consist of Nose Creek from Airdrie downstream and West Nose Creek within Calgary.

The IFN values for the rural reaches should be based on the unit area discharge rates presented in Figure 11, or the residual flows of 2 cfs for West Nose Creek and 3 cfs for Nose Creek, whichever yields the highest value.

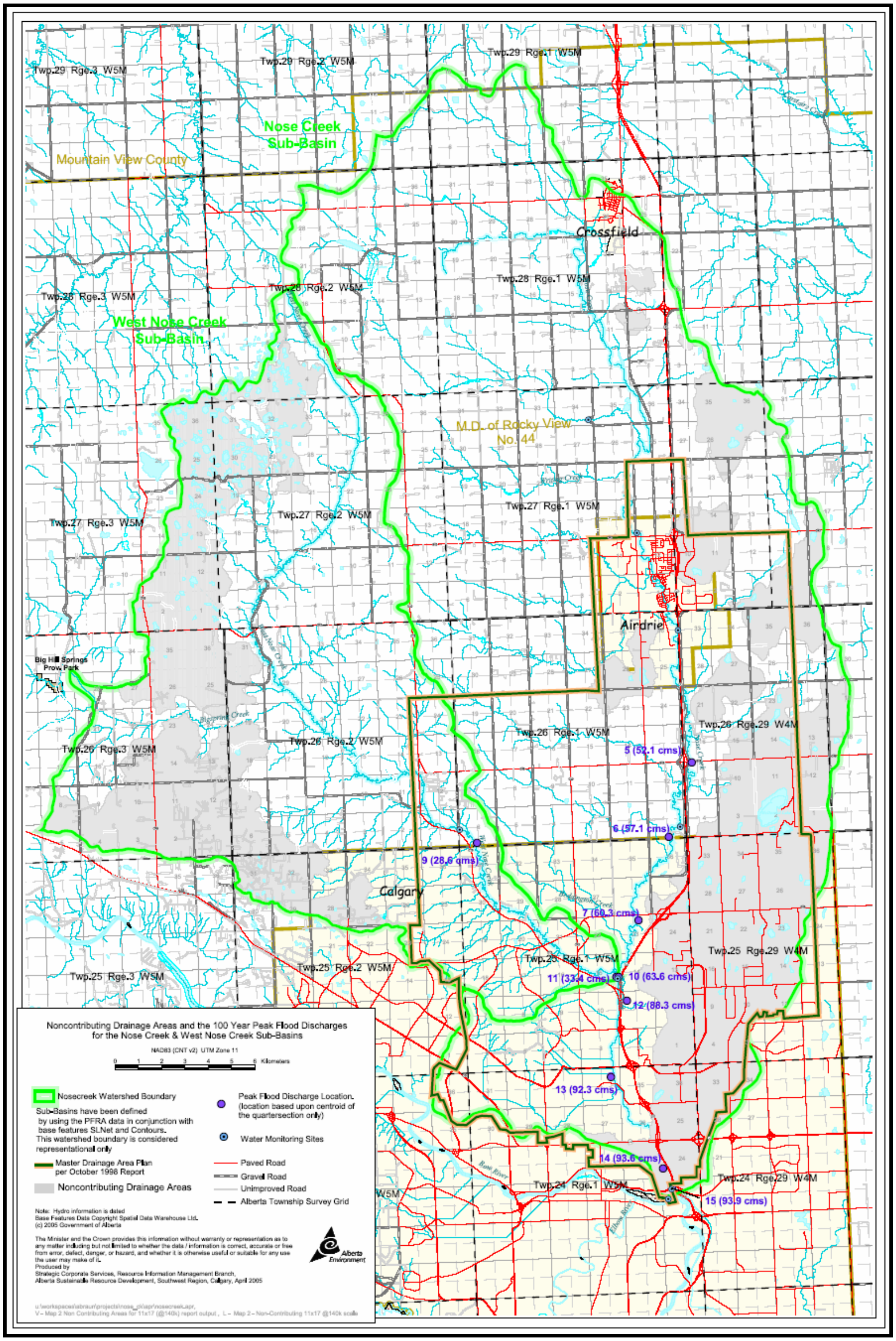
The low-flow IFN values for the urban reaches should be based on the IFN values for the rural areas. A fisheries impact assessment should be conducted in case of withdrawals upstream or along of urban reaches that are subject to channel enlargement.

The intermediate flow IFN values for the urban reaches should conform to the flow duration curves presented in Figure 22. The implementation of these IFN values would require volume control. The high-flow IFN values for the urban reaches should conform to the flow rates and permissible release rates that are summarized in Figure 23 and discussed in Section 6.6.

The following other recommendations are made:

- Implement the staged and prioritized plan for future data collection and follow-up studies outlined in Chapter 9.
- Update the existing stormwater management policies and standards and practices to arrive at more sustainable practices.
- Draft a drainage policy covering the self-contained areas within the Nose Creek Basin.
- Resolve potential conflicts with provincial policies.

Figure i Water Courses in Nose Creek Basin that IFNs apply to



1.0 INTRODUCTION

Nose Creek is a tributary to the Bow River, arising just north of Crossfield and flowing into the Bow River just downstream of the Calgary Zoo, see Figure 1. The eastern watershed boundary is just to the east of Deerfoot Trail and Highway 2. West Nose Creek is a major tributary that extends the western watershed boundary to about Bearspaw Road (Range Road 30). The lengths of the main stem of Nose Creek and West Nose Creek are about 60 km and 40 km, respectively.

The Nose Creek Watershed Partnership (Partnership) was created in 1998 by the City of Calgary, the City of Airdrie and the Municipal District of Rocky View #44. Alberta Environment has been involved with the Partnership to provide technical advice and assistance, including collaboration with water quality monitoring. By 2001 the Partnership broadened its partnership involvement to include the Town of Crossfield, Ducks Unlimited, the Calgary Airport Authority and the Bow River Basin Council.

The goal of the Partnership is to protect the riparian areas and to help improve and restore water quality in Nose Creek to its natural levels. All the partners involved are determined to rise above the differing obstacles affecting water quality and conservation and work together to achieve these important objectives. Its improvement strategy involves: learning about the quality of water throughout the watershed, identifying sources of contamination and initiating clean-up efforts and stewardship measures with all stakeholders, including individuals and community groups residing within the watershed.

In the late 1990s, the provincial government created a comprehensive new statute, the *Water Act*, to ensure sustainable water management and a healthy aquatic environment. Recognizing that effective and efficient water management planning is essential, Alberta Environment developed a document, *The Framework for Water Management Planning* (*Framework*), to guide this planning. A major component of the *Framework* and a requirement of the *Water Act* is the *Strategy for the Protection of the Aquatic Environment* (*Strategy*). The *Strategy* details the provincial government's commitment to maintaining, restoring or enhancing the condition of the aquatic environment.

In 2002, the need for a *Nose Creek Water Management Plan* (NCWMP) was identified through a consultative process between the Partnership and Alberta Environment. It was determined that, with the cumulative effects of increasing subdivision development, industrial growth, stormwater discharge, agricultural activities and channelization occurring within the Nose Creek Watershed, a water management plan would provide an essential decision-support tool to help ensure sustainable water management and a healthy aquatic environment.

In early 2003, the Partnership and Alberta Environment issued the Terms of Reference for developing the first phase of an approved, multi-phase NCWMP. One of the first steps in creating the NCWMP is the identification of Instream Flow Needs (IFNs) for the water courses in the Nose Creek Basin. Westhoff Engineering Resources, Inc. (WER) was retained in early 2004 to conduct a Nose Creek Basin Instream Flow Needs Scoping Study which included a review of existing methodologies for developing IFNs for fish habitat, recreation, water quality, riparian vegetation and channel structure, and recommended methods appropriate for the Nose Creek

Basin.
The following two methods for generating flow-based IFNs were proposed for the Nose Creek Basin in the September 2004 *Nose Creek Basin Instream Flow Needs Scoping Study* report:

1. The Tessman method for the rural reaches, based on a spatial extrapolation of the flow monitoring data that have been obtained at AENV's West Nose Creek stream gauge; and

2. The Tessman method for low flows and the predictive relationships between channel widening and dominant discharge that were presented in the West Nose Creek Stream Corridor Assessment Phase II for the high flows in the urban reaches.

The adoption of the above two methods was based on the premise that the budget that is available for the actual determination of IFNs that are appropriate for the Nose Creek Basin is relatively small, as per the draft Terms of Reference for Phase 1 of the NCWMP. This means that multi-year, broad-scaled field studies to support IFNs are not feasible. Nevertheless, while the Partnership needed guidance to establish appropriate IFNs within a short timeframe given the ongoing development pressures and in spite of the financial constraints, it was acknowledged that a staged implementation or evolution of IFNs might turn out to be necessary, especially for the urbanized lower reaches of the watershed. Recommendations to this effect were therefore included in the *Nose Creek Basin Instream Flow Needs Scoping Study* report.

Subsequently, WER was retained in the fall of 2004 to conduct the IFN actual determination. The following scope of work was agreed upon:

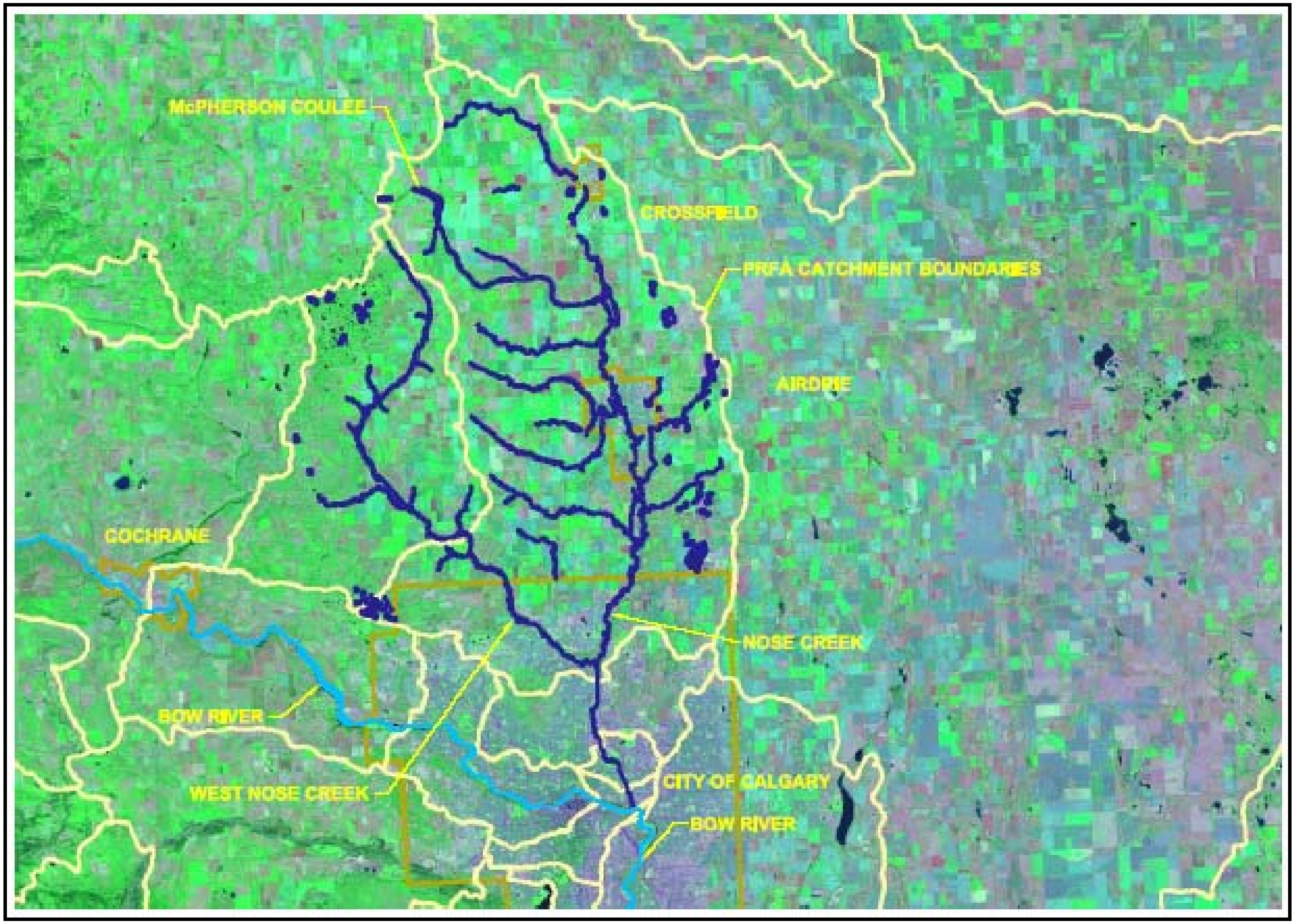
1. Collect historical flow monitoring data along Nose Creek and West Nose Creek;
2. Generate Instream Flow Needs for the rural reaches using the Tessman method, and based on a spatial extrapolation of the flow monitoring data obtained at Alberta Environment's West Nose Creek stream gauge;
3. Compare the Instream Flow Needs under (2) with the results of the proposed methodology for small and medium sized basins that is being developed by Golder Associates, if already available;
4. Generate Instream Flow Needs for the urban reaches using the Tessman method for low flows. The Instream Flow Needs under (2) would be modified to reflect the changed cross-sections in the urban reaches, where appropriate;
5. Generate Instream Flow Needs for flood conditions (i.e., 1:100 year conditions) based on a review of flow monitoring data, floodplain mapping, 1988 Nose Creek Basin report by Stanley and 2000 flood frequency analysis by Alberta Environment;
6. Generate Instream Flow Needs for intermediate flow conditions using flow frequency exceedance curves, based on a spatial extrapolation of flow monitoring data obtained at Alberta Environment's West Nose Creek stream gauge and the morphologic geometry relationships that were established in the West Nose Creek Stream Corridor Study – Phase 2 Hydrology and Hydraulics;
7. Provide commentary on how the Instream Flow Needs data could be used in stormwater management practices within the Nose Creek Basin;
8. Provide commentary on how the Instream Flow Needs data could relate to set-back "requirements", where appropriate;

9. Prepare staged and prioritized plan for future data collection and follow-up studies to fill in data gaps and verify whether desired outcome is being accomplished;
10. Prepare draft and final report;
11. Attend meetings with representatives of the Partnership and/or Alberta Environment; and
12. Attend Public Open House.

The IFN recommendations that are contained in this report are defined as preliminary science-based quantities and qualities of water that sustain the integrity of aquatic environments. The corresponding flows are believed to preserve the natural flow regime, water quality, fish and fish habitat, and channel maintenance processes of riverine environments. As such, these recommendations are essential inputs to decision-making processes, and can be integrated with social, economic and environmental information to establish flow regimes for a stream reach.

These decision-making processes result in the generation of Water Conservation Objectives, which are the legislative tools used to establish flows in rivers and streams in Alberta. The generation of Water Conservation Objectives that are appropriate for the various reaches of Nose Creek and West Nose Creek was not part of the current study; these are to follow, as per the draft Terms of Reference for Phase 1 of the NCWMP.

Figure 1 Nose Creek Basin



2.0 INSTREAM FLOW NEEDS

Streams and associated biological communities are among our most valuable natural resources. The biodiversity of streams and associated lands is rich. An estimated 40% of the fish species in North America use riverine habitats, and more than half of bird species live along streams (Whiting, 2002).

Changes in the flow of water in streams (i.e., changes in the quantity, timing, frequency) can lead directly to biologic and geomorphic changes, and geomorphic changes can lead indirectly to ecological adjustments. Geomorphic changes range from the grain sizes of sediment on the streambed to the width and depth of the channel, to the wetness of the floodplain. The hydrologic changes often alter the flux of energy and nutrients between the landscape and the channel, and along the channel. Biologic changes cascade from the physical and hydrologic alterations. By some measures, more than 80% of riparian ecosystems have been lost, and nearly 30% of freshwater fish species in North America are extinct, endangered, or threatened (Whiting, 2002). Within the Nose Creek Basin, these changes have been documented extensively as part of the 2002 and 2003 *West Nose Creek Stream Corridor Assessment* studies by WER.

Over the last few decades, we have seen the application of insight and tools from ecology, geomorphology, and hydrology to the challenge of identifying the stream flows necessary for environmental maintenance. Various methods have been developed that can be applied to determine the amount, duration and timing of stream flow required to retain specific important or desired environmental functions. Stream flows designed to provide resource protection by requiring flowing water in the channel are often called **instream flows** (Whiting, 2002). With respect to the resource, the entire “fluvial hydrosystem” should be considered, i.e., the whole stream corridor – channel, floodplain, riparian zone, and alluvial aquifer – in space and time.

In Alberta, the determination of Instream Flow Needs (IFNs) has been an integral element of Alberta Environment’s water management plan for the protection of aquatic habitat. These IFNs are generally developed by relating the amount of suitable aquatic habitat to the quantity of flow (Beersing et al). In 2003, AENV released a very comprehensive document *Instream Flow Needs Determination for the South Saskatchewan Basin, Alberta, Canada*, which provides an in-depth discussion of IFNs for some of the main river systems in Southern Alberta. The main emphasis has so far been on the establishment of IFNs for large river systems that are subject to regulation (e.g., for power generation) or withdrawal (e.g., for irrigation). Golder Associates has recently developed a tool to establish IFNs for small to medium-sized streams using a stream classification approach (Golder, 2004). Unfortunately, none of these approaches cover streams that are subject to significant urbanization such as the lower reaches of Nose Creek and West Nose Creek. In heavily urbanized streams the issue is not as much the impacts due to withdrawal of flow but the impacts due to significantly increased runoff rates and volumes generated by the hard surface area within the urban areas.

The September 2004 *Nose Creek Basin Instream Flow Needs Scoping Study* report provided a comparison of IFN methodologies for

- Fish Habitat;

- Channel Structure;
- Water Quality;
- Riparian Vegetation; and
- Recreation

It was found that the options to establish IFNs for the Nose Creek Basin are limited in view of the funding constraints and the need to establish appropriate IFNs within a relatively short time frame. The following methods were believed to hold most promise:

1. The Tessman method for the rural reaches [1], based on a spatial extrapolation of the flow monitoring data that have been obtained at AENV's West Nose Creek stream gauge; and

2. The Tessman method for low flows and the predictive relationships between channel widening and dominant discharge that were presented in the West Nose Creek Stream Corridor Assessment Phase II for the high flows in the urban reaches [2].

The Tessman method is a modification of the Tennant method which had been developed by Donald Tennant in 1976. This modification was introduced because Tennant's recommendations were considered to be not as well suited to prairie streams as they might be to mountain streams. The modification attempted to adjust the two-season approach (i.e., winter versus summer) that had been suggested by Tennant to a monthly approach that was believed to better represent the shape of the natural hydrograph. For applications in Alberta the Tessman recommendations are to be converted to weekly flow recommendations based on linear interpolation of the monthly values.

Tessman's approach is based on a reference to a flow magnitude that equals 40% of the Mean Annual Flow (MAF). This flow rate is described by Tennant as providing "good" conditions in the summer and "outstanding" conditions over the winter. The modification consists of adjusting this value on a month by month basis using the Mean Monthly Flow (MMF) as illustrated in the flow diagram of Figure 2.

To obtain weekly flow recommendations, the monthly recommendations are interpolated from mid-month to mid-month. Thus, the first two weeks of every month are calculated by interpolating the monthly recommendation of the month in question and the monthly recommendation of the previous month. Similarly, the last two weeks are calculated by interpolating the monthly recommendation of the month in question and the monthly recommendation of the next month.

In addition to low flow conditions discussed above, the Tessman method specifies a 14-day period with 200% Mean Annual Flow during peak runoff conditions to provide flushing/maintenance flows. This flow rate is the amount of water needed to flush the sediment entering the channel.

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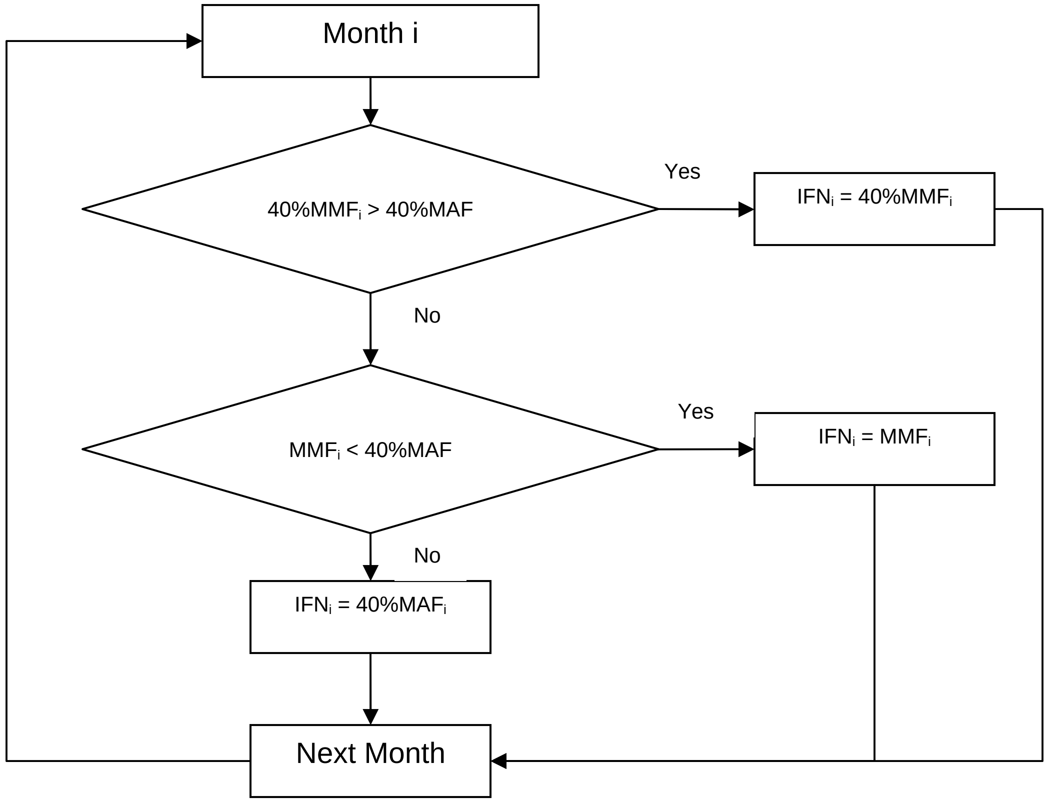
1 The rural reaches are assumed to consist of Nose Creek and its tributaries upstream of Airdrie or Crossfield, and West Nose Creek and its tributaries upstream of Calgary.

2 The urbanized reaches are assumed to consist of Nose Creek from Airdrie downstream and West Nose Creek within Calgary.

Figure 2 Flow Diagram of Tessman Method – Low Flows



3.0 SUMMARY OF AVAILABLE FLOW DATA

Table 1 summarizes the available flow data within the Nose Creek Basin. The three sources are Water Survey of Canada, Alberta Environment and the City of Calgary. Alberta Environment has recently reactivated its gauge along West Nose Creek just north of the (current) City of Calgary city limits, and the gauge along Nose Creek at the mouth. All data obtained for the stations along Nose Creek is currently influenced by urban development. Unfortunately, it is very difficult to isolate the urban runoff signal in the recorded flows along Nose Creek since it changes over time with the construction of new subdivisions and infrastructure. Only the Alberta Environment gauge along West Nose Creek fully reflects the rural, upper catchment.

Table 1 Available Flow Data

ID	Location	Gross Drainage Area (km^2)	Effective Drainage Area (km^2)	Source	Period	Characteristics
			Nose Creek			
05BH003	Nose Creek at Calgary (500 m downstream of confluence with West Nose Creek)	896.4	682.3	Environment Canada - HYDAT	1911-1919 1972-1986	Daily Daily
05BH901	Nose Creek near the mouth	988.9	733.2	Environment Canada - HYDAT	1980-1989	Daily
	Nose Creek - U/S Memorial Drive bridge	988.9	733.2	Alberta Environment	2003 2004	30-min interval 15-min interval
			West Nose Creek			
05BH904	West Nose Creek near Calgary, upstream of City limits	247	139	Environment Canada - HYDAT	1982-1995	Daily
				Alberta Environment	1992 1995	15-min interval 5-min interval
				Alberta Environment	2003 2004	30-min interval 15-min interval
WNC2	Near the confluence with Nose Creek	325.4	217.5	City of Calgary	Aug 2002 to July 2003	5min-interval

All flow monitoring that was available at the time of the preparation of this report is included on the CD-ROM that accompanies this report.

Drainage area values were taken from Alberta Environment's 2000 *Flood Frequency Analysis – Nose Creek Floodplain Study* report or from Environment Canada's HYDAT database if the value was not provided in the Alberta Environment report. The 2000 report lists the gross and effective drainage area sizes for the main stem of Nose Creek upstream of the confluence with West Nose Creek as 570.0 km^2 and 463.7 km^2, respectively. The computed gross and effective areas for the main stem of Nose Creek at Station 05BH003, i.e., about 500 m downstream of the confluence with West Nose Creek, are 571.0 km^2 and 464.8 km^2. These areas were computed by deducting the catchment area at Station WNC2 from the catchment area at Station 05BH003 (i.e., 896.4 km^2 – 325.4 km^2 = 571.0 km^2 and 682.3 km^2 – 217.5 km^2 = 464.8 km^2). Given the very small difference in catchment area, the flows for the main stem of Nose Creek at Station 05BH003, i.e., after deduction of the contribution by West Nose Creek, are interpreted as being the flows in Nose Creek above the confluence with West Nose Creek. The catchment area sizes at Station 05BH003 (i.e., 571.0 km^2 and 464.8 km^2 for the gross and effective areas, respectively) were used for the subsequent of flows on a unit area basis.

4.0 REVIEW OF AVAILABLE FLOW INFORMATION

4.1 Annual Flows

Figure 3 displays the annual flow rates for three of the four stream gauges in the Nose Creek Basin. The station at West Nose Creek near the confluence is not presented since the period of record did not cover one complete year.

Figure 3 Annual Flow Rates for Stream Gauges in Nose Creek Basin

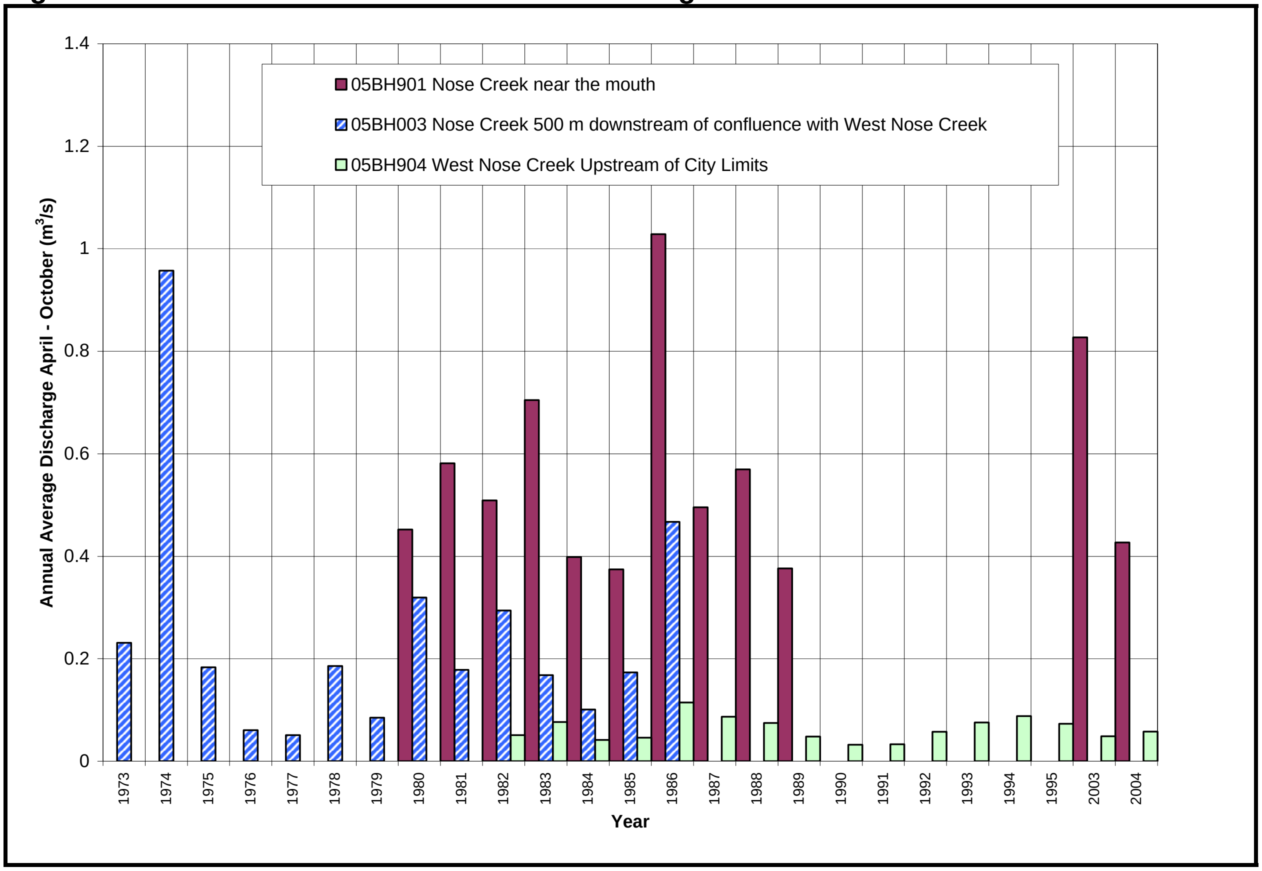
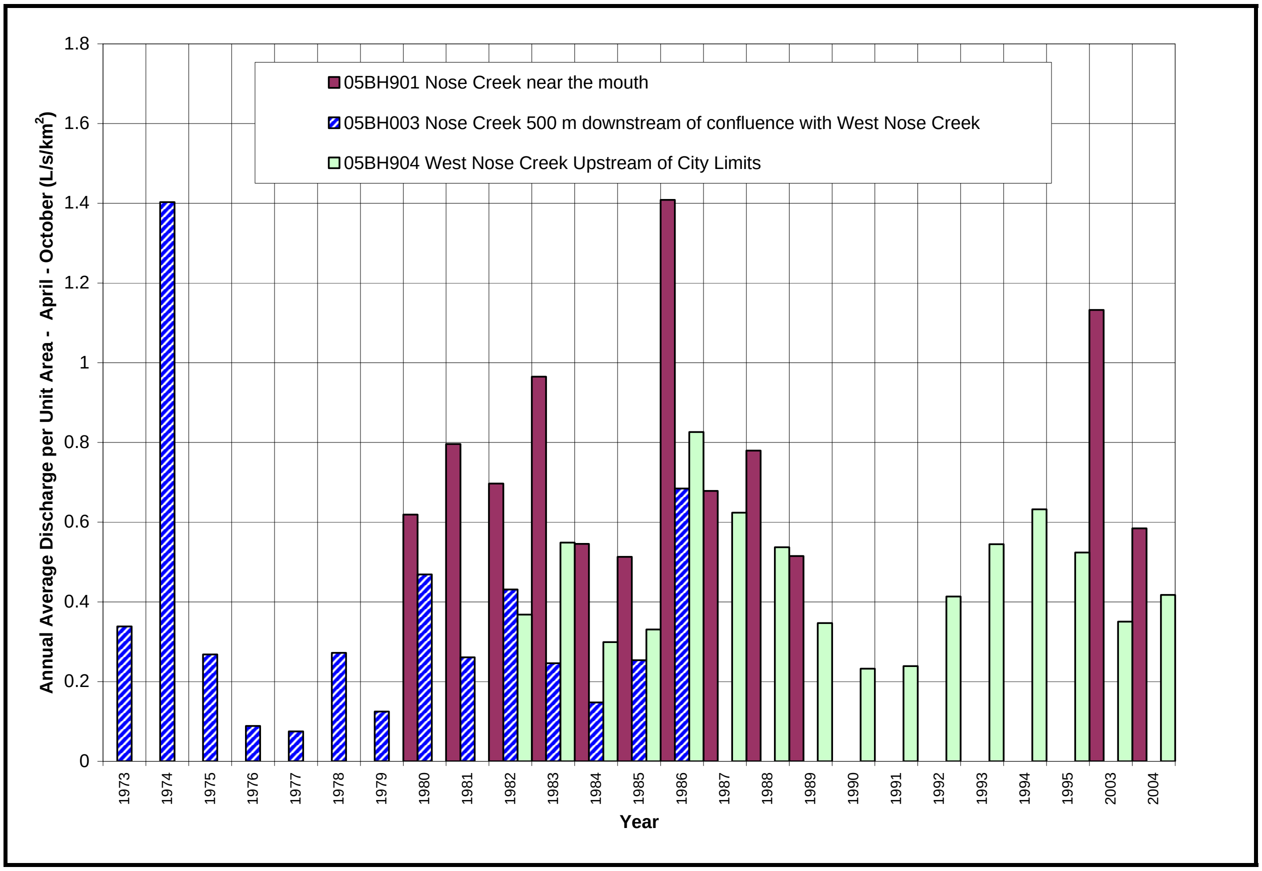


Figure 3 shows that the period with common records for the three stations is 1982 through 1986. The monitoring period covered the period of time that the creek has open water conditions, i.e., while it is not frozen over. This period is generally from the beginning of April through the end of September or October, and may vary from year to year. During the 1982-1986 time frame, the urbanized area draining into West Nose Creek (i.e., between Stations 05BH904 and 05BH003) was less than 5 km^2. On the other hand, the 51 km^2 area draining into Nose Creek between Stations 05BH003 and 05BH901was in its majority urbanized.

Figure 3 also shows that there is no information for a seven year period between 1996 and 2002. Figure 4 shows the annual flow rates that were displayed in Figure 3 on a unit area basis.

Figure 4 Annual Flow Rates on Unit Area Basis for Stream Gauges in Nose Creek Basin



Based on the common period 1982 through 1986, it appears that the unit area discharge rate for the upper, rural reaches of West Nose Creek is greater than the unit area discharge rate that was recorded for Nose Creek, just downstream of the confluence with West Nose Creek (i.e., Station 05BH003). Because the latter includes the entire West Nose Creek contribution, it can be concluded that the West Nose Creek sub-watershed yields more runoff than the upper Nose Creek sub-watershed that drains into the main stem of Nose Creek. This should not come as a surprise given that the West Nose Creek sub-watershed is closer to the mountains than the remainder of the Nose Creek catchment.

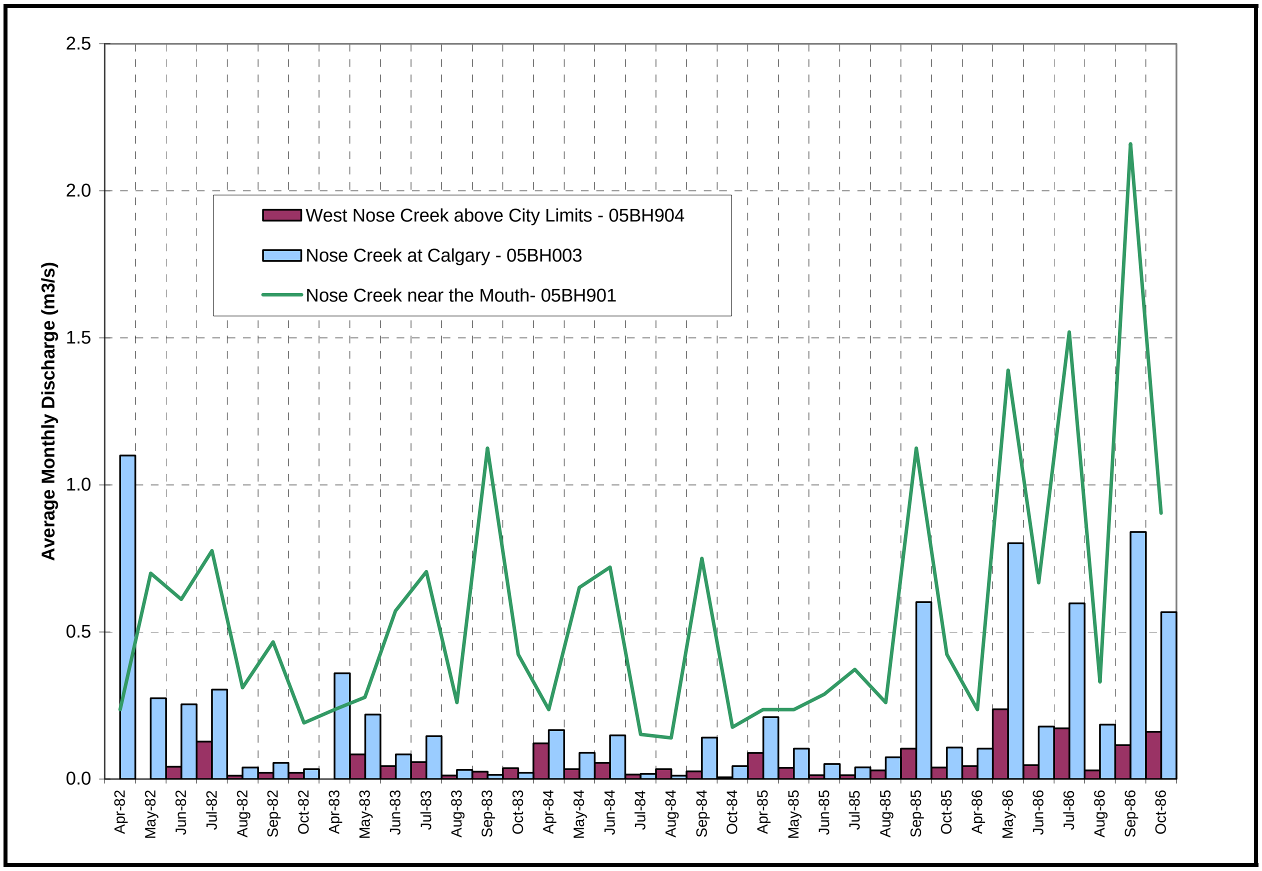
The unit area discharge rate for the entire Nose Creek catchment (i.e., at Station 05BH901, which is close to the confluence with the Bow River) is much greater (i.e., on average twice) than the rate for the upper parts of the Nose Creek catchment. This difference is a reflection of the increase in runoff associated with the urbanization of the lower parts of the catchment.

The annual average of the unit area discharge rate is 0.45 L/s/km^2 for West Nose Creek at Station 05BH904 and 0.36 L/s/km^2 for Nose Creek at Station 05BH003. Because the latter includes the entire West Nose Creek area, the rate for the upper reaches of Nose Creek, i.e., upstream of the confluence with West Nose Creek, is only about 0.29 L/s/km^2. This difference should be taken into account when transferring flow information from West Nose Creek to Nose Creek.

4.2 Monthly Information

Figure 5 shows the monthly flow data at the three stream gauges for the common period of record 1982 through 1986.

Figure 5 Monthly Flow Rates for Stream Gauges in Nose Creek Basin



It appears that the average monthly discharge was lower at Nose Creek than at West Nose Creek for the months of September and October 1983 and August 1984. Besides monitoring inconsistencies or errors, the reduction in flow could have been caused by a water withdrawal along West Nose Creek between the two stations.

This illustrates the need of investigating possible withdrawals or, alternatively, man-made discharges into Nose Creek and/or West Nose Creek. In order to identify the total “production” of runoff within the watershed, actual withdrawals should be added to and point-source discharges should be deducted from the recorded flow records.

4.3 Withdrawal Licences

Alberta Environment provided a list of the surface and groundwater withdrawal licences that have been granted by the department for the Nose Creek Basin. The entire list for surface water withdrawal licences contains more than 350 entries. Each licence has a specified maximum annual quantity of water that can be withdrawn; some licences have additional restrictions such as the rate of diversion, the minimum discharge in the creek in question after the location of the withdrawal, restricted dates, etc. About 30 licences authorize the withdrawal of more than 10,000 m^3 per year. Table 2 summarizes the main withdrawal licences within the Nose Creek Basin.

The licensed quantity is the maximum amount of water that is allowed to be withdrawn within any given calendar year. The actual quantities that have historically been withdrawn as well as the dates of the withdrawal are unfortunately unknown for the majority of the licenses. Some licenses supposedly have, as a condition, the submission of an annual monitoring report that would summarize the periods and rates of the water withdrawal, total monthly quantity of water that was withdrawn, etc. Because the necessary information about the actual quantities that were withdrawn and the periods that these withdrawals took place was not available at the time of the preparation of this report [3], only an evaluation of the magnitude of the potential cumulative withdrawals was done.

The licences were classified by location in the sub-basin upstream of the location where the flow monitoring records of Table 1 are available. By accounting for the date at which the licence was issued and in some cases the expiry date, the potential cumulative annual withdrawal quantities were computed for each sub-basin. This volume was subsequently compared to the total volume of runoff that was recorded at each stream gauge for the corresponding years. Figure 6A shows the results for the West Nose Creek basin upstream of the City of Calgary city limits, i.e., at Station 05BH904. As illustrated, for some years the potential withdrawal can be very important. Figure 6B shows a similar graphic for the main stem of Nose Creek, upstream of the City of Calgary city limits.

Several licenses correspond to stormwater management facilities within newly urbanizing areas. An example is the licence held by Tirion Properties Ltd. for the Hamptons subdivision in northwest Calgary. This license was omitted from the analysis because the volume corresponds to runoff generated by urban areas and not by the upper, undeveloped watershed.

As alluded to, some licences include conditions pertaining to the required residual flow in the creek in question downstream of the withdrawal. Residual flows of 2 cfs and 3 cfs are required for West Nose Creek and Nose Creek, respectively [4].

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3 Alberta Environment is currently searching for these records.

4 A prescribed residual flow rate of 4 cfs (as discussed in the *Nose Creek Basin Instream Flow Needs Scoping Study* report, Table 3, pages 15 and 17) was not found for the Nose Creek main stem.

Table 2 Summary of Key Surface Water Withdrawal Licenses in Nose Creek Basin [1]

PROJECT	INT_NO	LICENSE DATE	EXPIRY DATE	QUANTITY (m^3/year)
NOSE CREEK DOWNSTREAM OF 05BH003 – URBAN IMPACTED AREA				
CALGARY ELKS LODGE, WR, 08754	02647	21-Jun-88	23-Nov-00	318238
AL KLIPPERT LTD, WR, 10332	12191	30-Sep-83		246700
CITY OF CALGARY, WR, 12540	06300	6-Feb-84		185020
SILVER SPRINGS GOLF & COUNTRY CLUB, WR, 13082	06732	10-Dec-85		157890
CALGARY/RECREATION/FOX HOLLOW GOLF COURSE	16176	12-May-93		123347
NOSE CREEK UPSTREAM OF 05BH003 – MOST OF THE DRAINAGE AREA IS RURAL EXCEPT FOR AIRDRIE AND CROSSFIELD				
NOSE CREEK POND/DISTURBANCE/AIRDRIE, CITY OF - F70090	49549 00 00	14-Aug-98		588620
GENSTAR DEV CO, WR, 23976	17868	5-May-94		155410
AIRDRIE/RECREATION/APPLE CREEK GOLF - F10813	L04487	15-Jun-87		119929
CALGARY/STORAGE/ALBERTA ENVIRONMENT PROTECTION -F11795	L06224	17-Apr-69		104850
TOWN OF CROSSFIELD, WR, 10796	L04668	16-Feb-84		86350
GRAD & WALKER RESOURCES LTD, WR, 08291	L08077	20-Sep-82		62900
CAMERON, WR, 15376	07978	24-May-77		55510
AIRDRIE/RECREATION/408269 ALBERTA LTD. F 70016	20923	15-Mar-96	15-Mar-00	48105
AIRDRIE/RECREATION/CITY OF AIRDRIE - F70270	69855 00 00	18-Jan-99	18-Jan-05	34538
TOWN OF CROSSFIELD, WR, 10564	L04226	18-Jul-83		30840
LAW, WR, 15625	L07822	13-Jan-75		16040
BENNETT, WR, 13079	10372	27-Mar-80		14800
MADDEN/FARM UNIT/DARCEY & LEISA GALLELLI F-25638	L18493	25-Nov-91		14790
LYNN DEE RAY LTD, WR, 12051	L05833	12-Apr-66	21-Aug-98	12330
313239 ALTA LTD, WR, 03157	D0576	5-Jan-87		12330
THREE CROSS CATTLE LTD, WR, 13190	06799	7-Jul-86		11100
WEST NOSE CREEK DOWNSTREAM OF 05BH904 – URBAN IMPACTED AREA				
CALGARY/RECREATION/COUNTRY HILLS GOLF CLUB - F23412	L17867	14-Aug-98		395062
TIRION PROPERTIES LTD, WR, 25269	18170	5-Jan-93		314530
WEST NOSE CREEK UPSTREAM OF 05BH904 – RURAL AREA				
HOLE, WR, 09305	L05264	15-Jun-67		80180
AIRDRIE/FARM UNIT/MORISON FARMS FEEDYARD	155481 00 00	13-Mar-03	13-Mar-04	41000
COCHRANE/FARM UNIT/TURNER, ROBERT W	05755	8-Feb-88		33300
CHURCH SIMMENTAL RANCHES, WR, 05948	L01160	6-Jul-82		20970
CLAYHOLT, WR, 15225	L07542	13-Sep-73		14800
MCELROY, WR, 06071	D0828	16-Dec-85		14800
LOCKE, WR, 18308	09190	11-Apr-79		11100
MCELROY, WR, 06070	D0827	16-Dec-85		11100

[1] A summary of withdrawal licence information that was available at the time of the preparation of this report is included on the CD-ROM that accompanies this report.

Figure 6A **Comparison between Recorded Annual Flow at Stream Gauge and Potential Cumulative Annual Volumes of Licensed Withdrawals – West Nose Creek upstream of City Limits**

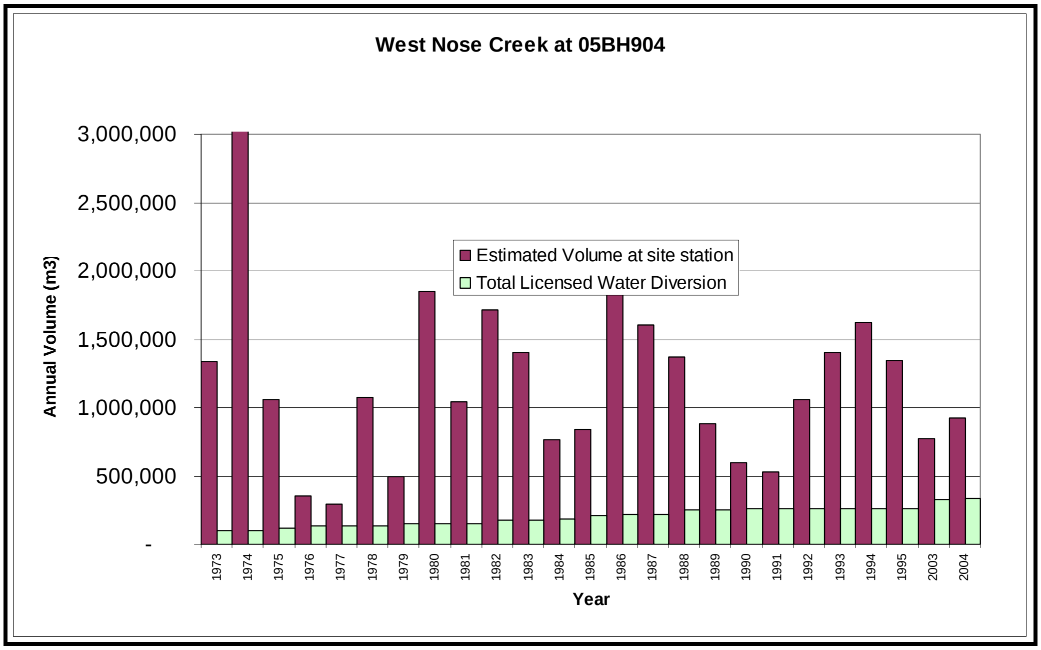
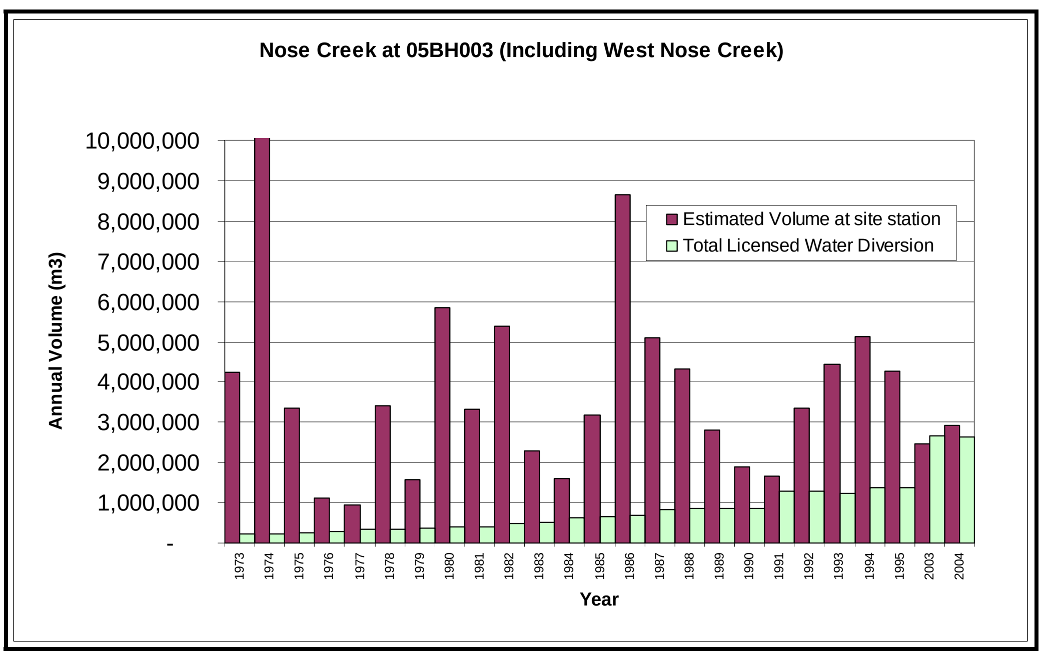


Figure 6B **Comparison between Recorded Annual Flow at Stream Gauge and Potential Cumulative Annual Volumes of Licensed Withdrawals –Nose Creek upstream of City Limits**



4.4 Point-Source Discharges

Only one point-source discharge is known within the Nose Creek Basin, i.e., the discharge from the sewage lagoon in Crossfield. No point discharges exist in Airdrie as its wastewater is pumped to Calgary. Table 3 summarize the available discharge quantities and dates for the discharge into the upper reaches of Nose Creek from Crossfield. The mean discharge rate can be as high as 320 L/s while the effect on the monthly average flow in Nose Creek can be as high as 125 L/s. The recorded flow data at Station 05BH901 (i.e., Nose Creek near the mouth) should be adjusted during the year 2003 (i.e., between September 25 and October 31). For the remainder of the years shown in Table 3, there is no corresponding flow data in Nose Creek.

Table 3 Historical Discharges from Sewage Lagoon in Crossfield

Year	Date of Discharge	Volume (m^3)
2003	September 25-October 31	272676
2002	October 10-October 31	238592
2001	No Discharge	0
2000	October 2-October 30	188601
1999	October 13-October 31	109070
1998	August 28-October 8	329484
1997	August 29-	Not available
1996	August 29-	Not available
1995	October 9-	Not available

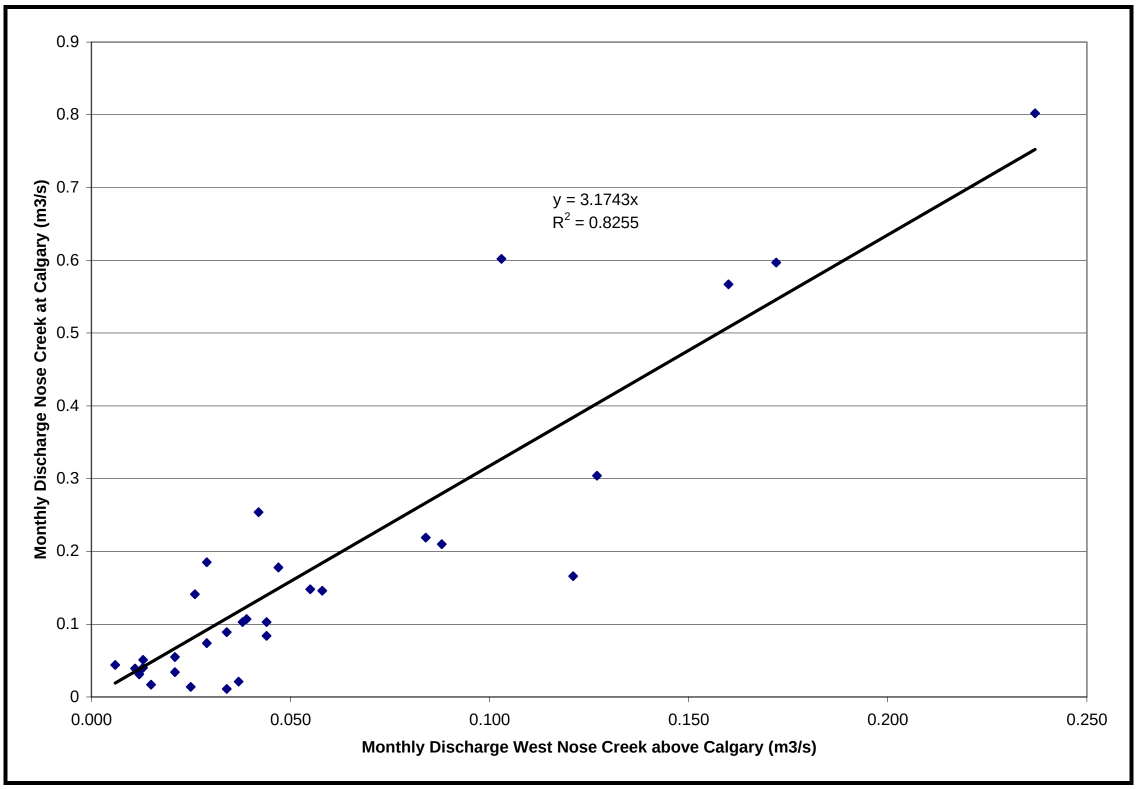
5.0 ANALYSIS OF RURAL REACHES

5.1 Flow Information Analysis

As alluded to in Section 4.1., the flow records for Station 05BH904 (i.e., West Nose Creek upstream of the City of Calgary city limits) represent the rural areas within the West Nose Creek sub-watershed. The flow records at Station 05BH003 (i.e., Nose Creek just downstream of the confluence with West Nose Creek) contain an urban signature, however, the proportion of the urbanized area upstream of this gauge was very small (i.e., less than 1%) when this station was closed in 1986. Because of the observed differences between the yield for the upper West Nose Creek and Nose Creek sub-watersheds, it was decided to utilize both gauges to represent the rural areas within the watershed.

Each station has a record of about 15 years; however, the common period is unfortunately relatively short, i.e., covering only 1982 through 1986. In order to examine the possibility of artificially extending the period of record at either station based on the recorded flows at the other station, the monthly flows at the two stations were correlated during the common period (i.e., 1982-1986). Figure 7 shows the correlation that was established.

Figure 7 Monthly Flows Correlation West Nose Creek - Nose Creek



By using the obtained correlation shown on Figure 7 the records for both stations were extended. The extended record covers the periods 1973-1995 and 2003-2004. Table 4 shows the extended record for both stations.

As alluded to in Section 4.1., the records in Table 4 show that the unit area average monthly discharge rate is greater for the West Nose Creek sub-watershed than for the Nose Creek sub-watershed. This is consistent with the commonly observed reduction in the average runoff from the Rocky Mountains to the east.

In order to establish separate unit area release rates for the West Nose Creek and Nose Creek sub-watersheds, the values for the latter can be calculated using Equation 1:

$$Rate_{NC\ Above\ Confluence} = \frac{\left(A_{total} \cdot Rate_{total} - A_{WNC} \cdot Rate_{WNC}\right)}{A_{NC\ Above\ Station\ 05BH003}} \qquad \textbf{Equation 1}$$

Figure 8 illustrates the recorded and computed average monthly unit area discharge rates for the rural areas. Table 5 presents the actual values shown in Figure 8.

Figure 8 Average Monthly Unit Area Discharge Rates for Rural Basins

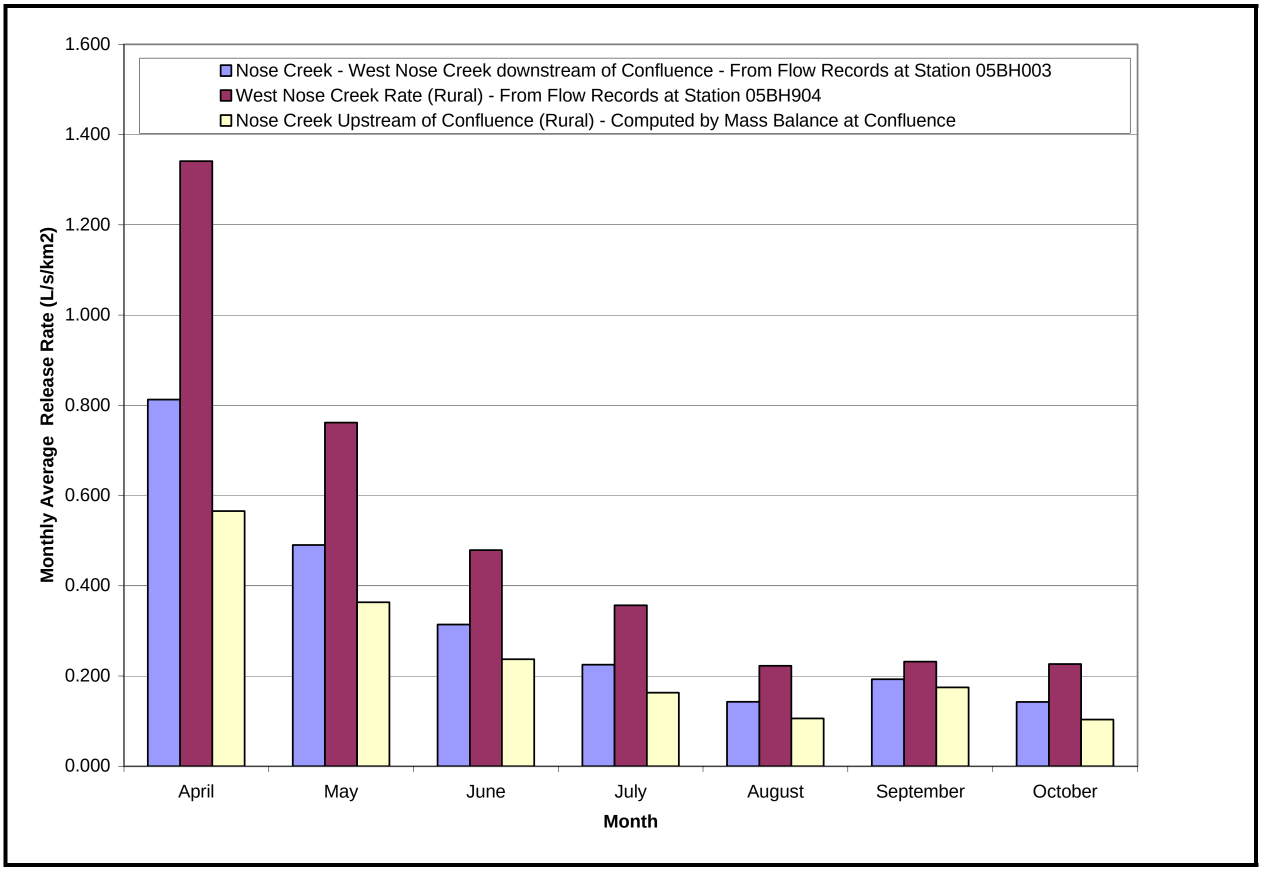


Table 4 Extended Monthly Record 1973-1995 and 2003-2004 for Nose Creek and West Nose Creek

Nose Creek Below Confluence — Effective Area ---> 682.3 km2

	FLOWS							
	April (m^3/s)	May (m^3/s)	June (m^3/s)	July (m^3/s)	August (m^3/s)	September (m^3/s)	October (m^3/s)	Annual (m^3/s)
1973	0.880	0.277	0.200	0.088	0.037	0.069	0.066	0.231
1974	3.825	2.252	0.310	0.068	0.062	0.085	0.100	0.957
1975	0.728	0.309	0.116	0.026	0.023	0.039	0.042	0.183
1976	0.206	0.058	0.043	0.021	0.061	0.015	0.023	0.061
1977	0.084	0.077	0.032	0.027	0.027	0.072	0.040	0.051
1978	0.560	0.173	0.186	0.038	0.177	0.123	0.043	0.186
1979	0.264	0.189	0.072	0.025	0.026	0.007	0.013	0.085
1980	1.154	0.311	0.412	0.164	0.088	0.063	0.047	0.320
1981	0.076	0.461	0.219	0.284	0.100	0.053	0.054	0.178
1982	1.098	0.275	0.254	0.304	0.039	0.055	0.034	0.294
1983	0.359	0.219	0.084	0.146	0.031	0.014	0.021	0.125
1984	0.166	0.089	0.148	0.017	0.011	0.141	0.044	0.088
1985	0.210	0.103	0.051	0.057	0.085	0.602	0.107	0.173
1986	0.103	0.802	0.178	0.597	0.185	0.840	0.567	0.467
1987	0.516	0.315	0.069	0.507	0.255	0.160	0.103	0.275
1988	1.024	0.116	0.161	0.080	0.134	0.050	0.094	0.237
1989	0.433	0.232	0.175	0.059	0.039	0.065	0.067	0.153
1990	0.117	0.214	0.251	0.061	0.042	0.008	0.025	0.103
1991	0.134	0.188	0.118	0.052	0.098	0.041		0.105
1992	0.085	0.097	0.462	0.278	0.141	0.120	0.093	0.182
1993	0.229	0.307	0.363	0.203	0.215	0.149	0.215	0.240
1994	0.185	0.597	0.661	0.086	0.100	0.107	0.214	0.279
1995	0.317	0.271	0.312	0.378	0.166	0.119	0.055	0.231
2003		0.230	0.188	0.116	0.130	0.136	0.128	0.155
2004		0.200	0.293	0.148	0.168	0.156	0.139	0.184
New Avg	0.554	0.334	0.214	0.153	0.098	0.131	0.097	0.226
Rel. Rate (L/s/km2)	0.812	0.490	0.314	0.225	0.143	0.193	0.142	0.331

Completed by using Correlation Formula (cyan: 1987–2004 monthly values)

West Nose Creek — Effective Area ---> 139 km2

	FLOWS							
	April (m^3/s)	May (m^3/s)	June (m^3/s)	July (m^3/s)	August (m^3/s)	September (m^3/s)	October (m^3/s)	Annual (m^3/s)
1973	0.278	0.087	0.063	0.028	0.012	0.022	0.021	0.073
1974	1.207	0.710	0.098	0.021	0.020	0.027	0.032	0.302
1975	0.229	0.097	0.037	0.008	0.007	0.012	0.013	0.058
1976	0.065	0.018	0.013	0.007	0.019	0.005	0.007	0.019
1977	0.027	0.024	0.010	0.008	0.008	0.023	0.013	0.016
1978	0.177	0.055	0.059	0.012	0.056	0.039	0.014	0.059
1979	0.083	0.060	0.023	0.008	0.008	0.002	0.004	0.027
1980	0.364	0.098	0.130	0.052	0.028	0.020	0.015	0.101
1981	0.024	0.146	0.069	0.090	0.032	0.017	0.017	0.056
1982	0.346	0.086	0.042	0.127	0.011	0.021	0.021	0.093
1983	0.275	0.084	0.044	0.058	0.012	0.025	0.037	0.076
1984	0.121	0.034	0.055	0.015	0.034	0.026	0.006	0.042
1985	0.088	0.038	0.013	0.013	0.029	0.103	0.039	0.046
1986	0.044	0.237	0.047	0.172	0.029	0.115	0.160	0.115
1987	0.163	0.100	0.022	0.160	0.080	0.050	0.032	0.087
1988	0.323	0.036	0.051	0.025	0.042	0.016	0.030	0.075
1989	0.136	0.073	0.055	0.019	0.012	0.021	0.021	0.048
1990	0.037	0.067	0.079	0.019	0.013	0.003	0.008	0.032
1991	0.042	0.059	0.037	0.017	0.031	0.013		0.033
1992	0.027	0.031	0.146	0.088	0.044	0.038	0.029	0.057
1993	0.072	0.097	0.114	0.064	0.068	0.047	0.068	0.076
1994	0.058	0.188	0.209	0.027	0.031	0.034	0.068	0.088
1995	0.100	0.085	0.098	0.119	0.052	0.037	0.017	0.073
2003		0.072	0.059	0.036	0.041	0.043	0.040	0.049
2004		0.063	0.093	0.047	0.053	0.049	0.044	0.058
Avg	0.186	0.106	0.067	0.050	0.031	0.032	0.031	0.072
Rel Rate (L/s/km2)	1.341	0.761	0.479	0.357	0.223	0.232	0.226	0.517

Completed by using Correlation Formula (yellow: 1973–1981 monthly values and April 1982)

Table 5 Average Monthly Unit Area Discharge Rates for Rural Basins

Basin	Unit Release Rates for Monthly Average Flow (L/s/km^2)						
	April	May	June	July	August	September	October
West Nose Creek	1.341	0.761	0.479	0.357	0.223	0.232	0.226
Nose Creek above Confluence	0.566	0.363	0.237	0.163	0.106	0.174	0.103

The rates presented in Table 5 are considered appropriate for the application of the Tessman method, discussed previously in Section 2.0, to derive the IFNs for the rural areas. Please note that no adjustments were made for water withdrawals in the tributary catchment. [5]

5.2 Duration Curves

The flow duration curve for West Nose Creek at Station 05BH904 (i.e., just north of the City of Calgary City limits) is shown in Figure 9. This curve is based on the years 1992, 1995, 2003 and 2004 [6], i.e., those years for which short-interval records are available.

Figure 10 shows the unit area flow duration curves for the rural areas in both the West Nose Creek and Nose Creek sub-watersheds.

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5 The unit area flow rates presented in Tables 5 and 6 are based on the effective catchment area rather than the gross catchment area in order to ensure that the flows left in the creeks reflect the actual tributary catchment size.

The unit area rates shown in Table 5 for Nose Creek above the Confluence are based on Equation 1, with A_{total} = Area at Nose Creek at Station 05BH003 = 682.3 km^2 and A_{WNC} = Area at West Nose Creek at Mouth = 217.5 km^2. The area for the main stem of Nose Creek above the confluence at 463.7 km^2 is almost identical to the area for the main stem of Nose Creek above Station 05BH003, which is 464.8 km^2. For this reason, the unit area rate for the contribution of the main stem of Nose Creek at these two locations will be virtually identical for all intents of purposes.

6 It is noted that some concerns have been expressed by the University of Calgary about the accuracy of the recent, i.e., 2004, flow monitoring data at Station 05BH904. This is currently being examined by representatives of AENV and the University of Calgary. These concerns highlight the importance of appropriate Quality Assurance and Quality Control provision as part of any monitoring program. They also highlight the importance of continuation of the monitoring efforts to increase the duration of the period upon which the flow duration curves are based, and to minimize the possibility of any bias in the record upon which Figure 9 is based.

Figure 9 Flow Duration Curve – West Nose Creek upstream of City Limits

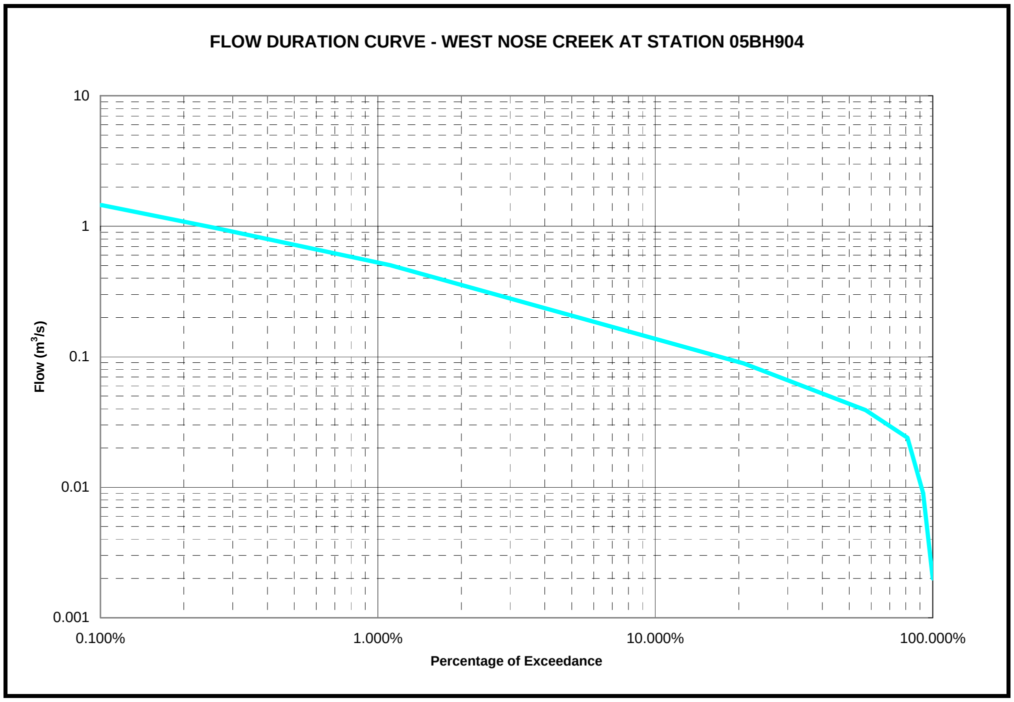
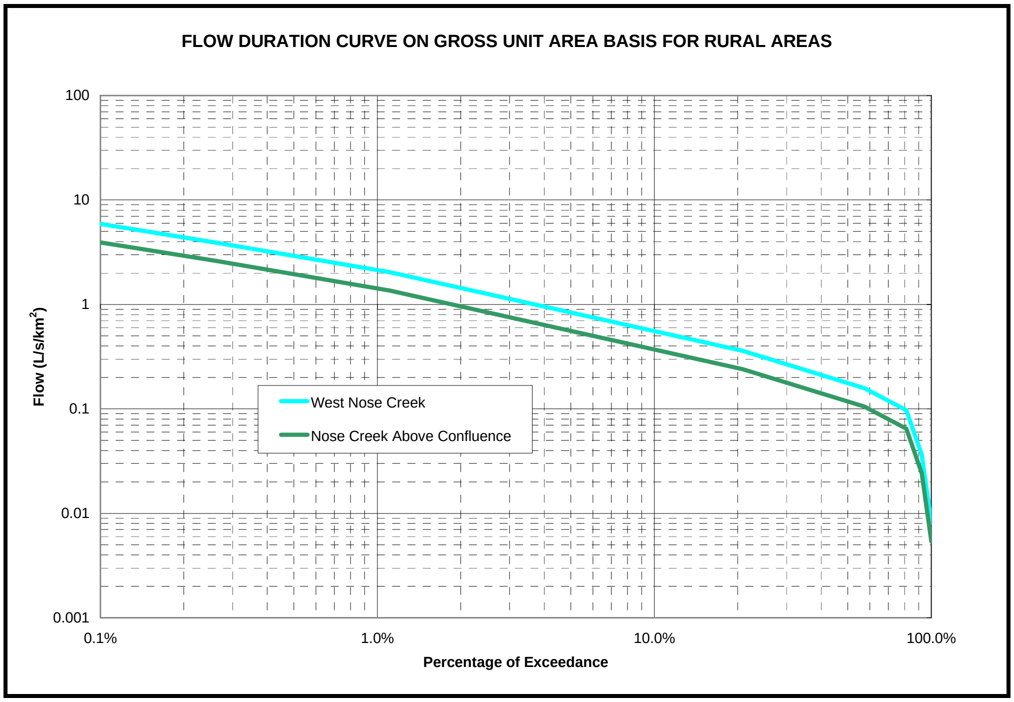


Figure 10 Unit Area Flow Duration Curves for Rural Areas in West Nose Creek and Nose Creek Sub-Watersheds



5.3 Instream Flow Need Recommendations - Low Flows

The Tessman method can be applied to obtain the monthly IFN values at any point within the rural areas within the West Nose Creek and Nose Creek sub-watersheds. As an example the mean monthly IFN values are computed for West Nose Creek.

The first step is to obtain the Mean Monthly Flows (MMFs) from the rates shown in Table 5. The Mean Annual Flow (MAF) is the average of the mean monthly flows.

The calculation for April is

MMF = 1.34 L/s/km^2 40% MMF = 0.536 L/s/km^2
MAF = 0.517 L/s/km^2 40% MAF = 0.207 L/s/km^2

Since 40% MMF > 40% MAF, the IFN for April is 40% MMF = 0.536 L/s/km^2, see also Figure 2.

The calculation for June is

MMF = 0.479 L/s/km^2 40% MMF = 0.192 L/s/km^2
MAF = 0.517 L/s/km^2 40% MAF = 0.207 L/s/km^2

40% MMF <= 40% MAF
MMF < 40% MAF This condition is false thus IFN for June is 40% MAF = 0.207 L/s/km^2

The results of the derivation of the monthly IFNs for West Nose Creek and Nose Creek are presented in Table 6.

After completion of the monthly calculations weekly IFN values are obtained by the interpolation process that was discussed in Section 2.0. A similar procedure can be executed for the rural reaches of the Nose Creek sub-watershed. Figure 11 shows the resulting IFN curves for the rural reaches of West Nose Creek and Nose Creek.

By applying the curves of Figure 11 for the areas upstream of the stream gauges along West Nose Creek and Nose Creek, the recommended Tessman IFN values are obtained at the locations of the stream gauges. [7] Figure 12 shows the resulting IFN values as well as the 2 cfs and 3 cfs residual values that are included as a condition in some of the withdrawal licences for West Nose Creek and Nose Creek, respectively. Figure 12 shows that the residual values are generally higher, except for the very early parts of the year. In practice, this means that the residual values are more restrictive than the unit area IFN values of Table 6, especially for the upper reaches of the watershed.

7 Please note that Figure 12 is only for illustration purposes. Strictly speaking, Nose Creek downstream of Airdrie is nowadays considered an urban reach rather than a rural reach. The IFN for Nose Creek was derived for the period in time (i.e., prior to 1986) that the influence of the urban signature on the stream records was still very small.

Table 6 Derivation of Mean Monthly Unit Area IFN values for West Nose Creek and Nose Creek

West Nose Creek								
Flows in L/s/km²	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**Annual**
Mean Monthly Unit Area Flow	1.341	0.761	0.479	0.357	0.223	0.232	0.226	0.517
40% Mean Monthly Flow	0.536	0.305	0.192	0.143	0.089	0.093	0.090	
40% Mean Annual Flow	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207
40% MMF > 40% MAF	Yes	Yes	No	No	No	No	No	
MMF < 40% MAF	No	No	No	No	No	No	No	
Resulting Mean Monthly Unit Area IFN	0.536	0.305	0.207	0.207	0.207	0.207	0.207	

Nose Creek								
Flows in L/s/km²	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**Annual**
Mean Monthly Unit Area Flow	0.566	0.363	0.237	0.163	0.106	0.174	0.103	0.245
40% Mean Monthly Flow	0.226	0.145	0.095	0.065	0.042	0.070	0.041	
40% Mean Annual Flow	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098
40% MMF > 40% MAF	Yes	Yes	No	No	No	No	No	
MMF < 40% MAF	No	No	No	No	No	No	No	
Resulting Mean Monthly Unit Area IFN	0.226	0.145	0.098	0.098	0.098	0.098	0.098	

Figure 11 Tessman Instream Flow Needs on Unit Area Basis for Rural Areas

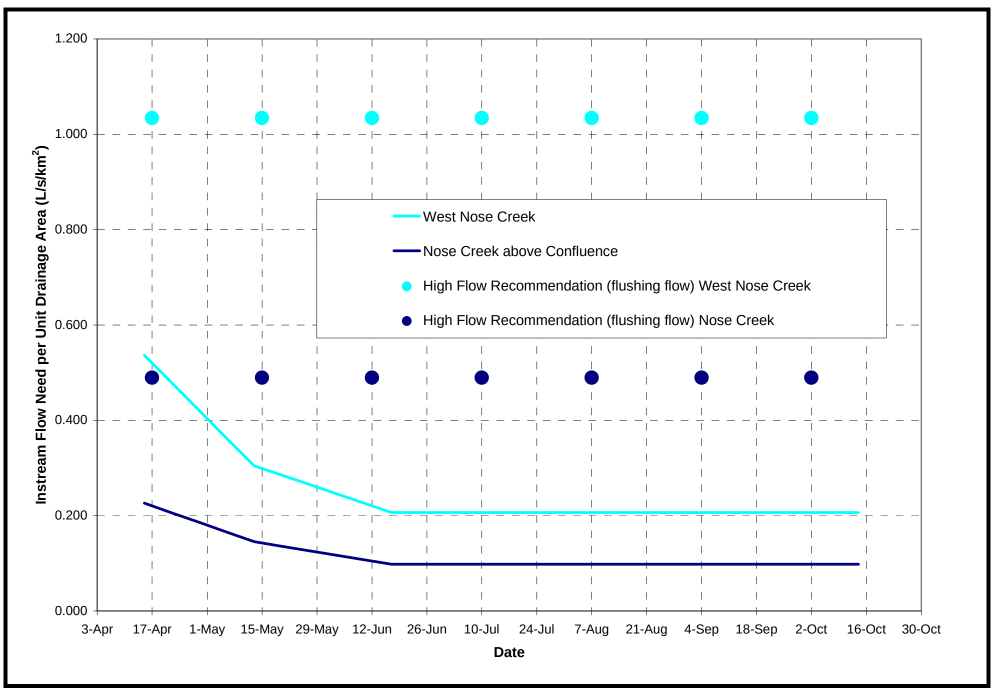
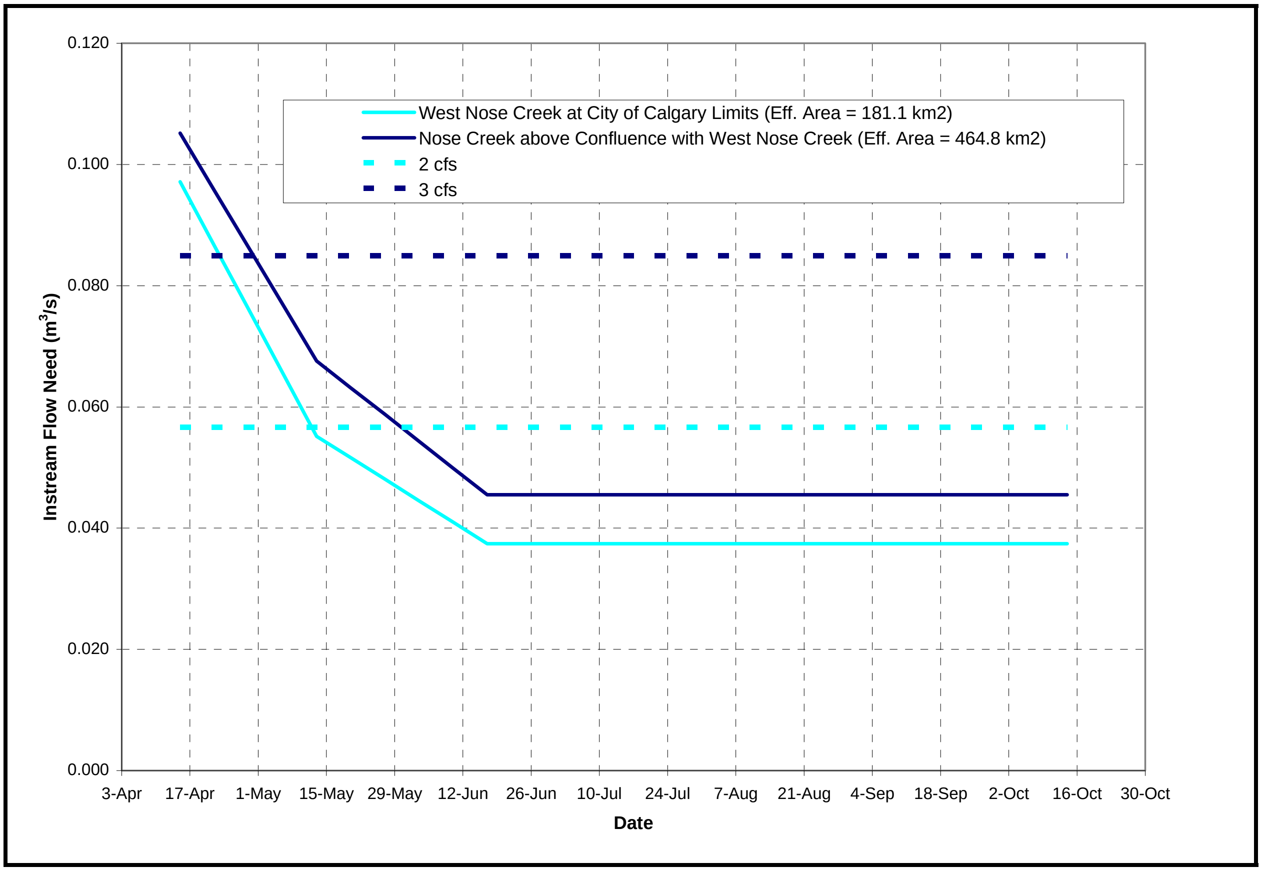


Figure 12 Tessman Instream Flow Needs for West Nose Creek at City Limits and Nose Creek at Confluence with West Nose Creek



A cautionary word is in place with respect to the actual application of the unit area IFN values. Research by the University of Calgary has shown that the majority of the base flow in e.g. West Nose Creek is largely generated by only a few springs across the catchment. The location of these springs should be mapped and accounted for in the approval process of future water withdrawal licenses.

5.4 Instream Flow Need Recommendations - High Flows

As mentioned in Section 2.0, the Tessman method specifies a 14-day period with 200% Mean Annual Flow during peak runoff conditions to provide flushing/maintenance flows. This flow rate is the amount of water needed to flush the sediment entering the channel. In case of the West Nose Creek and Nose Creek sub-watersheds, this flow rate would be 1.03 and 0.42 L/s/km^2, respectively.

The type of sediment that typically enters West Nose Creek and Nose Creek is very fine silt. The Mean Annual Flow rates shown in Table 6 are believed to be high enough to wash this material from the riffles. The Tessman recommendation for minimum flows during peak runoff conditions corresponds to a value that is very close to the Mean Annual Flow [8]. Therefore, “maintenance” of riffles is believed to be covered by the Tessman recommendation for minimum flows. As illustrated in Table 4, in principle, these 14-day duration high flows could happen during any month of the April to October monitoring period. The majority of the time, however, the high flows have happened during the spring melt.

Given the nature of these creeks, pools are prone to sedimentation of very fine material. A survey of the depth of sediment at the pools, which was carried out as part of the *West Nose Creek Stream Corridor Assessment*, showed that the average depth of sediment for pools is about 30 cm. At some locations values of up to 1 m were found for a flow rate of about 100 L/s, which equals about twice the Mean Annual Flow, i.e., the Tessman high-flow recommendation. While the Tessman high-flow recommendation may be sufficient to maintain riffles, the corresponding flow rate would not flush ‘all’ sediments in all pools. Higher flows in the order of the dominant discharge, which occurs between 1% and 3% of the time (i.e., 2 to 6 days per year), are required to wash most of the material out of the pools.

Because of the importance of flushing flows for the maintenance of the pools; the IFN should not be reduced from the Tessman high-flow recommendation. Otherwise, the depths of the pools would be reduced by sedimentation that would not necessarily be flushed out. Preferably, the dominant discharge should be maintained.

5.5 Alberta IFN Instream Classification

The recent *Alberta IFN Stream Classification Assessment Project – Validation of the Recommended Method - Final Report* by Golder Associates (October 2004) was reviewed in order to assess its applicability for the Nose Creek Basin IFN Study.

Golder’s proposed classification approach uses two key parameters:

- The 2-year flood peak flow (Q2), which represents the dominant discharge in terms of geomorphic function; and
- The reach-averaged channel bed slope (Slp), which can be used as an index for classifying stream hydraulics.

Based on observations of stream sections in the South Saskatchewan basin, there appears to be a close relationship between stream bed slope and size of bed materials for streams of equal Q2 in a homogenous hydrologic-geomorphic region. Eight of these regions were identified in the Golder report, with the Nose Creek Basin located in the region identified as NS4.

The classification parameters for Nose Creek and West Nose Creek are summarized in Table 7. The values are at the transition from the rural to the urban reaches, i.e., West Nose Creek at the

[8] The Mean Annual Flow was calculated based on an April to October period. No flow information is available for the winter months; however flows are expected to be minimal. This approach was adopted because the Tessman method is believed to have been derived for streams that have flow year round. The actual Mean Annual Flow rate is expected to be lower than the one used in Table 6. As a result, the IFN values are expected to be more conservative, i.e., higher, than when one would have used all months for computing the value of the Mean Annual Flow.

City of Calgary city limits and Nose Creek at the confluence with West Nose Creek. [9]

Table 7 Nose Creek Basin Parameters for Stream Classification

Sub-Watershed	Area (km^2)	Q2(m^3/s)*	Slp
West Nose Creek	181	1.9	0.2 %
Nose Creek	464	4.3	0.2 %

* From Flood Frequency Analysis Nose Creek Floodplain Study. AENV December 2000

Based on the values shown in Table 7, both sub-watersheds can be classified being in Class 1 of Q2 (i.e., Q2 less than 25 m^3/s) and in Class 1 of Slope (i.e., Slp less than 0.3%).

A comparison between the velocities computed as part of the hydraulic simulations conducted for the *West Nose Creek Stream Corridor Assessment* and those observed for the streams used by Golder for the validation of the recommended method, shows that the former are significantly greater. In fact, the velocities are even greater than for Beaverdam Creek, which is considered an outlier in Golder's report. For this reason, it is believed that Nose Creek and West Nose Creek may not share the similarities with the streams used by Golder for the NS4 region. As a result, the Alberta IFN Stream Classification method should not be adopted for the Nose Creek Basin until additional validations have been performed. One possibility, as already discussed in Golder's report, is the introduction of an additional class covering low values of Q2 for streams such as Nose Creek and Beaverdam Creek.

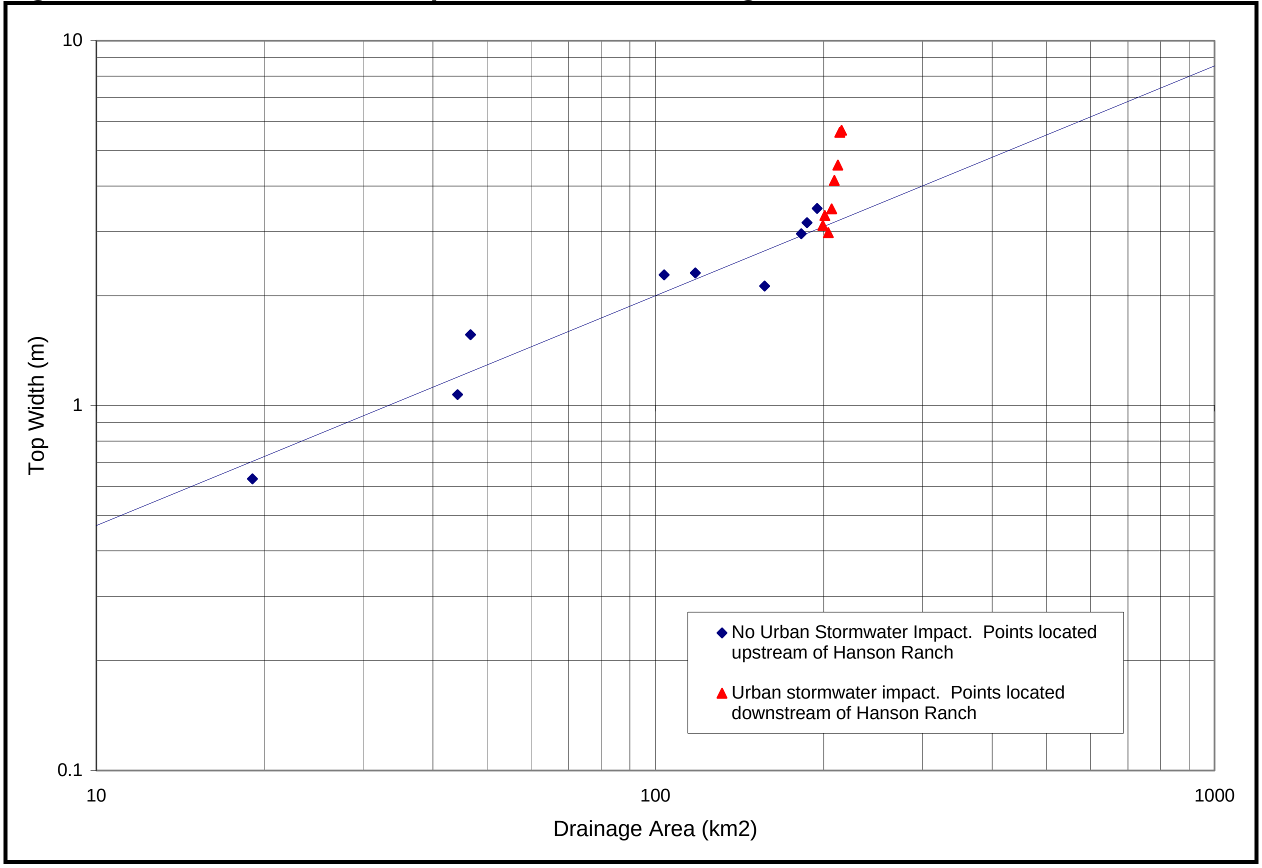
9 See also Footnote 5

6.0 ANALYSIS OF URBAN REACHES

6.1 Urbanization Impacts on Streams - West Nose Creek Stream Corridor Assessment

WER's *West Nose Creek Stream Corridor Assessment* illustrated how the lower reaches of West Nose Creek have been affected by urbanization, see Figure 13, which shows that urbanization can be equated to an artificial increase in catchment area.

Figure 13 Main Channel Top Width versus Drainage Area – West Nose Creek



The hydrologic and hydraulic analyses that were performed as part of the *West Nose Creek Stream Corridor* Assessment showed important changes in the flow duration curves as a result of urbanization. The importance of the more frequent flows with respect to the definition of the channel geometry was demonstrated. It was established that changes in the flow regime due to urbanization would produce changes in the channel geometry (e.g., widening) even though the flow rates into the creek would be controlled for extreme events. Current stormwater management practices change the flow duration curves to such an extent that the dominant discharge is increased, which leads to increases of the dependent geometric parameters.

6.2 Analysis of Flow Information

Figure 14 presents the recorded flow for the two stream gauges along West Nose Creek as well as the stream gauge along Nose Creek near the mouth for the common period of May 2003 through July 2003. At first glance it appears that the rural contribution (i.e., West Nose Creek at Station 05BH904) is constant, but this is a reflection of the scale of Figure 14.

Figure 14 Flow Records Comparison between Rural and Urban Impacted Areas – May 2003 to July 2003

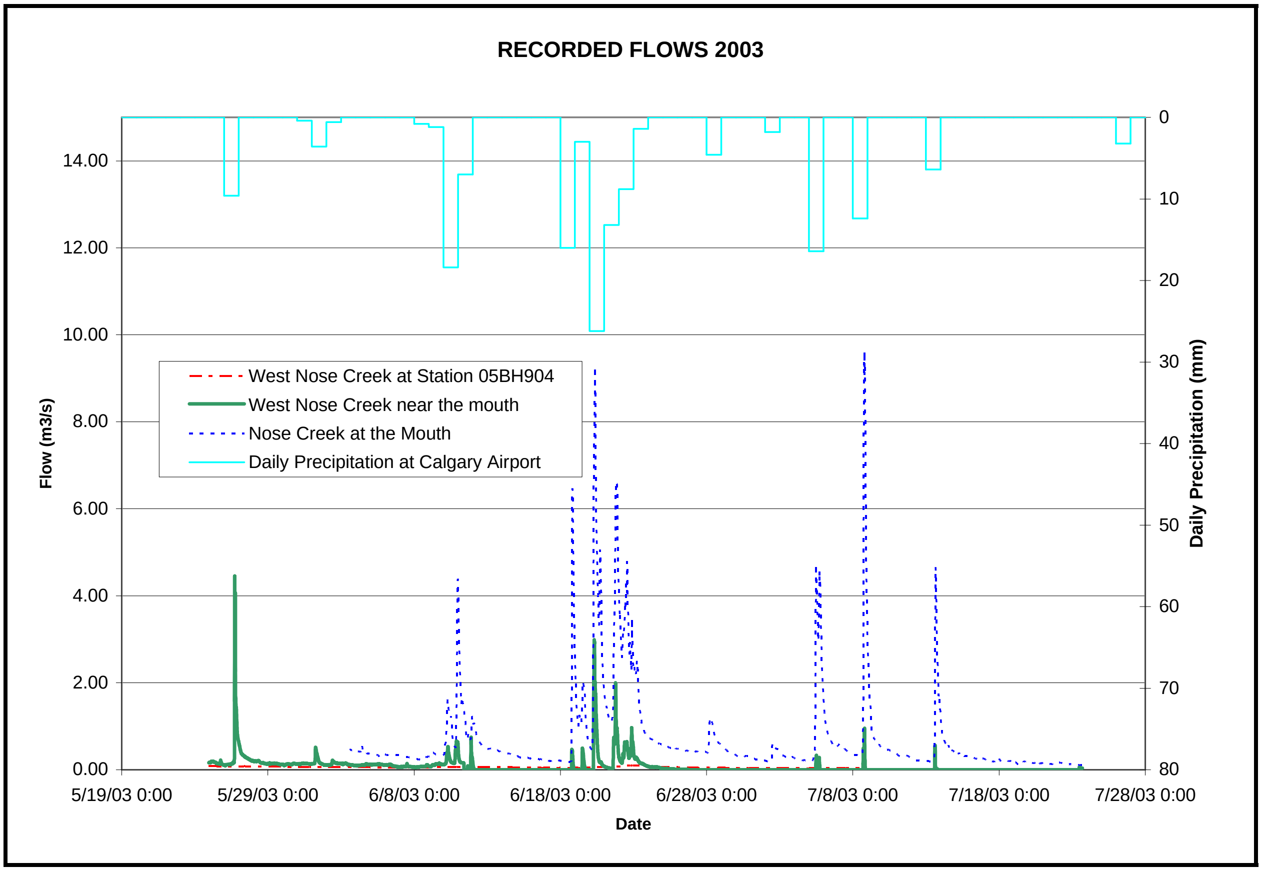
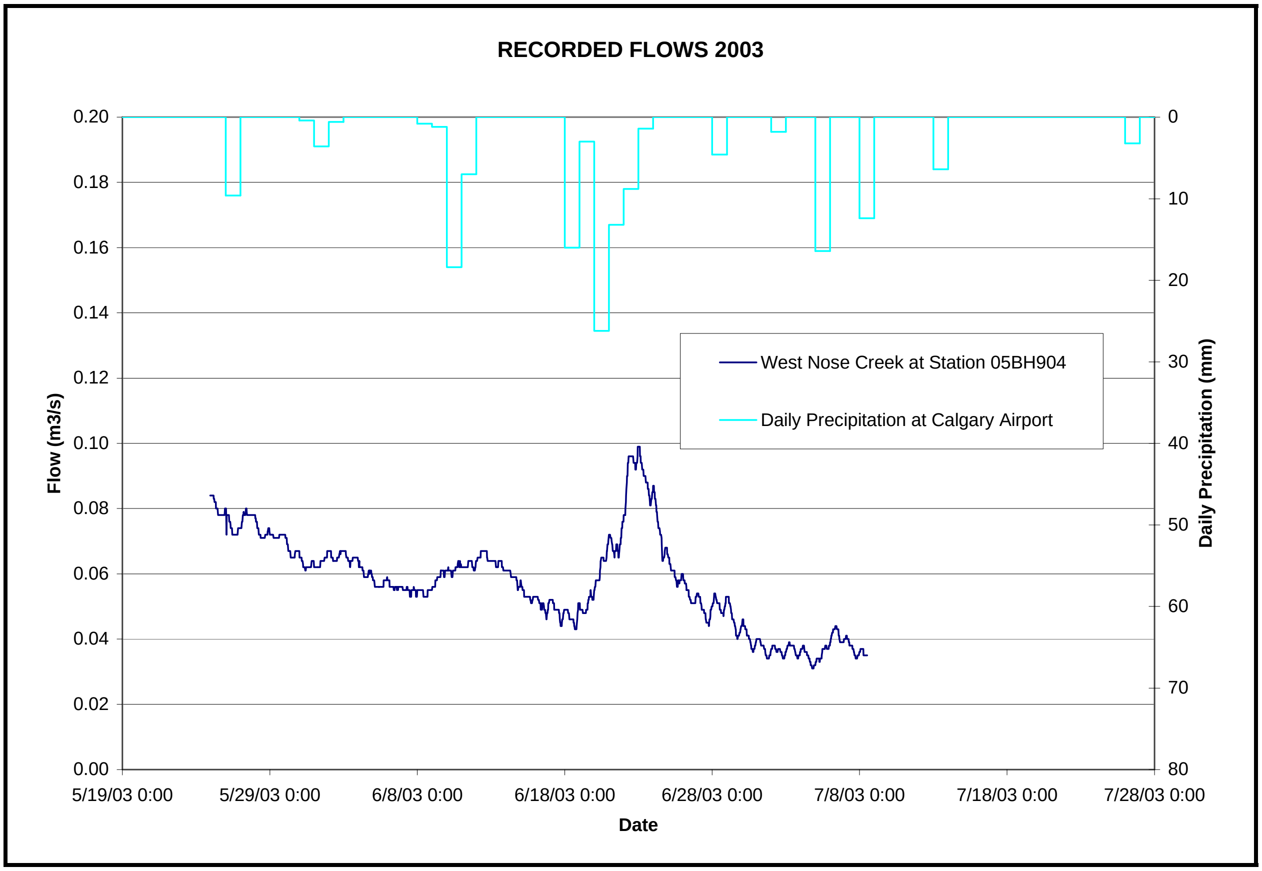


Figure 15 demonstrates the coincidence between the peaks of the hydrograph and the recorded storm events. This figure also illustrates the decrease in base flow from spring to summer.

The urban reaches show similar characteristics but the peak values and runoff volumes are significantly greater. Available data suggest that the base flows are similar on a unit area basis for the rural areas and the urbanizing reaches.

Figure 15 Flow Records West Nose Creek Upstream of City Limits – May 2003 to July 2003



6.3 Flow Duration Curves

Figure 16 shows a comparison of the flow duration curves for West Nose Creek just north of the City of Calgary city limits (with a rural catchment area of about 139.2 km^2) and near the mouth (with a total area of about 217.5 km^2). While the ratio in catchment area is only about 1.6, for an exceedance of 50%, which is close to the average flow, the flow at the mouth is about three times the flow at the city limits. The curves appear to converge for the base flows, i.e., flows that are exceeded 80% of the time. Given the short monitoring period for the stream gauge at the mouth additional monitoring should be conducted to draw conclusions for the very high or very low flows.

Figure 17 presents the curves of Figure 16 in terms of unit area discharge rates. The difference for exceedances between 1% and 3% is a factor of three to four; in the *West Nose Creek Stream Corridor Assessment* this flow rate is postulated to be associated with the dominant discharge, which governs the geometry of the stream.

Figure 16 Flow Duration Curves West Nose Creek – Comparison between Rural and Urban Impacted Areas

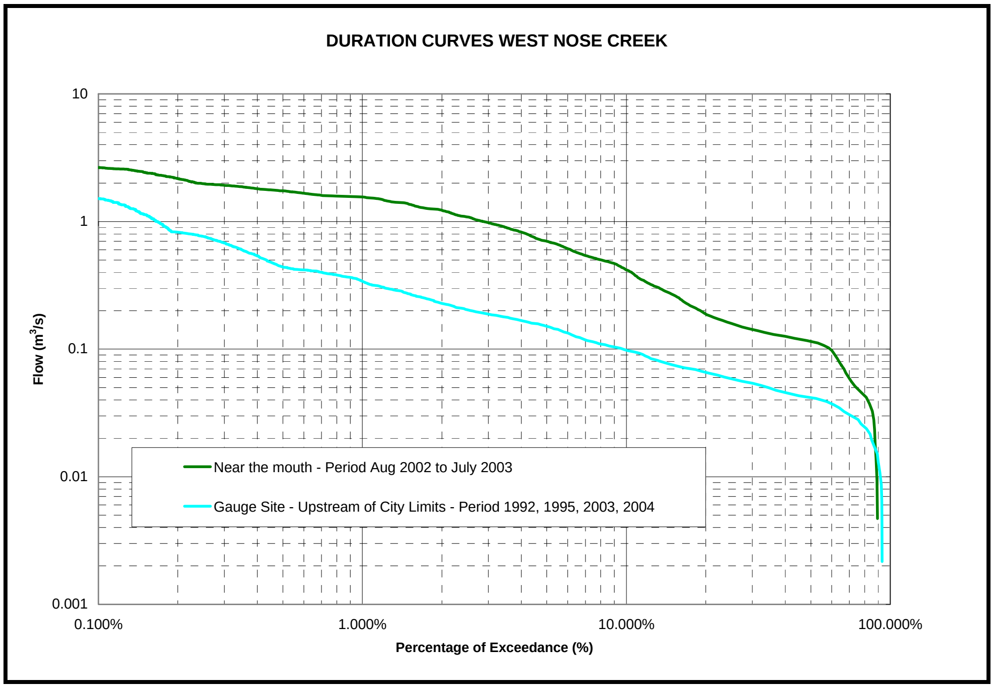
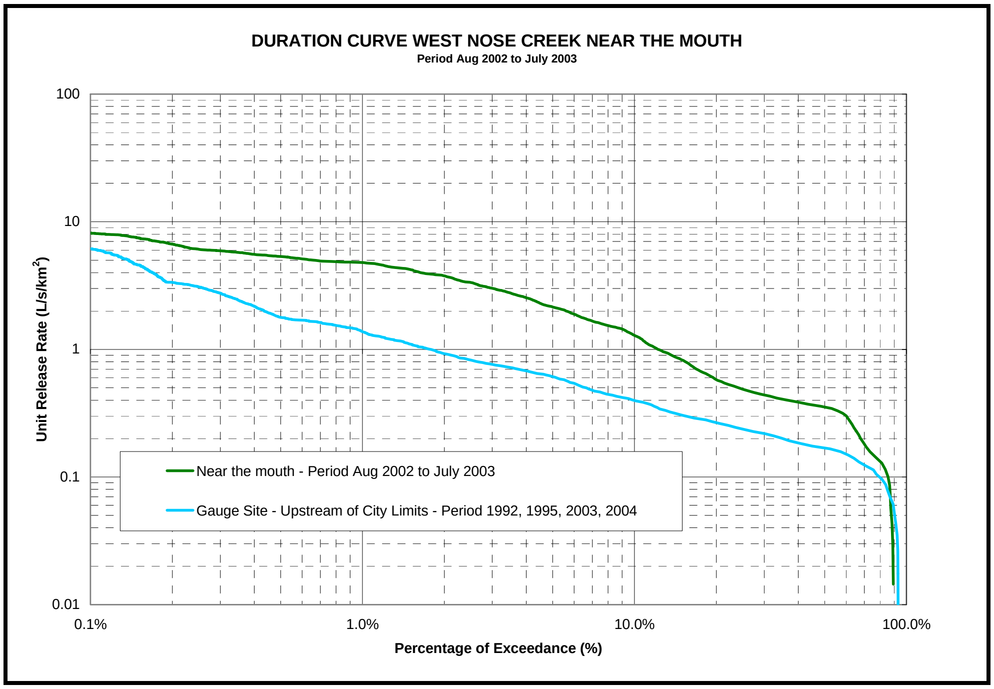


Figure 17 Flow Duration Curves West Nose Creek on Unit Area Basis – Comparison between Rural and Urban Impacted Areas



6.4 Urbanization and Fish Habitat Suitability

The impact of urbanization on one of the ecosystem components, i.e. channel structure, was explored as part of the *West Nose Creek Stream Corridor Assessment*. A predictive model of future geometry of the stream was established as a function of the future flow regime resulting from ongoing urbanization of the catchment up to the city limits.

In order to arrive at an appreciation of the urban impacts on another ecosystem component, i.e., fisheries, an analysis was conducted for a 300 m stretch of West Nose Creek where impacts by urbanization have only recently started. This stretch located just downstream of Panorama Road will be impacted in the near future by urbanization of the Symon's Valley Community area. Historical flows recorded at the AENV stream gauge north of the city limits as well as estimated future flows from the hydrologic analyses are available. In addition, the future geometry can be estimated based on the application of the predictive model.

The goal of the exercise discussed in this section is to explore the impacts of urbanization on fisheries in West Nose Creek using hydraulic-related habitat suitability curves for the White Sucker species which is common in the basin. These suitability curves had been developed by the Fish and Wildlife Service of the United States Department of the Interior (Twomey and Williamson, 1984). The hydraulic characteristics used are depth and velocity of flow.

Since the analyzed reach is still "rural" the Tessman IFN recommendations were applied to the "pre-development" flow records to get an appreciation of the correlation between the Tessman IFN recommendation and the habitat suitability.

Three variables were used as part of the analysis:

- Depth at riffles during spawning and incubation (April to July);
- Velocity at riffles during spawning and incubation (April to July); and
- Velocity at pools (April to October)

Figure 18 shows the theoretical suitability index graphs for the above variables:

Figure 18 Suitability Index Graphs - White Sucker

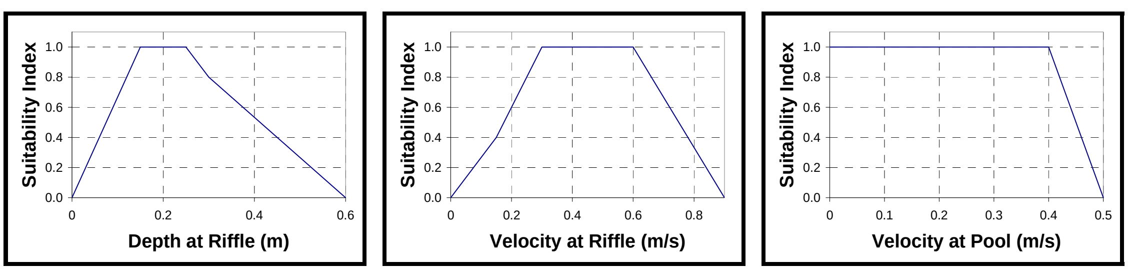


Figure 19 shows the profile of the selected reach along West Nose Creek. The results of this analysis are presented as suitability index duration curves, see Figure 20.

Figure 19 Profile of 300m-reach West Nose Creek

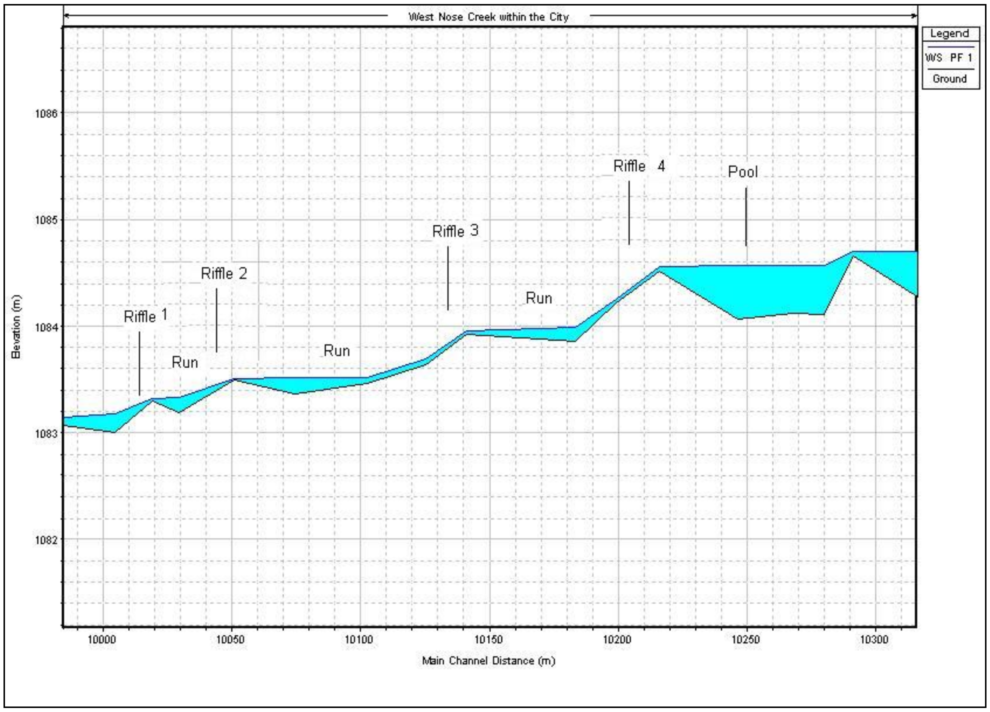
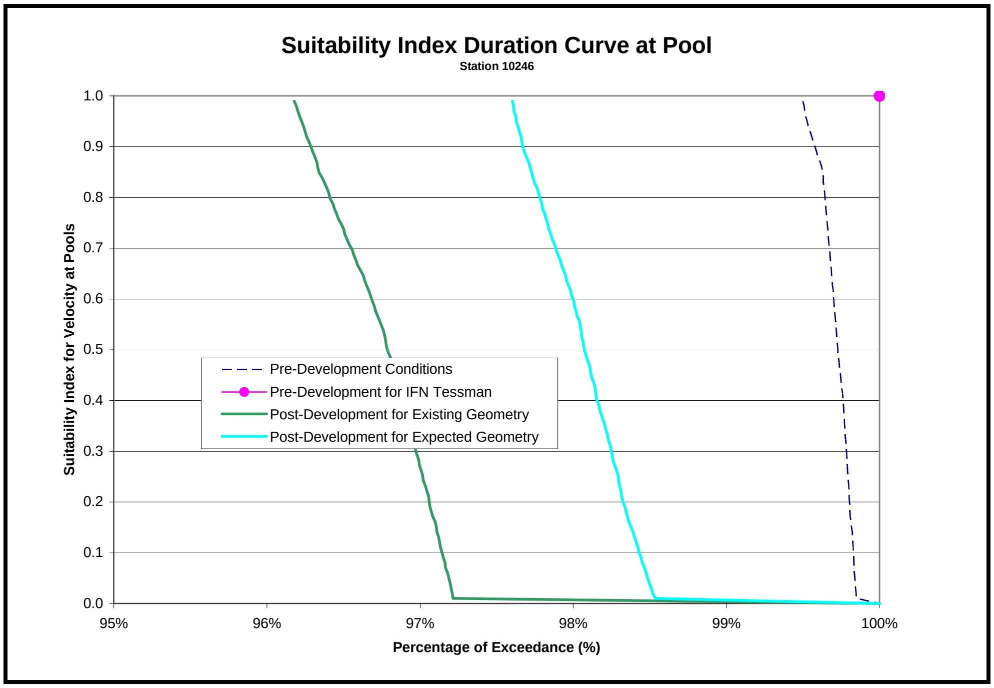


Figure 20 Suitability Index Duration Curves for Velocity at Pools – Four Different Scenarios (1982-1987)



In case of pools, the results show that urban impact before channel erosion marginally reduces the percentage of exceedance of optimal habitat from 99.5% to 96.5% of the time. Once the channel reaches its new equilibrium geometry (i.e., due to the increase of flows) the percentage of exceedance of the optimal habitat bounces back to a 98% value (see Figure 20). The flow rates associated with the Tessman IFN recommendation would yield optimal habitat for the entire year. Overall, the impact of urbanization on the habitat suitability within the pool of Figure 19 is minimal (i.e., based on pool velocity suitability index).

The situation is somewhat different for riffles, where the White Sucker species appears to be more sensitive to changes in the analysed variables than in pools. Based on the habitat suitability index curves for the White Sucker species, Riffle #3 has the greatest potential as a spawning area within the 300 m analysed reach. Figure 21, which shows graphs for the two indices of interest, illustrates that high index values (i.e., values greater than 0.8) are exceeded between 50% and 80% of the time for pre-development conditions. If the flows would conform to the Tessman IFN values for the entire year, the depth suitability would be reduced while the velocity suitability would be slightly increased. For instance, in case of the depth index, the prevalence of a high index value would be reduced from 50% to 20%.

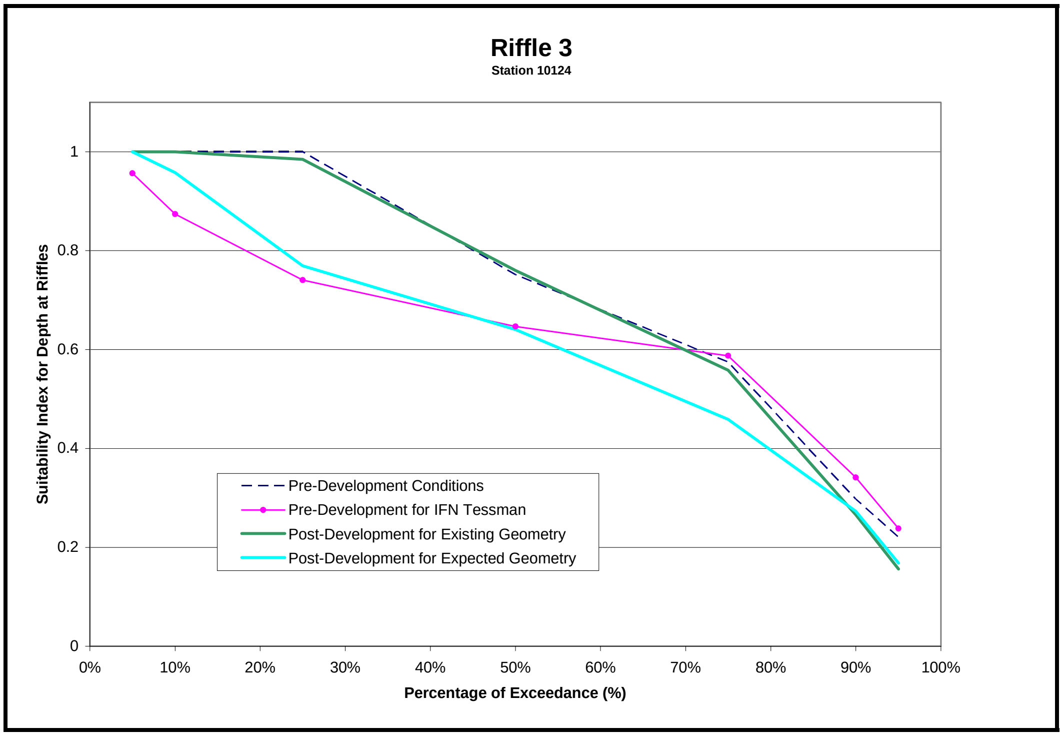
The introduction of urban runoff results in a very small reduction of the riffle depth suitability index until the channel starts to widen. Once it has reached its new equilibrium geometry, the index values fall even below the Tessman IFNs for pre-development conditions. If the resulting Tessman flows for the rural areas would be applied to the future urban conditions, the suitability would likely decrease even more.

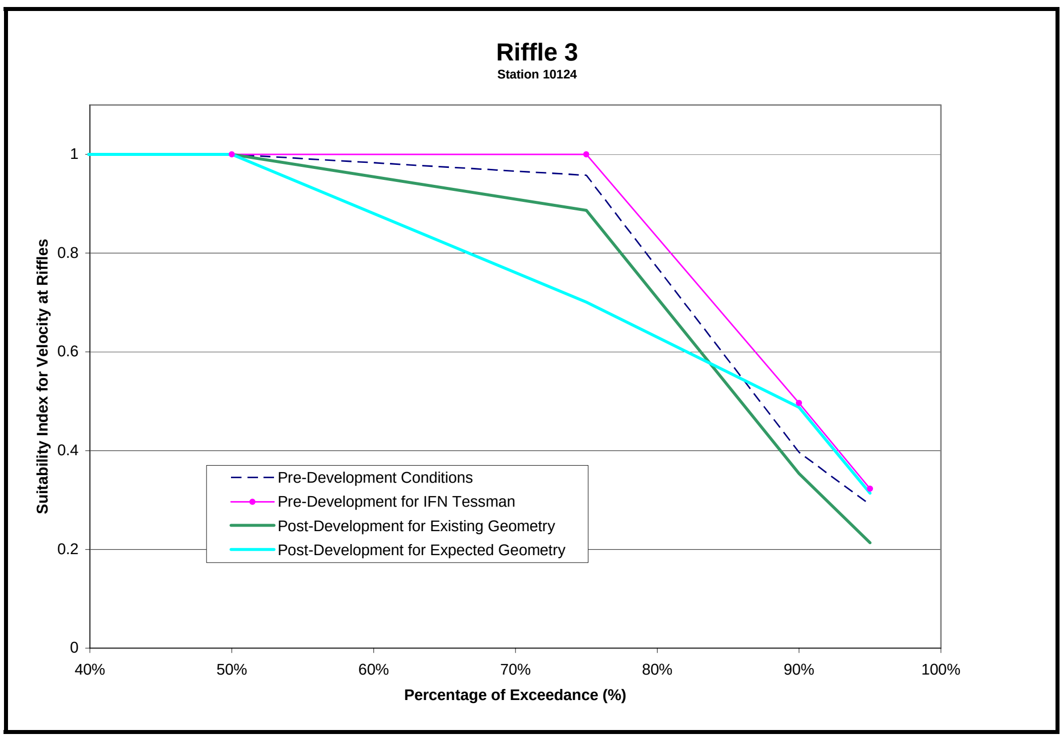
The riffle velocity suitability index is initially slightly reduced but worsens when the channel reaches its new geometry.

Similar analyses for other riffles and runs show that the impact of urbanization on the analyzed suitability indexes is greatly dependant of the local conditions. The results also suggest that the increase in the amount of water in the creeks due to urbanization does not necessarily mean that there is more water available for withdrawals. In some cases no withdrawals should be allowed in the enlarged cross section for low-flow conditions if one would want to maintain the functions obtained for pre-development conditions. Withdrawals could be conducted during intermediate and high-flow conditions to preserve the fluvial morphological characteristics of the creeks, thus protecting fisheries habitat.

It is believed that the above analysis would be quite useful to examine the impacts of the various stormwater management strategies in the catchment, specifically for the areas that are currently developed. It should be recognized that the analysis shown above was conducted in the upper part of the urbanizing catchment, and only for a few indices. Impacts will be more pronounced further downstream where there is a larger urban tributary area. In addition, impacts within the analysed reach will become more pronounced when development continues north of Calgary because of the cumulative effects.

Figure 21 Suitability Index Duration Curves for Velocity and Depth at Riffles - Four Different Scenarios (1982-1987)





6.5 Instream Flow Need Recommendations - Low Flows

Based on the fisheries habitat analysis, it is expected that the application of the Tessman method would lead to a reduction in habitat suitability, although it would still be considered "good" within the rural reaches. This does not necessarily apply to the urbanizing reaches where the effects could be compounded by changes in the geometry of the channel. The enlarged cross sections are more prone to habitat suitability reductions under low flow condition because, as discussed in Section 6.3, the magnitude of the minimum flows after urbanization seems not to have changed much from pre-development conditions. In order to be consistent between the rural and urban reaches, the Tessman IFN recommendations shown in Figure 11 could be applied as well to the urban reaches, but only if no channel enlargement is allowed! Therefore, the main recommendation for the urbanizing areas is to minimize the potential of channel enlargement. In case of desired withdrawals within the urbanizing areas, a habitat suitability analysis should preferably be conducted to evaluate the impacts, especially where channel enlargement has already occurred or is expected to occur.

6.6 Instream Flow Need Recommendations – Intermediate and High Flows

The main impact of urban development is the exponential increase in peak flow rates and runoff volumes discharged to the creeks. The consequences are visible in two ways:

1. Much larger floods in the creeks during extreme storm events; and
2. Channel enlargement, downcutting and headcutting of the channel due to ongoing erosion.

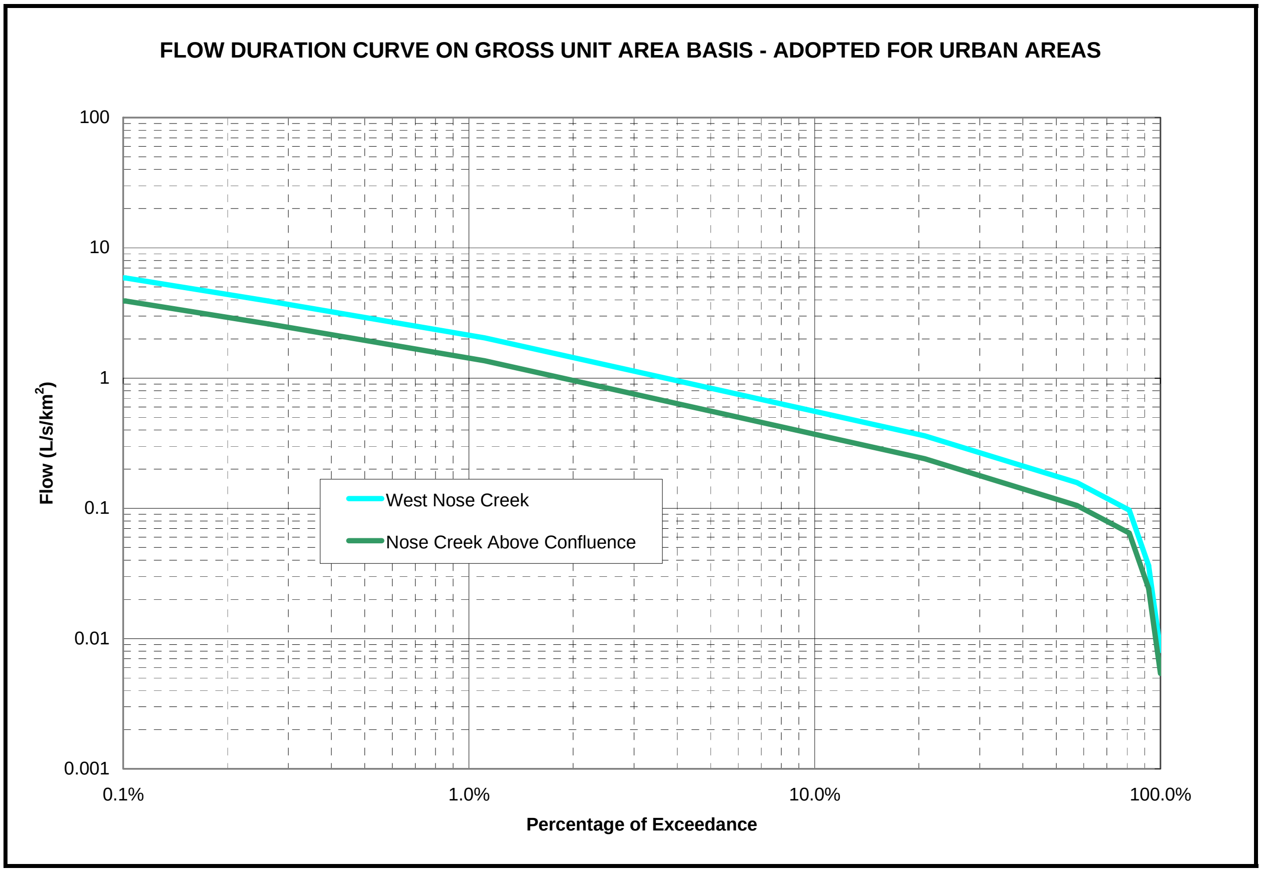
Both consequences can be minimized by having the urban discharge conform to the flow duration curve that is shown in Figure 22 [10]. While the first consequence could be controlled, as historically has been attempted, by solely reducing the permissible discharge rate for extreme events, the second one requires the volume control that is necessitated if one would try to conform to Figure 22.

The IFN for high flow conditions represents a flood conveyance safety issue. Historically, this was the only condition considered within the Nose Creek Basin. The IFN for intermediate flow conditions represents an environmental issue in that the erosion phenomena have a detrimental impact on fisheries habitat and riparian vegetation but also a maintenance and safety issue. Maintenance could be a concern in that the eroded bank sediments might have to be removed at downstream locations along the streams. Safety could be a concern in that the accelerated erosion may undercut bridge abutments and storm sewer outfalls as is already being experienced along West Nose Creek. The change in hydrologic regime may also lead to adjustments in the plan form of the streams which over time could threaten urban infrastructure or dwellings. These issues are expected to be more pronounced along the relatively pristine reaches of West Nose Creek and Nose Creek, upstream of the confluence with West Nose Creek. The downstream reaches of Nose Creek were significantly altered with the construction

10 The flow duration curves of Figure 22 are expressed on a gross unit area basis rather than an effective unit area basis to reflect the need to minimize the magnitude of the discharges into the creeks in order to prevent channel geometry changes.

of Deerfoot Trail in the 1970s.

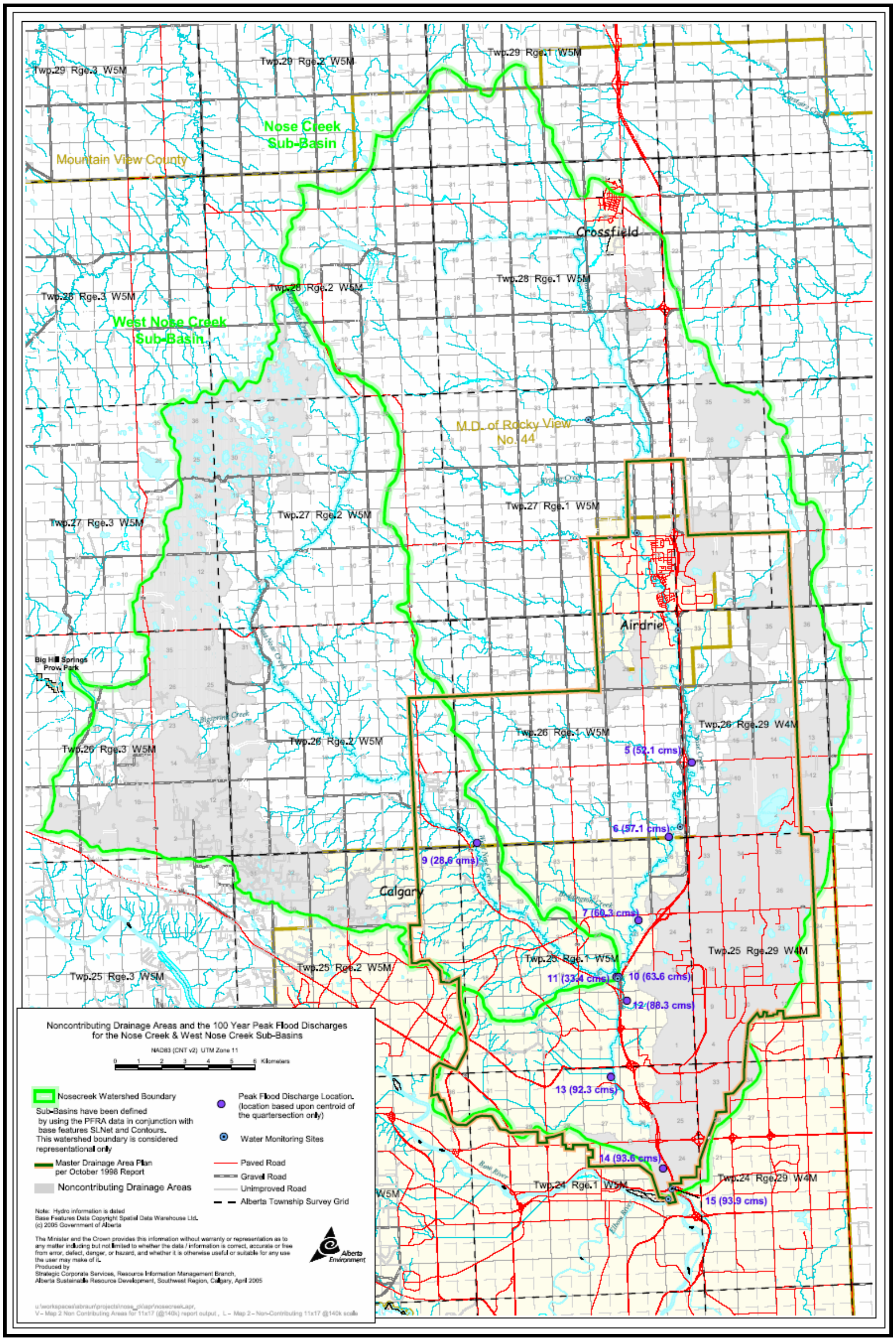
Figure 22 Flow Duration Curve on Gross Unit Area Basis to Prevent Channel Geometry Changes



It was alluded to in previous sections that the dominant discharge of an urban stream is postulated to occur between 1% and 3% of the time (i.e., 2 to 6 days per year). While volume control as per Figure 22 would have definite benefits in reducing the peak flood flows as well, in principle, it might not be necessary – even if it were practical in the first place – to apply volume control principles to the entire event that would define flood conveyance safety because of their infrequent occurrence. This requires therefore that the IFN for high flow conditions defines the flow rates that the streams are able or should be able to convey safely.

Figure 23 illustrates the 1:100 year flow rates that are currently being used by Alberta Environment for floodplain mapping purposes along the lower reaches of West Nose Creek and Nose Creek. These flow rates appear not have accounted for the *limited increase in flow* principle that adopted in the *Nose Creek Basin Storm Drainage Study* of the 1980s. Following are some pertinent excerpts from the Phase 4 report:

Figure 23 High Flow IFN for Urban Areas and Ultimate Development Area



A concept based on a limited increase in flow in Nose Creek was developed to utilize increased channel capacity in Nose and West Nose Creeks. This concept was developed based on the relatively inexpensive increase in channel capacity available for Nose Creek downstream of the confluence of Nose and West Nose Creeks, and a more expensive, but environmentally sensitive, increase in channel capacity feasible for Nose and West Nose Creek above their confluence. Storage of stormwater runoff in individual developments is utilized to reduce peak rates of stormwater discharge to allowable maximum channel capacity in Nose/West Nose Creeks.

A maximum practical channel capacity of 120 m^3/s was established for Nose Creek through the existing Calgary area. This channel capacity proved to be the most cost effective capacity.

The 120 m^3/s channel capacity was reduced for the 1-in-100-year return period peak discharge of the existing and near future development areas and upstream non-developed areas in order to determine the allowable discharge for the ultimate urban development area of the Nose Creek Basin. The remaining capacity was apportioned throughout the ultimate development area on an areal basis.

In essence, the area designated as “ultimate development area” in the mid 1980s was allowed to discharge at rates greater than pre-development conditions. Stormwater management facilities would be implemented distributed across the basin to store excess runoff, thus ensuring that the allowable discharge for the ultimate urban development area would be adhered to for a 1:100 year condition. In addition to the 1:100 year flow rates for floodplain mapping purposes, Figure 23 also shows the extent of the mid 1980s “ultimate development area” as well as the extent of those areas along specifically the western perimeter of the Nose Creek Basin that are considered to be self-contained.

Typically, in Calgary a permissible 1:100 year flow rate of 2.6 L/s/ha has been used for those catchments within the “ultimate development area” that drain to the main stem of Nose Creek. In the 1990s, a permissible 1:100 year flow rate of 2.73 L/s/ha was used for those catchments in the “ultimate development area” that drain to West Nose Creek; this rate was reduced to 2.6 L/s/ha after 2000. For comparison purposes, Table 8 summarizes the pre-development flow rates in West Nose Creek and Nose Creek, respectively. In the case of West Nose Creek, this *limited increase in flow* amounts to either 162% or 65% of the pre-development 1:100 year flow rates, based on the gross and the effective areas, respectively. In the case of the main stem of Nose Creek, the *limited increase in flow* amounts to either 107% or 86% of the pre-development 1:100 year flow rates.

Table 8 Nose Creek Basin Pre-Development Unit Area Flow Rates

	West Nose Creek at Township 26 Southern Boundary			**Nose Creek at Township 26 Southern Boundary**		
	Gross Area (km^2)		288.9	Gross Area (km^2)		454.2
	Effective Area (km^2)		181.1	Effective Area (km^2)		408.8
Return Period (years)	Q (m^3/s)	Rate based on Gross Area (L/s/ha)	Rate Based on Effective Area (L/s/ha)	Q (m^3/s)	Rate based on Gross Area (L/s/ha)	Rate Based on Effective Area (L/s/ha)
100	28.6	0.990	1.579	57.1	1.257	1.397
50	20.9	0.723	1.154	41.7	0.918	1.020
20	13.0	0.450	0.718	25.9	0.570	0.634
10	8.50	0.294	0.469	17.0	0.374	0.416
5	5.08	0.176	0.281	10.2	0.225	0.250
2	1.91	0.066	0.105	3.82	0.084	0.093

A number of comments are offered with respect to the above:

1. It is not believed that any of the proposed channel capacity upgrades upstream of the confluence of Nose Creek and West Nose Creek were ever carried out. As a result, Airdrie currently uses a permissible release rate equal to 1.84 L/s for the future developments along its western fringe. This release rate is based on the western tributary to Nose Creek as documented in AENV's 2000 *Flood Frequency Analysis – Nose Creek Floodplain Study*. Since discharge rates tend to decrease on a unit area basis when going downstream, this 1.84 L/s unit area discharge rate is still greater than the 1.257 L/s/ha unit area discharge rate in Nose Creek at the City of Calgary city limits.

2. Because the stormwater management facilities only target a 1:100 year condition they provide limited control of flow rates for the more frequent storm events. As demonstrated in the *West Nose Creek Stream Corridor Assessment*, this limited flow rate control in combination with the complete absence of volume control leads to acceleration of erosion along the creeks and channel enlargement.

3. An issue was raised in the *West Nose Creek Stream Corridor Assessment* in that the 1:100 year flows that would have to be safely conveyed by West Nose Creek could be substantially greater than the flow rate that is shown in Figure 23. This view was based on a cursory analysis of the coincidence between a 1:100 year flood hydrograph from the rural area and the urban discharges from a 1:100 year storm event. The 1:100 year flood hydrograph was based on the peak flow rates presented in the 2000 *Flood Frequency Analysis – Nose Creek Floodplain Study.* It appeared that the critical event was not as much a typical summer thunderstorm but rather a long duration, low intensity event when all urban catchments would contribute with minimal attenuation effects.

   Unfortunately, the various reports that were prepared for the 1980s *Nose Creek Basin Storm Drainage Study* did not provide flow rates for the *upstream non-developed areas*. A comparison of the results of the flood frequency analyses carried out for the 1983

Calgary Floodplain Study and the 2000 *Flood Frequency Analysis – Nose Creek Floodplain Study* showed that the 1:100 year estimate for the latter is 16% greater than the one generated by the former study. This difference, however, does not entirely explain the differences noted in the *West Nose Creek Stream Corridor Assessment*. It is questioned to what the existing analyses have adequately examined the potential coincidence of high flows generated by the upper catchment and urban discharges.

The reports associated with the 1980s *Nose Creek Basin Storm Drainage Study* provided little detailed information on the actual hydrologic simulations that were carried out to express the contribution of the existing developments at that time. A cursory review revealed that the percentage of hard surface area used in the QUALHYMO simulations was relatively low. In addition, there is no information if comparisons were carried out with the combined capacity of the various urban outfalls along West Nose Creek and Nose Creek. In view of the relatively low assumed imperviousness ratios and the ongoing densification within the existing areas it is questioned whether the contribution from the existing urban areas might be substantially greater than what was assumed in the 1980s.

The hydrologic analyses that were carried out as part of the 1980s *Nose Creek Basin Storm Drainage Study* may have been “state-of-the-art” at the time. However, given the above questions and new insights, it is believed that the hydrologic analysis of the Nose Creek Basin should be revisited. Since the basin has not yet been urbanized to the limits of ultimate development as identified in the mid 1980s, there is still opportunity to downgrade the permissible 1:100 year release rates if that would turn out to be appropriate. It is noted though that - specifically in the West Nose Creek sub-watershed - development has progressed beyond the west boundary of the original 1980s ultimate development area.

4. The flow estimates presented in the 2000 *Flood Frequency Analysis – Nose Creek Floodplain Study* are based on the *effective* rather than the *gross* or total catchment areas. This has implications for future development – whether it is ultra-urban, industrial, commercial **or** country-residential – within the area that has been identified in Figure 23 as being self-contained. The drafting of a drainage policy covering these lands is highly recommended! Preferably, these areas should continue to be self-contained because of the potential increase in runoff to the creeks unless wholesale and effective volume control by distributed source control measures was implemented. If, for any reason, these areas were allowed to drain into the creeks, the high-flow permissible release rate should be based on the *gross* catchment area. Possibilities might exist where runoff generated by extreme events were allowed to drain towards the creeks, while the basin would remain self-contained for the more frequent events that affect the morphology of the creeks.

7.0 COMMENTARY ON RELATIONSHIP BETWEEN PROPOSED URBAN IFNs AND STORMWATER MANAGEMENT PRACTICES WITHIN THE NOSE CREEK BASIN

The definition of the IFNs for the urban reaches that were presented and discussed in Chapter 6 will have definite repercussions for our stormwater management practices, specifically if volume control targets would be adopted as part of the Water Conservation Objectives for the Nose Creek Basin.

In the report on the hydrologic and hydraulic analyses conducted as part of the *West Nose Creek Stream Corridor Assessment* numerous options were identified to address the impacts of urbanization on West Nose Creek. No specific option was recommended since adoption of any options would first of all require extensive stakeholder consultation. It was, however, very clear that only volume control would truly minimize impacts due to urbanization. Similar observations have been made in other jurisdictions, most notably in British Columbia where volume control reductions are now part of provincial policy.

The implementation of volume control is still in its infancy in the Calgary region. The City of Calgary Wastewater Services is currently drafting a BMP and Source Control Manual but it is acknowledged that a considerable amount of local design information is necessary before it can be uniformly adopted across the region. Nevertheless, some local success stories already exist, most notably the Hamptons subdivision in northwest Calgary. This subdivision was constructed in the early 1990s with no discharge to West Nose Creek; accumulated runoff is re-used for irrigation of the golf course that is located in this subdivision. While environmental reasons or concerns about long-term impacts on West Nose Creek might not have played any role whatsoever at the time that this subdivision was conceived – i.e., one did not want to create the necessary off-site services – it is an example that zero-runoff developments can be created in the Calgary area. Since not every development will have a golf course where runoff can be re-used for irrigation purposes, local source control design information will be required that addresses costs and benefits, long-term sustainability and maintenance. Local pilot projects will be needed to assemble some of this pertinent data.

As alluded to in Section 6.6, volume control would not necessarily have to be applied to the entire range of storm events. Rather, the events that correspond to the dominant discharge should be targeted. This means that volume control could be limited to those events generating less than say 20 mm, and not to an entire 1:100 year event [11]. Rate control as per the permissible 1:100 year unit area release rate for the “ultimate development area” shown in Figure 23 and the gross area pre-development unit area flow rates of Table 8 for the areas beyond the “ultimate development area” would still have to be applied for extreme events. These very same principles are actually now followed in British Columbia. Similar concepts are also advocated on a national level in a recent Infraguide document on best practices for sustainable municipal infrastructure.

11 For comparison purposes, a 20 mm event corresponds closely to a 4 hour - 1:2 year event, a 1 hour - 1:5 year event, a 30 minute - 1:10 year event, a 15 minute – 1:25 year event or a 10 minute – 1:50 year event, based on the Intensity-Duration-Frequency curves for the Calgary International Airport.

This drainage philosophy is illustrated in Figures 24 through 26. Figure 24 shows that, on average, about 100 days have some degree of precipitation each year. The vast majority, however, have a depth of less than 10 mm. Figure 25 illustrates that about 95% of all storm events have a depth smaller than or equal to about 20 mm, assuming a 6 hour interevent time. Figure 26 shows flow exceedance curves for several scenarios: pre-development conditions, post-development conditions assuming about 55% hard surface area and three post-development source control scenarios. Figure 26 demonstrates that both the magnitude and frequency of flow, hence the runoff volume, would exponentially increase with development. A 20 mm source control target, however, appears to yield a similar frequency for the low flow range as pre-development conditions. Little improvement is achieved for a 30 mm source control target. The magnitude of the flow rate for the infrequent events would still have to be controlled by rate control. Please note that the above assessment is very preliminary and does not account for hydrograph alterations due to large-scale stormwater management facilities or travel time effects within larger watersheds. Additional investigations are highly recommended to arrive at a fully defendable approach and source control targets.

Figure 24 Histogram of Historical Events recorded at the Calgary International Airport

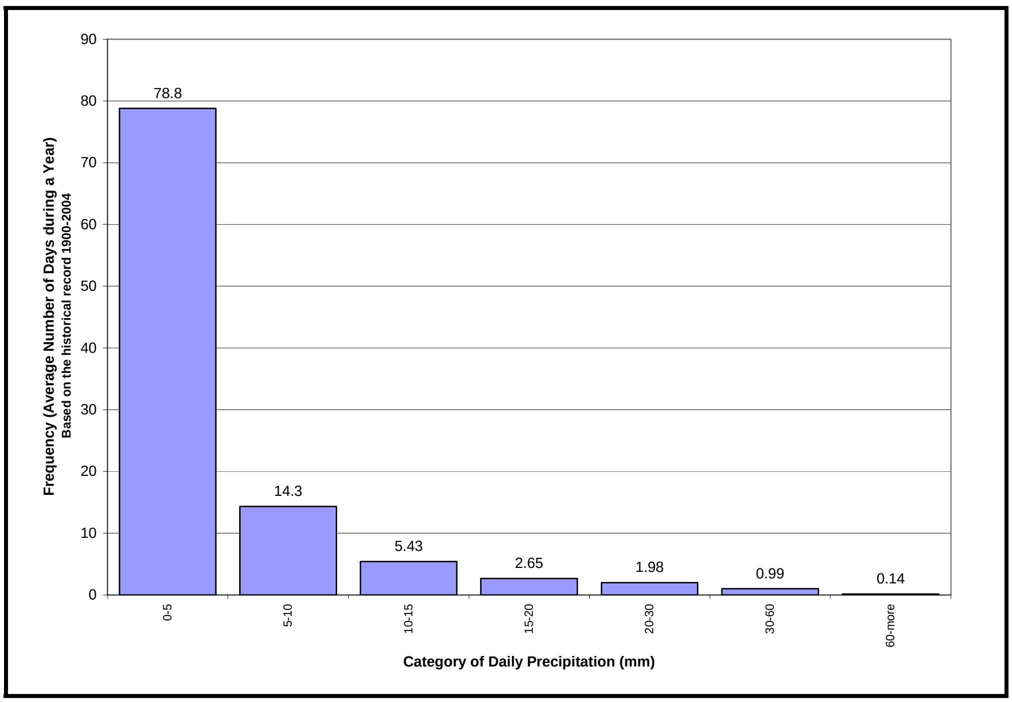


Figure 25 Rainfall Depth Exceedance Curve

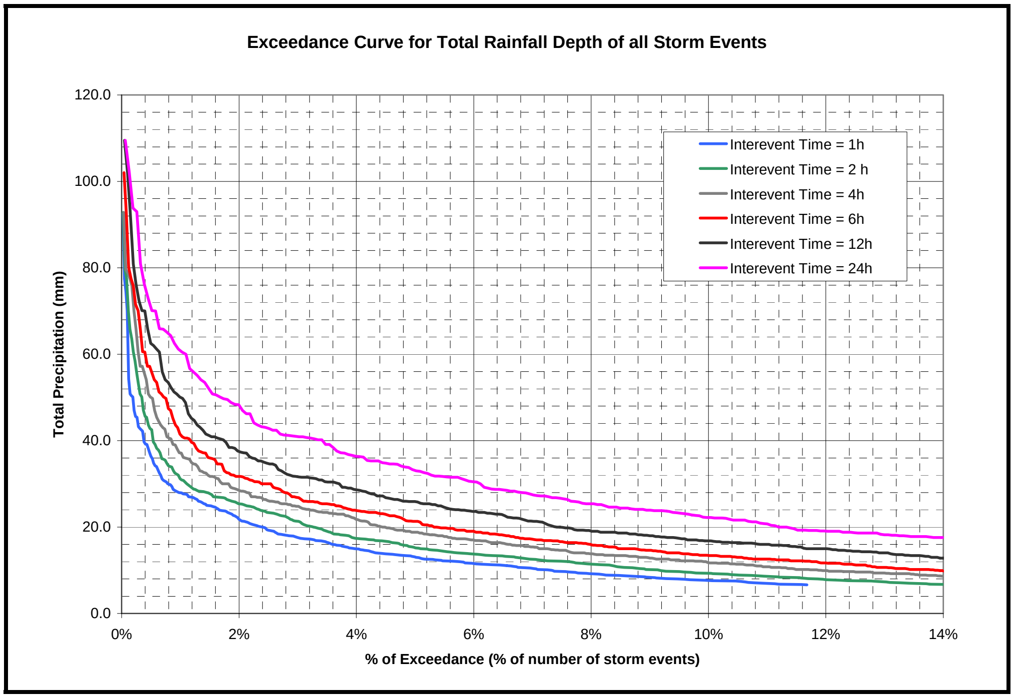
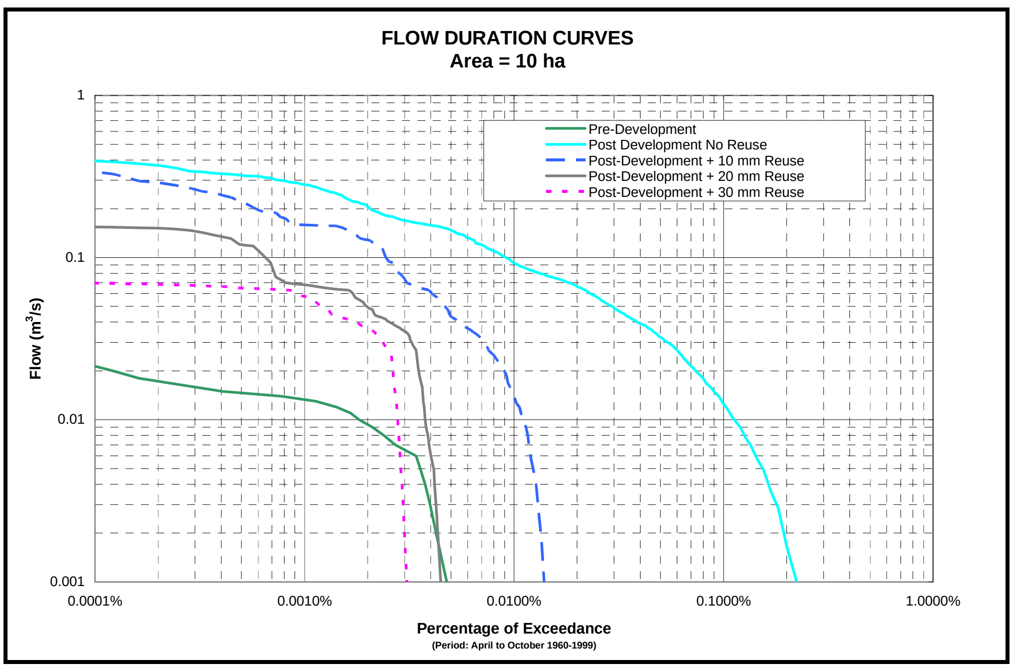


Figure 26 Flow Duration Curve for Several Source Control Targets



The hydrologic and hydraulic analysis and the design of these new stormwater management

practices and specifically the benefits for the receiving streams will require an evolution of the currently available tools. Continuous simulation tools will be essential to assess the impacts on a basin wide basis. These tools however need to reflect what ultimately can be accomplished during design, and need to be able to represent source control practices, water quality enhancement measures and the response of the drainage system to extreme events.
The analysis and design of these evolving drainage systems will need a creative approach and above-all multi-disciplinary approach of dealing with runoff. Standards, policies and practices will need to be updated across the region and in some cases at a provincial level where existing policies may conflict. Because of the multi-disciplinary angle, this will not solely affect those that have historically dealt with drainage but also others in planning, parks and recreation, and transportation. The lack of local design information is compounded by the lack of qualified specialists who can design, construct, operate and maintain this new generation of drainage features. Similarly, there is currently no review capacity within the City of Calgary let alone the other members of the Partnership.

The resolution of these issues will not happen overnight. As a result, degradation of the creeks will continue at a time that development still proceeds at a rapid pace. The *West Nose Creek Stream Corridor Assessment* discussed some options for stream restoration techniques that could alleviate some of the impacts of urbanization, but these measures could have to be implemented along the entire creek at considerable cost.

The next few years should therefore be used to:

- Review fisheries impacts as discussed in Section 6.4 to establish what degree of volume control would be appropriate;
- Implement source control pilot projects;
- Evaluate options to optimize the operation of the existing drainage system; and
- Evaluate the response of the watershed to extreme events (i.e., update the hydrologic analyses of the entire basin conducted in the 1980s).

The members of the Partnership should continue with the hydrologic and hydraulic assessments of the watershed using continuous simulation tools. These assessments should be commenced as soon as possible in order to provide the necessary flexibility for the analysis and design of the new urbanizing areas.

8.0 COMMENTARY ON RELATIONSHIP BETWEEN IFNs AND SET-BACK REQUIREMENTS

Historically, the only set-backs considered had the goal of addressing safety and nuisance concerns associated with flood conveyance. Some have hypothesized that the existing set-backs in the Calgary area as outlined in the 1980s River Valley Plan, which was adopted by City Council, covers aesthetical issues as well.

In Calgary, the current guidelines call for a 6 m set-back from the floodway and a 30 m set-back from the top of the bank, as defined by an Alberta Land Surveyor, to buildings. It is not clear what kind of urban encroachment, e.g., pathways or parking areas, would be allowed within this 30 m set-back zone.

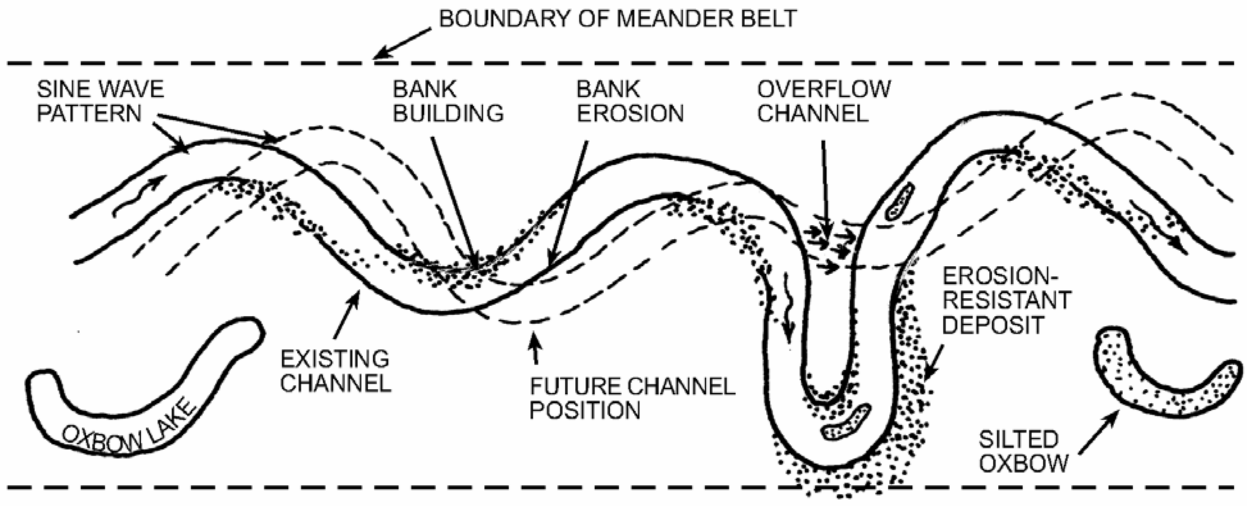
Lately, concerns have been raised about the need to establish appropriate set-backs for recreational and environmental purposes. For instance, Fish Creek Provincial Park is suggested as a prime example of how larger set-backs have created a hugely popular area that is very attractive and greatly contributes to Calgary's liveability. At the same time, the open space has enhanced the value of the properties along the perimeter of the park. This document, however, cannot offer insight as to what would constitute possible set-backs for recreational, environmental and wildlife movement concerns as there is no direct link to the magnitude of the flows within the streams.

As mentioned, flood conveyance set-backs are ultimately associated with public safety and nuisance in terms of members of the public being swept away by flood flows or damage to public and/or private property. One concern associated with traditional floodplain mapping is that it innately has a static component, i.e., the alignment and cross-section of the stream are not "supposed" to change over time. This inherent assumption may be appropriate where extensive training works are utilized to prevent the stream from moving, but it is at odds with natural stream evolution concepts, specifically for urban streams that are subjected to changes in the hydrologic regime. The "natural" movements of a stream may in due time change the floodplain delineation or threaten urban infrastructure.

An attempt to address this secondary safety issue is the adoption of a so-called meander belt principle, where the zone in which a stream is allowed to move freely is defined, see Figure 27.

This approach stems from the realization that streams have moved in the past and that there is no reason for assuming that they will stay fixed in place in perpetuity. It is also important to realize that the width of the meander belt is a function of the flow rate, i.e., an increase in flow rate would cause an increase in belt width. This link between flow rate and meander belt width is related to the adopted IFNs and stormwater management practices. In Ontario, an adjustment factor is suggested that is equal to the ratio between the 1:2 year post-development flow rate and the 1:2 year pre-development flow rate. The *West Nose Creek Stream Corridor Assessment* suggests that this ratio is quite large for the lower reaches of West Nose Creek. While different factors and ratios might be appropriate for the Nose Creek Basin, it is important to assess how the creeks might move as a function of changes in hydrologic regime. This does not mean that encroachment onto the meander belt is not possible at any time; rather, encroachment increases the potential of extensive and expensive human intervention at some time in the future – an example is the required stream restoration works along the lower reaches of West Nose Creek.

Figure 27 Meander Belt Principle



The delineation of the meander belt and the definition of appropriate set-backs should be conducted as early in the planning process as possible, preferably at the Area Structure Plan stage, well before the submission of Outline Plans.

9.0 STAGED AND PRIORITIZED PLAN FOR FUTURE DATA COLLECTION AND FOLLOW-UP STUDIES

As alluded to in Chapter 1, the budget available for the actual determination of IFNs that are appropriate for the Nose Creek Basin was relatively small. Hence, broad-based studies to support the derivation of the IFNs were not available. Both in the *Nose Creek Basin Instream Flow Needs Scoping Study* report as well as in the previous chapters, various issues were raised where future data collection and follow-up studies are appropriate to fill in the identified data gaps. In addition, long-term monitoring will be required to evaluate whether the desired outcomes are being accomplished and to steer the future management of the water resource in the Nose Creek Basin.

Following are recommendations for a staged and prioritized plan for future data collection and follow-up studies:

1. Continue the existing flow monitoring along Nose Creek and West Nose Creek.

2. Install long-term stream gauges along the rural reaches of Nose Creek or its main tributaries, upstream of Airdrie.

3. Install additional long-term flow monitoring stations in the urban areas, specifically at locations where there is a clear change in stormwater management philosophy for the catchments.

4. Map the location of springs within the Nose Creek Basin and monitor the magnitude of flows delivered by these springs.

5. Install reference sites to monitor long-term erosion by means of an annual or bi-annual comparison of surveyed cross-sections and possibly longitudinal profiles.

6. Conduct benchmark photography along select reaches of Nose Creek and its tributaries to allow periodic visual assessments of changes to the creeks.

7. Draft fisheries, invertebrates and other habitat indicator criteria for performance monitoring.

8. Implement fisheries, invertebrates and other habitat indicator monitoring stations to monitor the long-term quality of the creeks.

9. Update the hydrologic analyses of the entire basin to evaluate the response of the watershed to extreme events.

10. Update the high-flow IFNs and permissible release rates for the urbanizing areas based on the results of the updated hydrologic analyses of the entire basin.

11. Review fisheries impacts as discussed in Section 6.4 to establish what degree of volume control would be appropriate.

12. Acquire detailed water license withdrawal information including actual amounts withdrawn and timing of withdrawals.

13. Assess meander belt needs within and upstream of newly urbanizing areas.

14. Evaluate options to optimize the operation of the existing drainage system.

15. Evaluate the need to expand the intended dissolved oxygen and temperature monitoring and expand the monitoring frequency to allow a QUAL2E or WASP analysis of the creeks.

16. Review provincial and federal guidelines to establish IFNs for other water quality parameters of concern such as coliforms, pesticides and herbicides, metals and sediments.

17. Review setback policies to establish what amounts to a healthy corridor for both the urban and rural reaches.

18. Implement source control pilot projects.

19. Update IFN values for West Nose Creek incorporating future flow monitoring data.

20. Create IFN values for upper rural watershed, i.e., upstream of Airdrie, and update the IFN flow duration curve for Nose Creek main steam sub-watershed, based on future flow monitoring data.

21. Adopt adaptive management principles for Nose Creek of West Nose Creek based on assessment and monitoring tools such as Biologic Integrity, the Riverine Community Habitat Assessment and Restoration Concept and the Biological Response to Flow Correlation Method, preferably correlated with an Index of Hydrologic Alteration.

22. Compare frequency duration curves for existing and new stream gauges in urbanizing areas to evaluate if volume control benefits are achieved.

23. Compare results of long-term erosion monitoring program to assess trends in erosion and channel enlargement phenomena.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The Nose Creek Basin Instream Flow Needs Study is a second step in creating the Nose Creek Watershed Management Plan. It builds on the methodologies for defining IFNs that were outlined and discussed in the 2004 Nose Creek Basin Instream Flow Needs Scoping Study report.

The IFN recommendations that are contained in this report are preliminary science-based quantities and qualities of water that sustain the integrity of aquatic environments. The corresponding flows are believed to preserve the natural flow regime, water quality, fish and fish habitat, and channel maintenance processes of riverine environments. As such, these recommendations are essential inputs to decision-making processes, and can be integrated with social, economic and environmental information to establish flow regimes for a stream reach.

These decision-making processes result in the generation of Water Conservation Objectives, which are the legislative tools used to establish flows in rivers and streams in Alberta. The generation of Water Conservation Objectives that are appropriate for the various reaches of Nose Creek and West Nose Creek was not part of the current study; these are to follow, as per the draft Terms of Reference for Phase 1 of the NCWMP.

The IFN recommendations contained in this report distinguish between the rural reaches and the urbanized reaches. The rural reaches are assumed to consist of Nose Creek and its tributaries upstream of Airdrie or Crossfield, and West Nose Creek and its tributaries upstream of Calgary.
The urbanized reaches are assumed to consist of Nose Creek from Airdrie downstream and West Nose Creek within Calgary.

The IFN values for the rural reaches should be based on the unit area discharge rates presented in Figure 11, or the residual flows of 2 cfs for West Nose Creek and 3 cfs for Nose Creek, whichever yields the highest value.

The low-flow IFN values for the urban reaches should be based on the IFN values for the rural areas. A fisheries impact assessment should be conducted in case of withdrawals upstream or along of urban reaches that are subject to channel enlargement.

The intermediate flow IFN values for the urban reaches should conform to the flow duration curves presented in Figure 22. The implementation of these IFN values would require volume control.

The high-flow IFN values for the urban reaches should conform to the flow rates and permissible release rates that are summarized in Figure 23 and discussed in Section 6.6.

The following other recommendations are made:

- Implement the staged and prioritized plan for future data collection and follow-up studies outlined in Chapter 9.

- Update the existing stormwater management policies and standards and practices to arrive at more sustainable practices.
- Draft a drainage policy covering the self-contained areas within the Nose Creek Basin.
- Resolve potential conflicts with provincial policies.

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