Updated 2018

Nose Creek Watershed Water Management Plan

Nose Creek Watershed Partnership

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EXECUTIVE SUMMARY

Integrated resource management planning is increasingly important in Alberta's urbanizing watersheds. The Nose Creek watershed, situated in the Bow River basin, is impacted by the cumulative effects of increasing residential and commercial development, industrial growth, stormwater discharge, agricultural activity, and stream channelization. The Nose Creek Watershed Partnership (NCWP or Partnership) was formed in 1998 to undertake joint watershed planning to address concerns regarding the future condition of Nose Creek and West Nose Creek. The Partnership is currently represented by the Calgary Airport Authority, City of Airdrie, City of Calgary, and Rocky View County.

In 2008, the Partnership completed the Nose Creek Watershed Water Management Plan (Plan) as a means to protect riparian areas and improve water quality. The Plan recognized that watershed management is a shared responsibility. Common goals and objectives were identified to maintain the ecological integrity (function) of the watershed and minimize risks associated with land use and development.

Current Watershed Condition

Since implementation of the Plan began in 2008, water quality in Nose Creek and West Nose Creek continues to rate fair, with a number of water quality indicators rating poor (e.g., nutrients, suspended sediment). While some improvements in riparian condition have been observed, continued effort is needed to restore riparian condition and to retain wetlands in the watershed. Healthy riparian areas mitigate impacts of flood and drought, maintain streambank stability, filter contaminants from overland runoff water, and support biodiversity.

Stormwater management remains a priority concern in the watershed. About 137 outfalls currently discharge stormwater to Nose and West Nose creeks. Higher release rates and runoff volumes generated from impervious surfaces increase streambank erosion, widen stream channels, and degrade water quality and aquatic habitat. Impacts may be amplified in urbanizing areas where riparian areas, wetlands and ephemeral/intermittent watercourses have been encroached on or filled-in. A desire to maintain stream channel morphology and improve water quality in Nose and West Nose creeks requires a continued commitment to improving stormwater management.

Update of the Nose Creek Plan

In 2016, the NCWP initiated the process to update the Nose Creek Plan. The update was necessary to reflect advancements in knowledge, changes in provincial and municipal policies, and to address new challenges in land and water resource management. The NCWP engaged with watershed stakeholders, and municipal and provincial staff throughout the process, and considered their experience with Plan implementation. Recommendations in the Plan were made to systematically work toward achieving desired outcomes for improved stormwater management, good water quality, retention of riparian areas and wetlands in urbanizing areas, and preservation of biodiversity in the watershed. The updated Plan represents a renewed commitment by the Partnership to support common goals and objectives that aim to improve and maintain watershed conditions for future generations.

Water Quantity and Stormwater Management

An integrated hydrologic, hydraulic and water quality model is recommended in the Nose Creek Plan. The model will help to understand current watershed conditions and measure success in achieving the Plan's objectives. The model will also be used as a predictive tool to better evaluate the impacts of stormwater (e.g., on high flows, low flows, and stream channel morphology) at the watershed-scale. In response to input from stakeholders, a further recommendation is made to delay the implementation of the 2017 runoff volume control target until provincial and municipal policies align to allow for water re-use and stormwater use. Greater consideration is also given to redevelopment areas in this Plan. As redevelopment occurs, green space tends to be absorbed by new buildings and infrastructure. Policy is needed to reduce runoff volumes, upgrade stormwater infrastructure, and improve water quality in these areas.

Surface Water Quality

Existing and applicable surface water quality guidelines and objectives for Nose and West Nose creeks are summarized in the updated Plan. An improved, standardized monitoring program is recommended that will support future modelling efforts and watershed condition reporting. In addition to monitoring a variety of water quality indicators, the collection of continuous streamflow data at multiple sites across the watershed is recommended. Total Maximum Load limits are recognized as a tool to manage water quality in the watershed and may be set in the future as an objective of the standardized water monitoring program. Preservation of natural features, such as stream channel morphology, escarpments, native vegetation, and riparian areas is recognized as essential to maintaining water quality in the watershed.

Riparian Protection

Riparian areas, including wetlands and ephemeral and intermittent watercourses, serve to mitigate impacts of flood and drought, preserve water quality, and maintain biodiversity. The updated Plan establishes riparian health targets and thresholds, and refines riparian setback guidelines considering new provincial guidance documents and municipal policies. Wetland loss in the Calgary area was estimated at 80-90% (Parks Foundation Calgary 2003; The City of Calgary 2004). More recently, the loss of ephemeral and intermittent watercourses draining to Nose Creek (in Calgary) was estimated to be 57% (AMEC Foster Wheeler and Tannas Conservation Services Ltd. 2017). Preservation of wetlands and ephemeral and intermittent watercourses in urbanizing areas is a priority. The Plan recommends the integration of wetlands in urban development design in an effort to retain them in the future.

Groundwater

Groundwater is an important resource in the watershed that provides water to rural residents, and contributes to base flow in Nose and West Nose creeks. A source water protection plan is recommended for the watershed, focused on the groundwater resource. Decommissioning abandoned wells, as a potential source of contamination to groundwater, and continued research related to groundwater quantity and quality are recommended.

Biodiversity

Measures needed to sustain biodiversity in the watershed are identified. Recommendations focus on maintaining habitat for fish, particularly for Brown Trout that spawn in West Nose Creek and other trout species observed in Nose Creek. Recommendations are made to maintain native vegetation adjacent to watercourses to maintain stable streambanks and quality habitat for wildlife. Invasive aquatic species (e.g., Prussian Carp, crayfish, and flowering rush) and Whirling disease continue to be a concern in the watershed. An Early Detection and Rapid Response Plan is recommended to effectively manage these threats.

Priorities

The Nose Creek Plan Implementation Guide was completed as part of the Nose Creek Plan update process. The implementation guide prioritizes implementation actions for the short-, medium- and long-term, as resources allow. The key implementation actions for the Nose Creek Watershed Partnership are:

1. The development of a hydrologic/hydraulic and water quality modelling tool for the Nose Creek watershed;
2. The implementation of a co-ordinated and long-term, standardized water monitoring program to support the modelling tool, and improve water condition reporting;
3. Erosion monitoring; and
4. Watershed condition reporting.

Watershed management and planning is an iterative process and shared responsibility. The Nose Creek Watershed Partnership encourages all partners and stakeholders to implement the recommendations in the Plan to the best of their ability. The Partnership remains committed to engaging stakeholders and to updating the Plan when new information and supporting policy are available.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS i

EXECUTIVE SUMMARY ii

LIST OF ABBREVIATIONS vii

1.0 INTRODUCTION 1

1.1 Background 1
1.1.1 Planning Area 1
1.1.2 Nose Creek Watershed Condition 3
1.1.3 Plan Implementation Progress 4
1.1.4 Alignment with Current Planning Initiatives 4

2.0 PURPOSE, INTENT AND AUTHORITY 5

3.0 ISSUES, Goals and Objectives 5

3.1 Issues 5
3.2 Goal 6
3.3 Objectives and Outcomes 6
3.4 Tools to Achieve the Goals and Objectives 7

4.0 STAKEHOLDER ENGAGEMENT 7

5.0 ROLES AND RESPONSIBILITIES 9

6.0 RECOMMENDATIONS 11

6.1 Administration 11
6.1.1 Recommendations to Support Administration 11

6.2 Water Quantity and Stormwater Management 13
6.2.1 Background 13
6.2.2 Recommendations for Water Quantity (General) 15
6.2.3 Recommendations for Integrated Stormwater Management 16

6.3 Surface Water Quality 23
6.3.1 Background 23
6.3.2 Recommendations for Surface Water Quality 24
6.3.3 Recommendations to Protect Natural Features and Improve Water Quality 28

6.4 Riparian Protection 31
6.4.1 Background 31
6.4.2 Riparian Health Targets and Thresholds 31
6.4.3 Recommendations to Protect Riparian Lands (Lotic Systems) 32
6.4.4 Recommendations to Protect Wetlands (Lentic Systems) 38
6.4.5 Recommendations to Protect Riparian Lands in Agricultural Areas 40
6.4.6 Recommendations for Riparian Restoration and Stewardship 41

6.5 Groundwater 43
6.5.1 Background 43
6.5.2 Recommendations for Groundwater Protection 43

6.6 Biodiversity 44
6.6.1 Background 44
6.6.2 Recommendations to Preserve Biodiversity 44

6.7 Nose Creek Watershed Partnership Priorities 47
6.7.1 Priorities 47
6.7.2 Staged Work Plan 47

7.0 GLOSSARY 49

8.0 LITERATURE CITED 55

APPENDIX A. Relevant legislation, policy, plans, guidance documents and programs 61

APPENDIX B. Summary of new and emerging issues in the Nose Creek watershed. 63

APPENDIX C. History of stakeholder engagement in the Nose Creek Watershed Water Management Plan planning process. 65

APPENDIX D. Indicators and performance measures for the Nose Creek watershed. 66

APPENDIX E. Internal Drainage Area Policy (NCWP 2015). 67

APPENDIX F. Summary of current riparian condition at Nose Creek (Table A) and West Nose Creek (Table B). 69

APPENDIX G. The role of ephemeral and intermittent watercourses in watersheds. 72

APPENDIX H. Maintenance and monitoring of bioengineering and restoration projects. 73

APPENDIX I. Summary of fish species utilizing Nose and West Nose creeks, and temperature requirements. 74

APPENDIX J. Key reference maps supporting the Nose Creek Watershed Water Management Plan. 76

J-1. Internal drainage areas (non-contributing areas) 77
J-2. Historic and current water monitoring locations. 78
J-3. Alberta Merged Wetland Inventory. 80
J-4. Groundwater vulnerability. 81
J-5. Human footprint in the Nose Creek watershed (ABMI 2014) (AEP 2018). 82

APPENDIX K. NCWP implementation priorities. 83

LIST OF ABBREVIATIONS

ABMI	Alberta Biodiversity Monitoring Institute
AEP	Alberta Environment and Parks
ALIDP	Alberta Low Impact Development Partnership
ALUS	Alternative Land Use Services
AOPA	*Agricultural Operations Practices Act*
ASP	Area Structure Plan
BIA	Biophysical Impact Assessment
BMP	Best Management Practice
BRBC	Bow River Basin Council
BR PMP	Bow River Phosphorus Management Plan
CCME	Canadian Council for Ministers of the Environment
CPR	Canadian Pacific Railway
DRP	Dissolved Reactive Phosphorus
EPEA	*Environmental Protection and Enhancement Act*
ER	Environmental Reserve
GIS	Geographic Information System
GOA	Government of Alberta
IDA	Internal Drainage Area
IFN	Instream Flow Needs
LUB	Land Use Bylaw
LID	Low Impact Development
MGA	*Municipal Government Act*
MR	Municipal Reserve
NCWP	Nose Creek Watershed Partnership
NCWWMP	Nose Creek Watershed Water Management Plan
PESL	Palliser Environmental Services Ltd.
RAP	Restricted Activity Period
SARA	*Species at Risk Act*
SSRB	South Saskatchewan River Basin
SSRP	South Saskatchewan Regional Plan
TDL	Temporary Diversion Licence
TML	Total Maximum Load
TP	Total Phosphorus
TSS	Total Suspended Solids
U of A	University of Alberta
WCO	Water Conservation Objective
WER	Westhoff Engineering Resources
WMP	Water Management Plan
WNC	West Nose Creek
NC	Nose Creek

1.0 INTRODUCTION

The Nose Creek Watershed Partnership (NCWP or Partnership) was formed in 1998, and is currently represented by the Calgary Airport Authority, City of Airdrie, City of Calgary, and Rocky View County. The Partnership was established with the goal to protect riparian areas and improve water quality in the Nose Creek watershed.

In 2008, the Partnership, in collaboration with watershed stakeholders, completed the Nose Creek Watershed Water Management Plan (NCWWMP or Plan)[1]. The Plan was the culmination of legislation, research, and recommendations that were made to the Partnership. The Nose Creek Plan recommended actions needed to protect riparian areas and improve water quality, and specifically addressed the issues of channelization, stormwater volume, and protection for riparian areas through consistent application of setbacks. The recommendations aimed to establish a consistent approach to protecting riparian areas and improving water quality throughout the watershed. The 2008 Plan was endorsed by all municipalities represented in the watershed, and supported by Alberta Environment.

In 2016, the Partnership initiated the process to update the Nose Creek Plan to reflect advancements in policy and evolving practices. This Plan recommends actions to address new challenges and opportunities to ensure the Plan remains relevant as a guiding document for land and resource managers.

1.1 Background

1.1.1 Planning Area

Nose Creek originates near the northern boundary of Rocky View County and the Town of Crossfield, and flows south through Airdrie and Calgary, joining the Bow River in Calgary near the Calgary Zoo (Figure 1). The watershed drains a gross area of 989 km^2 and an effective area of 743 km^2. The mainstem of Nose Creek is about 75 km in length and is fed by numerous intermittent watercourses; the most notable is McPherson Coulee. The main, permanent tributary to Nose Creek is West Nose Creek.

The mainstem of West Nose Creek is about 65 km in length and has a gross watershed area of 325 km^2 and effective watershed area of 217 km^2. West Nose Creek encompasses about 33% of the entire Nose Creek Watershed area. The creek originates in Rocky View County, northwest of Calgary. West Nose Creek joins Nose Creek near Deerfoot Trail (Hwy 2), directly west of the Calgary International Airport.

[1] PESL 2008

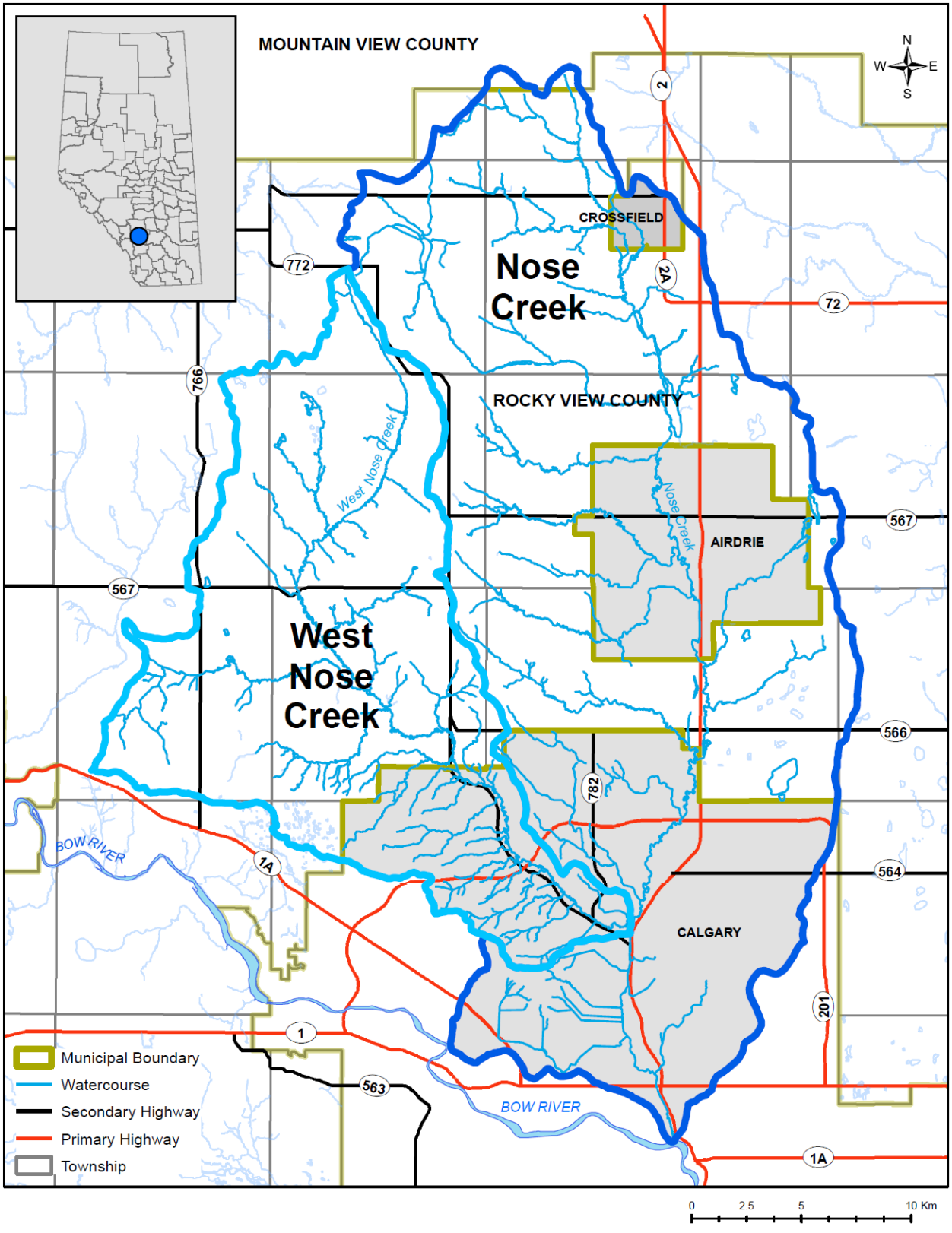

Figure 1. Map of the Nose Creek watershed. Map produced by J. McTavish, Rocky View County, January 2018.

1.1.2 Nose Creek Watershed Condition

The Nose Creek watershed is impacted by the cumulative effects of increasing residential and commercial development, industrial growth, stormwater discharge, agricultural activity, and channelization. Urban development and agricultural activity have resulted in degraded water quality, loss and degradation of riparian areas, an overall reduction in channel length, and an increase in water flows above natural in urban areas during certain times of the year. In 1980, Alberta Environment retained Dillon Consulting to undertake an Interim Storm Water Management Study[2] in the Nose Creek watershed. The authors were first to identify some of the future challenges that urbanization posed for the watershed:

> *"Proposed urban development, in recently annexed lands and other areas of Calgary and the Town of Airdrie, have a potential for changing several thousand acres of drainage areas of Nose Creek and its tributary, West Nose Creek. ... The runoff from this further urbanization may substantially change Nose Creek by increasing flood flows; by reducing low flows; by impairing water quality; by increasing sediment discharges during construction, and by increasing channel erosion."*[2]

Following these early stormwater management investigations[3], the Nose Creek Watershed Partnership commissioned several studies. These studies included water quality monitoring (1998-2000), groundwater investigations, instream flow needs investigations, and riparian health assessments.[4] Additional projects were undertaken by municipalities that supported ongoing municipal planning and policy development, as well as NCWP goals, such as the West Nose Creek Stream Corridor Assessment[5].

The instream flow needs studies showed that development in the watershed increased impervious surface area, and these impervious areas generated larger stormwater runoff volumes and higher streamflows compared to predevelopment conditions. Higher streamflows have contributed to streambank erosion, widening of the creeks in the lower reaches, and degraded water quality. The impacts were compounded by channelized creeks, and the loss and/or degradation of wetlands and riparian areas that generally function to mitigate the impacts of flood and drought, and buffer surface water from pollutants (e.g., salt, nutrients, suspended solids).

More recent studies include an internal drainage areas investigation, implementation of a surface water monitoring program (2009-13), a stormwater quality study (2014-16), and a microbial source tracking project.[6] Individual municipalities continue to assess watershed condition and identify tools to inform decision-making within each jurisdiction. Some of this work involves riparian health assessments (Airdrie and Calgary), preliminary fisheries investigations, and implementation of low impact development pilot scale projects (Calgary).

Results generally show that improvements to water quality and riparian function have been made through the implementation of better management practices (e.g., storm ponds, riparian

[2] Dillon 1980
[3] Dillon 1980; Stanley 1988
[4] Cross 2002; Hayashi 2004; WER 2004; WER 2005; Cows and Fish 2001
[5] WER 2002
[6] MPE 2013; PESL 2014a; PESL 2014b; PESL 2015; PESL 2017

setbacks). However, these practices are not consistently implemented throughout the watershed and the improvements are not widespread. Current watershed conditions are further discussed by topic area in Section 6.0.

1.1.3 Plan Implementation Progress

During the past 10 years, the NCWWMP has inspired riparian policy and setbacks for development, increased use of best management practices to improve water quality, and improved understanding of the importance of ecological processes in the watershed. Nose and West Nose creeks were reclassified from provincial Class D waterbodies that have no restrictions for timing of instream activity, to Class C waterbodies that are associated with a restricted activity period (RAP) for instream activity under Alberta's *Water Act*[7]. Further, the Plan has encouraged the use of advanced stormwater management practices, including runoff volume controls, maximum release rates, and retrofits to existing infrastructure (e.g., oil/grit separation, stormwater retention ponds, and salt storage facilities). On-farm beneficial management practices in rural areas have been promoted and implemented.

1.1.4 Alignment with Current Planning Initiatives

The Nose Creek Watershed Water Management Plan is supported by the provincial *Water Act,* legislation that ensures water is managed sustainably and aquatic environments are healthy. A requirement of the *Water Act* and a major component of The *Framework for Water Management Planning* was the *Strategy for the Protection of the Aquatic Environment (Strategy)*. The Strategy outlines the Alberta government's dedication to protecting, maintaining and improving the condition of the aquatic environment, and encourages cooperation among stakeholders through the development of a Water Management Plan (WMP).

The *Water for Life Strategy* (2003) established the framework for watershed partnerships at regional and local scales. Alberta's Land-use Framework (LUF, Framework)[8] outlines the provinces approach to managing land and natural resources to achieve long-term economic, environmental and social goals. The South Saskatchewan Regional Plan[9] recommends strategies to achieve these goals as part of the Framework. *Stepping Back from the Water*[10] provides guidance for greater riparian protection, and the Alberta Wetland Policy[11] defines the province's approach to maintaining wetlands through the actions of avoidance, minimization and replacement. The Alberta Wetland Policy also acknowledges the value of wetland functions to healthy watersheds. In 2014, the collaborative provincial/municipal Bow River Phosphorus Management Plan was completed to help manage current water quality conditions in the Bow River through control of phosphorus inputs. The process for watershed management planning is outlined in the Guide for Watershed Management Planning in Alberta. [12]

[7] Government of Alberta (GOA) 2014
[8] GOA 2008
[9] GOA 2017
[10] ESRD 2012
[11] GOA 2013
[12] GOA 2015a

At the Municipal level, Municipal Development Plans have been updated, Area Structure Plans approved, and open space plans developed. A list of relevant municipal plans, policies and programs is provided in Appendix A.

2.0 PURPOSE, INTENT AND AUTHORITY

The Nose Creek Watershed Water Management Plan provides broad guidance for water management and sets out clear, strategic direction that will result in consistent, specific actions to protect riparian function and improve water quality in the watershed. It is expected that the updated Plan will continue to guide all levels of government, individuals, landowners and non-profit organizations when making land and water management decisions in the Nose Creek watershed.

The updated Plan was prepared under the direction of the NCWP and in collaboration with Alberta Environment and Parks and other watershed stakeholders. Provincial authority to develop and implement recommendations in the Water Management Plan is provided in the *Water Act*[13] and municipal authority is provided partly by the *Municipal Government Act*[14]. Recommendations are consistent with existing Provincial and municipal policies and guidelines[15].

The NCWP will seek renewed support for the updated Nose Creek Watershed Water Management Plan from Alberta Environment and Parks, the Calgary Airport Authority, and the municipal councils of the City of Airdrie, City of Calgary, Rocky View County, and the Town of Crossfield. The Partnership strongly encourages provincial and municipal jurisdictions to integrate the Plan recommendations into existing plans or as stand-alone policies. The recommendations in the Plan apply only to those areas of the municipality located within the boundaries of the Nose Creek watershed. However, the relevance of the Plan may extend beyond the watershed boundary.

3.0 ISSUES, GOALS AND OBJECTIVES

3.1 Issues

Riparian health and function, and water quality have been compromised[16] in the Nose Creek watershed due to:

- Elevated flows from addition of stormwater resulting in streambank erosion and changes to stream channel morphology[17];
- Encroachment by development and agricultural activity (i.e., infilling, channelization, grazing); and
- Alteration and/or elimination of the native plant community and natural features that protect water quality.

[13] *Water Act* Section 9(1)(2)
[14] *Municipal Government Act* 60(1) Section 617
[15] Government of Alberta - Framework for Water Management Planning, Government of Alberta – Water for Life Strategy, City of Calgary/Rocky View County - Intermunicipal Development Plan, Rocky View County/City of Airdrie Intermunicipal Development Plan
[16] Cows and Fish 2001; Cross 1999, 2002
[17] WER 2002; WER 2005

A comprehensive summary of new and emerging watershed issues identified during stakeholder engagement is provided in Appendix B.

3.2 Goal

Protect riparian areas and manage streamflows in the Nose Creek watershed to mitigate impacts of flood and drought, and improve water quality for water users and aquatic life.

3.3 Objectives and Outcomes

Table 1. Summary of Nose Creek Plan objectives and shared desired outcomes for the watershed.

Theme	Objectives	Desired Outcomes
Water Quantity and Stormwater Management	Recommend actions to manage streamflow and water quantity through the practice of integrated stormwater management.	• Degradation of natural hydrology and stream channel morphology is minimized.
		• Through mitigation, the cumulative impacts of urban development on watershed resources are minimized.
Surface Water Quality	Identify appropriate surface water and stormwater quality guidelines.	• Surface water and stormwater quality improve.
	Recommend management actions to improve water quality.	• Water quality condition supports a variety of uses, and aquatic life.
		• The cumulative impact of land use on water quality is minimized.
Riparian Protection	Identify health targets, riparian setbacks, and other management actions that maintain functioning riparian systems in the watershed.	• Local and regional flood and drought mitigation efforts are supported.
		• Contiguous and healthy riparian corridors maintain water quality and support biodiversity.
		• Permanent watercourses are able to naturally meander within their floodplain.
		• Ephemeral and intermittent watercourses are maintained.
		• Wetlands are integrated into development and retained in the watershed.
Groundwater	Recommend actions to better understand, manage, and preserve groundwater.	• Groundwater quality and quantity is protected for users and the aquatic environment.
Biodiversity	Identify measures needed to sustain biodiversity in the watershed.	• Native plants support stable streambanks. • Conditions for fish and aquatic life are improved. • Invasive species are managed appropriately.

3.4 Tools to Achieve the Goals and Objectives

- Water Conservation Objectives (WCO)
- Maximum allowable release rates
- Runoff volume control targets for greenfield developments and areas of redevelopment
- Low Impact Development strategies
- Provincial water re-use guidelines and stormwater use policies
- Water quality guidelines and objectives
- Policies and development setbacks for riparian lands
- Implementation of agricultural Best Management Practices
- Mitigation of impact, consideration for loss, and restoration of natural system function

4.0 STAKEHOLDER ENGAGEMENT

In 2016, the NCWP developed a Stakeholder Engagement Strategy[18] to guide engagement during the update of the Nose Creek Plan in accordance with the Guide for Watershed Management Planning in Alberta[19]. Similar to earlier stakeholder engagement (i.e., 2004-2006; Appendix C), the goal for engagement during the Plan update process was to create and maintain a constructive dialogue with watershed stakeholders to ensure the long-term viability of the Plan.

Engagement Session I was held in May and June 2016. Sixty stakeholders representing municipal government (36), provincial government (6), industry (10) and non-government organizations (8) attended one of three sessions. The objectives were to better understand challenges regarding the implementation of the current Plan, and to identify new and emerging watershed issues. Participants discussed the current state of the watershed, progress on the implementation of the Plan, and challenges and opportunities for watershed management. A summary document of "What We Heard" was prepared following the session.[20] Key highlights from Engagement Session I are summarized in Table 2.

Engagement Session II was hosted in November and December 2016. Forty-three stakeholders attended one of three sessions, including municipal staff (23), provincial staff (1), development industry representatives (14), and non-government organization (5). A follow-up meeting was held with provincial staff from multiple departments. Engagement Session II focused on the discussion of early recommendations proposed for the Plan, as well as identifying solutions to some of the ongoing and new challenges in the watershed. A summary document of "What We Heard" was prepared following the session.[21] Key highlights from the engagement session discussion are provided in Table 2.

In addition to formal engagement with stakeholders, a series of meetings were held with municipal staff in summer 2016 to discuss specific aspects of the Plan update. All feedback was considered by the NCWP in the update of the Plan, along with technical and scientific information.

[18] PESL 2016a
[19] GOA 2015
[20] PESL 2016b
[21] PESL 2017

Table 2. Key discussion highlights from the Nose Creek Plan engagement sessions.

Topic	Discussion Highlights
Engagement Session I	
Support for NCWP goal	• Stakeholders generally support the NCWP goal • More discussion on how to achieve the goal is needed
Collaboration	• A general need expressed to increase communication and networks among municipal staff within jurisdictions and between jurisdictions, and between the NCWP and stakeholders in general
Challenges	• Industry stakeholders expressed concern with the existing 2013 runoff volume control targets, and questioned whether or not the 2017 target was practically achievable. Implementation challenges are related to the lack of provincial policy and guidelines, and limited tools available to achieve targets • Stormwater management in redevelopment areas • Process for wetland compensation and restoration (e.g., multiple levels of review, length of time to make decisions), and general wetland retention • Recognizing the value of ephemeral and intermittent watercourses to overall watershed hydrology and water quality
Monitoring and evaluation tools	• Lack of consistent monitoring programs to support and measure Plan implementation and measure progress • Lack of monitoring data to validate assumptions and the effectiveness of best management practices being implemented
Engagement Session II	
Runoff volume control target	• To address challenges identified with the implementation of the 2017 runoff volume control targets, the implementation date was delayed. This was viewed as a positive. More direction was desired on how to achieve the targets.
Redevelopment areas	• Generally accepted that managing runoff volume and water quality in redevelopment areas is critical to improving watershed condition. Applying runoff volume control targets will create a level playing field for all developments (e.g., greenfield, redevelopment). The scale of redevelopment should be considered. Offsets could be used to achieve targets.
Watershed-scale model	• A watershed-scale model is a useful tool for future forecasting, and for identifying where the greatest benefits to water quality can be achieved.
Wetland integration	• The Alberta Wetland Policy has had unintended consequences. The process is simpler and it is more cost-effective for industry to compensate for wetland loss than to retain wetlands. • Generally accepted that there are benefits to retaining wetlands in new developments, but only if they can be integrated into stormwater management plans. Wetlands are becoming hydrologically isolated in urbanizing areas as landforms change and water is redirected. Current policies and regulations prevent stormwater from being directed to a wetland. • More guidance is sought regarding wetland values (high valued wetlands should be protected) and wetland integration in developments.
Ephemeral and intermittent watercourses	• Need to be properly defined and identified. They contribute to connectivity, open space, better water quality, and reductions in runoff volume. They can act as emergency water drainage routes during extreme events. • Challenges to maintaining these watercourses include site grading and road networks. Strategies to maintain them included MR vs ER designation, and early identification in the planning process.

5.0 ROLES AND RESPONSIBILITIES

The management of land and water resources in the Nose Creek watershed is a shared responsibility and requires collaboration among multiple levels of government, industry, non-government agencies landowners and residents. The successful implementation of this Plan will be achieved when stakeholders recognize and accept their individual or shared responsibility for addressing the collective watershed goals and objectives that are established. The general roles and responsibilities of key stakeholders in watershed management are described below. A list of applicable legislation, policy, plans, and guidelines is provided in Appendix A.

5.1 Nose Creek Watershed Partnership

The Nose Creek Watershed Partnership encourages the implementation of the Nose Creek Plan by all partners and stakeholders to achieve desired watershed outcomes. The Partnership aims to:

- Develop and provide common watershed-scale resources (e.g., tools, maps, information) that support the implementation of recommendations across the watershed;
- Identify and address data gaps (e.g., monitoring, new science);
- Report on watershed condition (e.g., How are we doing?) as a way to measure progress in Plan implementation; and
- Support collaboration, education and stewardship in watershed management (e.g., inter-municipal share-forums, workshops).

5.2 Municipal Government

Municipalities in the Nose Creek watershed include Rocky View County, City of Airdrie, The City of Calgary, and the Town of Crossfield. Under Part 17 of the *Municipal Government Act* (MGA), municipalities have responsibilities in planning, regulating, subdividing, and developing land in Alberta. They have authority to create planning and regulatory documents that prescribe how the land will be developed, including statutory plans that describe planning policies and types of land uses permitted. Agricultural Service Boards (ASBs) are part of the rural municipal governance structure. The ASB is responsible for administering and developing programs to compliment Provincial legislation, including the *Agricultural Service Board Act*, the *Weed Control Act*, the *Agricultural Pests Act*, and the *Soil Conservation Act*. Many municipalities also support programs, services and education initiatives that promote stewardship of watershed resources. The Nose Creek Plan should be integrated into municipal policy and planning frameworks.

5.3 Provincial Government

Alberta Environment and Parks - AEP has a legislated mandate to manage air quality, water resources, waste management, cumulative effects, provincial Crown (public) lands, the bed and shore of naturally occurring waterbodies, and fish and wildlife resources. AEP is responsible for legislation and polices relevant to watershed management, including Alberta's *Water Act*, the *Environmental Protection and Enhancement Act* (EPEA), the *Public Lands Act*, and the Alberta Wetland Policy. Water Conservation Objectives (e.g., objectives set within a range of natural variability to meet needs of a variety of end uses) are established by AEP under the *Water Act* in Water Management Plans. AEP provides input into the development of water and watershed

management plans. AEP may develop policies and guidelines to support the implementation of the Nose Creek Plan, and ensure that decisions are made (e.g., EPEA and *Water Act* approvals) in alignment with the goals and outcomes set out in the Plan.

Alberta Health - Alberta Health sets guidelines for recreational water quality and issues health advisories if guidelines are exceeded. Alberta Health Services provides environmental services to the public, including the analysis of private drinking water quality. This is particularly important for rural residents reliant on groundwater for household use

Alberta Municipal Affairs (AMA) – Administers the MGA and assists municipalities to provide accountable local government to Albertans. To ensure appropriate safety standards for the construction and maintenance of buildings and equipment, the Safety Codes Council supports the administration of the *Safety Codes Act.* The *Safety Codes Act* has implications for water re-use and stormwater use in the Nose Creek watershed (e.g., below-ground water storage, water quality that is fit-for-purpose).

5.4 Federal Government

The *Canada Water Act* enables cooperation between federal and provincial governments to regulate, apportion, and monitor water resources, and to implement joint programs. The federal government has authority for water quality and publishes water quality guidelines pertaining to the environment, drinking water and recreation. Fisheries and Oceans Canada (DFO) manages and protects fish habitat from harm pursuant to the federal *Fisheries Act* (Section 35(2)). This responsibility is shared with Environment Canada who administers the pollution prevention provisions of the *Fisheries Act*. The Nose Creek Plan recognizes and adheres to federal legislation.

5.5 Industry

Agriculture - Agricultural lands cover a substantial part of the watershed (Appendix J). On deeded lands, sustainable agricultural practices are generally applied to achieve highest production. Standards for agricultural production are outlined in the *Agricultural Operations Practices Act* (AOPA), in municipal Acts, and in industry guidelines (e.g., Alberta Beef Producers, Alberta Wheat Commission).

Development - The Nose Creek watershed is located in a rapidly urbanizing area. Development in the watershed is regulated by the MGA, and corresponding municipal statutory documents (e.g., MDPs, LUBs), policies and processes (e.g., Development Permits). Industry should strive to develop land in a manner that will achieve the shared outcomes outlined in the Nose Creek Plan.

5.6 Watershed Stewardship Groups, Non-Government Organizations and Academia

As partners in the *Water for Life Strategy*, Watershed Stewardship Groups have a role in watershed management planning, the implementation of best management practices (BMPs) and education and outreach programs. Non-government organizations support watershed management and stewardship efforts through planning, environmental condition monitoring and evaluation, and education initiatives. Universities and research institutes provide essential data

and perspective on emerging watershed issues, and environmental conditions by undertaking primary research. Academia may identify and fill research needs, as well as develop tools that may be used to address data and knowledge gaps.

6.0 RECOMMENDATIONS

The recommendations in this Plan are organized under the following headings:

6.1 Administration
6.2 Water Quantity and Stormwater Management
6.3 Surface Water Quality
6.4 Riparian Protection
6.5 Groundwater
6.6 Biodiversity
6.7 Implementation

Additional background information related to the Nose Creek Watershed Water Management Plan recommendations is compiled in the Appendix.

6.1 Administration

6.1.1 Recommendations to Support Administration

Adoption

6.1.1 a The goal, objectives and desired outcomes in the Nose Creek Watershed Water Management Plan should be adopted by each municipal council and supported by Alberta Environment and Parks.

Governance

6.1.1 b Recommendations should be considered in the development and update of municipal and provincial policies, procedures, and planning and development standards and guidelines. These documents may include Municipal Development Plans, Regional Policy Plans, Area Structure Plans, Outline Plans, Redevelopment Plans, and as conditions in review processes.

6.1.1 c An Inter-municipal Team should be formed to work together to aid with implementation. This may include members of the NCWP Technical Team, but should be expanded to include more departments and sections within each jurisdiction.

6.1.1 d NCWP Board and Technical Team members should continue to work with their respective colleagues in each jurisdiction to implement the Plan and achieve desired outcomes according to each jurisdiction's priorities. These "internal working groups" may include staff from various departments or sections (e.g., engineering, planning, public works, parks and/or water services) as needed.

Plan Review

6.1.1 e The NCWP should undertake an annual review of the Nose Creek Plan implementation progress to evaluate whether the desired results of the Plan are being achieved.

6.1.1 f Amendments to the Plan may be made periodically by consensus of the Nose Creek Watershed Partnership. Minor changes should be made at the discretion of the NCWP; fundamental changes (e.g., targets) should be brought to municipal councils. The Plan should remain adaptive and flexible to respond to new information as it becomes available.

Communication with Stakeholders

6.1.1 g External focus group sessions should be hosted, where members of the Partnership, industry and other stakeholders come together to discuss the implementation of the Plan recommendations. Each stakeholder group should establish an internal process to support the deliverables of the Plan.

6.1.1 h The NCWP website should be redesigned. Information relating to each of the Plan areas should be posted and the site should be updated regularly, at least quarterly. Additional communication tools should be considered, including website, newsletters, workshops, social media, field days and demonstrations, surveys and signage.

Implementation

The following recommendations provide general strategies to support Plan implementation. The Nose Creek Plan Implementation Guide, organized by the main themes addressed in this Plan, was developed to provide additional guidance with respect to implementation actions, jurisdiction roles, responsibility and priorities.[22]

6.1.1 i All Partners having a role in Plan implementation (Section 5.0) should review the recommendations and prioritize actions according to the guidance provided in the implementation guide. Some of the recommended actions may be accomplished by individual partners, while other actions may be undertaken collectively.

6.1.1 j Partners should continue to contribute to the NCWP's core operational budget requirements to support the implementation of the Plan. In-kind support, by way of staff time for Board and Technical Team representation should continue.

6.1.1 k The NCWP should seek additional funding opportunities (e.g., grants) or inkind support to support the implementation of the Plan priorities (Appendix K).

6.1.1 l Products developed by individual jurisdictions (e.g., reports, maps, general learning) that support implementation of the Plan should be shared, if possible, to minimize costs, provide consistency to approach, avoid duplication of work, and build on successes.

[22] PESL 2018

Monitoring and Reporting

6.1.1 m Indicators of watershed condition should be monitored to support the implementation of the Plan. A monitoring program and appropriate budgets should be developed through working teams assigned to each indicator (Appendix D). These indicators should be periodically reported in a document evaluating the state of the watershed and used to update progress toward achieving desired outcomes. The report can be used to communicate watershed condition to stakeholders and the community, and to support future updates of the Plan.

Additional monitoring recommendations are made in the following sections.

6.2 Water Quantity and Stormwater Management

6.2.1 Background

The natural hydrology of the Nose Creek watershed has been altered through time by changing land management practices. Urban growth and country-residential developments have increased impervious cover, compacted subsoils, drained or filled-in depressions or wetlands, and eliminated natural vegetation. These practices generate higher rates and volumes of stormwater compared to pre-development conditions.[23] More than 137 stormwater outfalls currently direct water from urban developments to Nose and West Nose creeks.[24]. The addition of stormwater to the creeks alters peak flow characteristics and increases streamflow. Higher streamflow increases streambank erosion, alters channel morphology, increases sediment transport, and degrades water quality and aquatic habitat (Figure 2). Prolonged, elevated streamflow threatens infrastructure (e.g., pathways, bridges and culverts) and public safety in the watershed at a substantial cost to municipalities and residents. Poor water quality in the watershed is observed particularly in older developments where stormwater infrastructure (e.g., ponds, wetlands, oil/grit separators) is minimal or absent (Refer to Section 6.3).[25]

[23] Chithra et al. 2015; van Duin and Garcia 2008
[24] Sixty-three outfalls in Calgary, fifty-one outfalls in Airdrie, and five outfalls in Rocky View County drain to Nose Creek. Twenty-two outfalls drain to West Nose Creek.
[25] PESL 2014

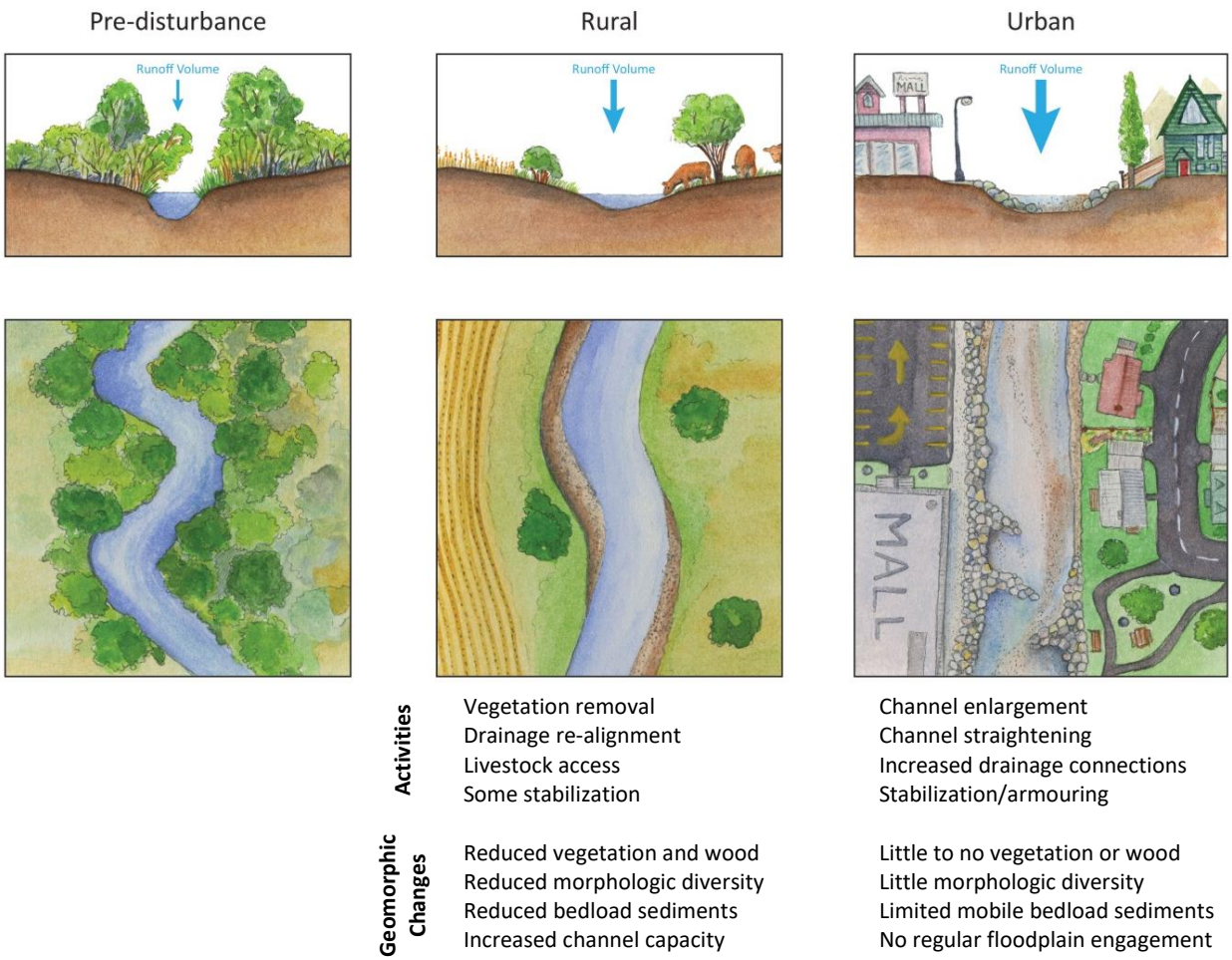

Figure 2. The impacts of typical urbanization on Nose and West Nose creeks (adapted from Vietz et al. 2016).

A hydrologic and hydraulic analysis of stormwater impacts on stream morphology was completed for West Nose Creek.[26] It was demonstrated that the urbanization of the West Nose Creek watershed led to an artificial increase in catchment area by a factor of 5 to 6. The result was a widening and deepening of the stream channel in the lower reaches. The study found that peak flows and base flows increased as a result of urbanization. The combination of large impervious areas, compacted soils, and artificial precipitation from lawn watering or input from leaking water mains, led to an exponential increase in runoff compared to pre-development conditions[27]. Similar impacts were noted in a more recent study. Stormwater inflows may increase the 1:20 year peak discharge by a factor of 3, and the 1:2 year discharge by a factor of 8.[28] These local observations highlight the unique hydrology in the Calgary area where pre-development runoff volumes were extremely low, especially for the smaller, frequent events.

[26] West Nose Creek Stream Corridor Assessment (WER 2002)
[27] WER 2002
[28] The City of Calgary 2017 draft

Instream Flow Needs (IFNs)[29] investigations were undertaken to inform water conservation objectives (WCOs)[30] and upper streamflow limits for Nose and West Nose creeks (PESL 2008). The upper limit is important to provide for flood control and protect the creeks from excessive morphological change. Continued effort to manage high streamflow in Nose and West Nose Creek is necessary as urbanization of the watershed continues at a rapid pace. The management of streamflow in the watershed will require a combination of traditional and innovative stormwater management strategies.

High streamflows generated from stormwater can effectively be managed by

- Setting water conservation objectives and runoff volume control targets
- Reducing runoff volumes through improved development design
- Incorporating a combination of conventional and green infrastructure in developments
- Water re-use and stormwater use
- Maintaining and restoring natural morphology of creek corridors (Section 6.3)
- Retention of natural riparian lands (i.e., wetlands and ephemeral and intermittent streams) in rural areas (Section 6.4)
- Retention or creation of altered riparian lands in urban development (Section 6.4)

6.2.2 Recommendations for Water Quantity (General)

Hydrologic/Hydraulic and Water Quality Model

6.2.2 a Collaborate with partners to develop a watershed-scale predictive model to understand the consequences of alternative management actions on hydrological/hydraulic, ecological, economic and social systems. The objectives of the model are to:

i. Measure and predict changes in watershed hydrology through time;
ii. Understand the potential effects of climate change on hydrology and water quality;
iii. Understand the importance of wetlands and aquifers to water storage;
iv. Understand the importance of ephemeral and intermittent streams to maintaining streamflow and water quality;
v. Determine the impact of water allocation and use on streamflow in the creeks;
vi. Better understand the interaction among existing communities, recently built communities, and future development in relationship to Nose and West Nose creeks, from a hydrologic/hydraulic, water quality and fluvial-morphological perspective;
vii. Evaluate the ability of the runoff volume control targets to support an appropriate flow regime, addressing greenfield and redevelopment hydrology; and
viii. Refine water conservation objectives, runoff volume control targets, and water quality objectives.

6.2.2 b Implement a water monitoring program to populate the hydrologic/hydraulic and water quality model with current, comprehensive data, including streamflow and water quality

[29] WER 2004; WER 2005; Instream needs are defined as the quantity and quality of water required to satisfy the instream hydrological process demands and to protect river ecology and riparian environments. See glossary for full definition.
[30] GOA 2014. See glossary for definition.

(this may include groundwater and soil moisture data, as needed). Refer to 6.3 for more detail regarding a standardized water monitoring program.

6.2.2 c Initiate an erosion monitoring program to establish baseline conditions, better understand erosion processes and channel migration, and to refine the present method of delineating meander belt needs. The results of long-term erosion monitoring should be assessed for trends in erosion, sedimentation, and channel enlargement (e.g., increase in creek width and/or channel incisement).

Water Conservation Objectives

6.2.2 d Update information regarding surface water licences, allocations, and use in the watershed to inform the model. Include detailed water withdrawal information (i.e., actual withdrawal volume, timing of withdrawals).[31]

6.2.2 e The low-flow water conservation objective (WCO) is either 45% of the natural flow, or the existing instream objective increased by 10%, whichever is greater at any point in time.[32] Based on the current instream objectives in the Nose Creek watershed, the WCO for Nose Creek is either 0.094 m^3/s (3.3 ft^3/s) and 0.062 m^3/s (2.2 ft^3/s) for West Nose Creek and McPherson Coulee or 45% of the natural flow, whichever is greater at any point in time.[33]

6.2.2 f Review the application and relevance of the current low-flow water conservation objectives (6.2.2 e) by applying the hydrologic/hydraulic and water quality model developed for the watershed. Evaluate low-flow water conservation objectives, considering

i. Morphological changes to Nose and West Nose creeks,
ii. Updated information regarding water licences, use and allocation, and
iii. Options that would satisfy an interim flow environmental objective.

Refine the WCO as determined through detailed analysis.

6.2.2 g Manage high (i.e., 1:2 year to 1:5 year) flows to minimize changes to the morphological characteristics of the creek channels in the upper reaches of Nose and West Nose creeks through the implementation of the integrated stormwater management recommendations (Section 6.2.3).

6.2.3 Recommendations for Integrated Stormwater Management

Stormwater management strategies for greenfield developments, areas of redevelopment, and internal drainage areas are recommended in the following sections. Water management in urban areas requires an integration of end-of-pipe solutions, low impact development, and green infrastructure strategies to achieve sustainable outcomes.

[31] Water use information was compiled in the Nose Creek IFN Study (WER 2005)
[32] Consistent with the water conservation objective recommendation in the South Saskatchewan River Basin Water Management Plan (Alberta) for tributaries in the Bow River sub-basin (AENV 2006).
[33] The instream objective currently used by AEP for Nose Creek is 0.085 cms (3 ft^3/s) and 0.057 m^3/s (2 ft^3/s) for West Nose Creek and McPherson Coulee.

Maximum Allowable Release Rate

6.2.3 a To achieve intermediate and high flow instream objectives, the Maximum Allowable Release Rate should be 0.99 L/s/ha on West Nose Creek and to 1.257 L/s/ha on Nose Creek, based on gross catchment area.[34]

Runoff Volume Control Target

Runoff volume control targets are applied to better match predevelopment streamflow hydrology, to minimize impacts to stream channel morphology, and to improve water quality. Predevelopment runoff volumes for Nose Creek and West Nose Creek amounted to about 6.1 mm and 9.6 mm (April-October), respectively. Average precipitation at the Calgary International Airport for the period April through October is about 350 mm (based on Environment Canada's climate normals). Predevelopment runoff volumes, therefore, represented about 2% of total rainfall volumes (April-October)[35].

The runoff volume control targets in the Nose Creek Plan[36] were established with the understanding that the targets would still likely result in: a near doubling of stream width, lower habitat suitability for aquatic life, unstable streambanks, degraded riparian areas, and limited protection for existing infrastructure upstream of the Calgary City Limits.[37] The impacts were expected to be greater in Calgary as many of the older communities were built without runoff volume controls. The targets apply at the time of land use designation to all new developments without a previously approved drainage plan. The planning stage varies by jurisdiction.

During the Stakeholder Engagement sessions, there was discussion regarding the ability of new developments to meet the 2017 targets without provincial stormwater use and water re-use policies and performance criteria in place to support innovative development designs. The following recommendations reflect these limitations.

6.2.3 b The implementation date for the 2017 runoff volume control target for Nose Creek (11 mm) and West Nose Creek (17 mm) should be delayed, and the current 2013 targets should be maintained according to Table 2. The delay addresses current implementation challenges, and allows time to:

i. Advance Alberta's Water Re-use and Stormwater Use Policy that will provide clear and unified direction from the Government of Alberta;
ii. Develop performance criteria for stormwater use that will be based, in part, on the results of the study "Evaluating Microbial Risks and Performance Criteria for Safe Management of Stormwater and Rainwater Re-use";
iii. Advance the watershed-scale hydrologic/hydraulic/water quality model to evaluate streamflow and stormwater management strategies;
iv. Advance understanding of the fluvial morphology of Nose Creek and West Nose Creek; and
v. Implement the monitoring program (described in Section 6.3) to measure changes in stream channel morphology and water quality through time.

[34] Nose Creek Basin IFN Study, Table 8 (WER 2005)
[35] WER 2006
[36] PESL 2008
[37] van Duin and Garcia 2008

Table 2. Updated implementation schedule for reduction in runoff volume control targets.

Implementation Date	Runoff Volume Control Targets			
	2007	Jan 2010	Jan 2013	Jan 2017 Delayed to Jan 2021
Nose Creek mainstem	90 mm (50 mm)[z]	30 mm	16 mm	11 mm
West Nose Creek	90 mm (50 mm)[z]	50 mm	26 mm	17 mm
% Precipitation Volume Capture	75%-85%	85-90%	93-95%	95-97%
% Increase in Channel Width	~100-200 %	~100%	~50%	0-25%
Impacts of Runoff Volume on Creeks	High	High	Moderate	Low

[z] The 50 mm runoff volume control target applied to country residential developments and low density industrial, commercial and institutional developments.

Implications: Delaying the implementation of the 2017 target, will likely result in the continued degradation of Nose and West Nose creeks in terms of stream widening, aquatic habitat degradation, streambank erosion, and riparian health, and will provide limited protection for existing infrastructure.

The 2013 runoff volume control target represents a 93-95% on-site capture of average annual rainfall (April to October) for new developments. In a dry year, the runoff volume to Nose Creek and/or West Nose Creek is expected to be less, while in a wet year, the runoff volume may be higher, as long as the long-term median equals the above targets.

6.2.3 c Continue to apply the 2013 runoff volume control targets. The targets should apply to all new developments without a previously approved drainage plan (for the catchment area draining to a stormwater pond or constructed wetland). The targets should be applied when land use is defined or designated, as per each jurisdiction zoning process (Table 3). Each partner should evaluate the application of runoff volume control targets on a site-specific basis with considerations to Plan goals and objectives. Impacts should be addressed and opportunities for innovation pursued.

Table 3. Planning stage associated with land use designation for each municipality in the Nose Creek watershed.

Municipality	Planning Stage	Stormwater Document
Airdrie	Neighbourhood Structure Plan	Master Drainage Plan
Calgary	Outline Plan	Staged Master Drainage Plan
Rocky View County	Land Use Planning and Re-designation / Subdivision Plan	Sub-catchment Master Drainage Plan/Stormwater Management Plan

6.2.3 d The 2013 runoff volume control target will continue to be applied until additional tools are available to meet future targets (i.e., 11 mm and 17 mm). An annual review of progress should include the status and availability of supporting policy, performance

criteria, hydrologic/hydraulic and water quality model, and other additional, relevant studies (e.g., water quality and erosion monitoring, fluvial morphology study).

6.2.3 e Evaluate options to eliminate, reduce, or mitigate the need for relaxations of the runoff volume control targets as part of the development approval process. Implement the preferred options.

Redevelopment Areas[38]

The practice of redevelopment is increasing in urban centres as cities seek ways to manage overall urban footprint, minimize environmental impacts associated with growth, and more effectively utilize existing infrastructure. While there are multiple benefits to redevelopment, green space tends to be absorbed by new buildings and infrastructure during the process. For example, infills tend to be much larger homes and/or buildings compared to the original square footage of the older home or building it replaced. Impervious surface area may increase substantially (e.g., in some jurisdictions lot coverage of single detached infills have increased from 25% to 45-50% and, for developments like row houses, coverage is upwards of 60%). Furthermore, large single lots are being subdivided, resulting in increased lot coverage. Increased impervious areas result in larger stormwater runoff volumes.

Runoff volumes generated by older communities should be addressed to effectively manage stream flow and water quality in the Nose Creek watershed. Most older neighbourhoods (pre-2007) do not have associated runoff volume controls. Current annual runoff volumes in these neighbourhoods may range from about 115 mm in residential neighbourhoods (assuming 40% total imperviousness and 25% directly connected imperviousness) to about 240 mm in commercial/industrial areas (assuming 75% total and directly connected imperviousness), respectively (*The City of Calgary User Manual for Water Balance Spreadsheet, Version 1.2, Appendix D: Design Tables and Figures, Table D.3).* Some areas may have TSS removal criteria (i.e., 85% removal of TSS for particle size greater than or equal to 50 µm) and historic release rates (Area Master Drainage Plans (MDPs)) may apply.

6.2.3 f Strategies should be developed to retain open space/green space in redevelopment areas.[39]

6.2.3 g Evaluate options needed to manage stormwater for redevelopment in established communities using the Nose Creek watershed hydrologic/hydraulic and water quality model. Implement the preferred options.

6.2.3 h Establish redevelopment water quantity and quality objectives and an approach to stormwater management using results from the hydrologic/hydraulic and water quality model analysis.

6.2.3 i Areas proposed for redevelopment should strive to reduce the effects of increased impervious surface areas, where possible. Studies suggest that impervious surface areas of greater than 10% cause substantial impairments to water quality and stream health.[40]

[38] Redevelopment: If an area can be subdivided, it is considered a greenfield development.
[39] As per current legislation, including the MGA.

6.2.3 j Use Low Impact Development (LID) practices such as absorptive landscaping, green roofs, soil cells, and cisterns to manage runoff volumes in redevelopment areas that are constrained by space (e.g., lot-level residential, commercial/industrial areas). At all times, existing natural areas should be preserved.

6.2.3 k Community-scale retrofits to existing stormwater infrastructure (e.g., introduction of oil/grit separation, bioretention, storm ponds) should be made to improve water quality. Acquisition of public space for community-scale retrofits should be explored.

Internal Drainage Areas

Internal drainage areas (IDAs) are important to the overall hydrological regime in the watershed. Key IDAs are located in the eastern part of the Nose Creek watershed, and in the western part of the West Nose Creek sub-basin (Appendix J). These areas have unique drainage characteristics that contribute significantly to groundwater recharge and evapotranspiration processes. Precipitation in the IDA is generally stored in wetlands and "prairie potholes" before infiltrating into the ground to replenish local groundwater reserves. The groundwater contributes base flow to Nose and West Nose creeks, maintaining stream flow during drier summer months and groundwater for drinking water purposes.[41] Special applications of the runoff volume control target in the internal drainage areas apply since water discharged from the IDAs typically does not flow overland to the creeks. Increasing overland drainage may reduce groundwater recharge, and contribute to streambank erosion and further widening of the downstream reaches of Nose and West Nose creeks.[42]

The Internal Drainage Area Policy[43] was approved by all partners[44] so that these areas remain isolated from the effective watershed area to the fullest extent possible.

6.2.3 l Continue to integrate internal drainage areas into existing and future policies to minimize discharges from these areas, and to protect property. Apply the Internal Drainage Area Policy requirements to undeveloped areas that are currently not serviced by stormwater infrastructure.

The Policy requirements allow a discharge to Nose and West Nose creeks during prolonged rainfall or snow melt events and thus minimize the need for evaporation ponds in these areas. Table 4 provides the recommended runoff volume control targets and the maximum allowable release rates for Nose and West Nose creek IDAs.

Implementation of the 2019 internal drainage areas runoff volume control target should be delayed, and the current 2015 target should be maintained according to Table 4. Continue to apply the 2015 runoff volume control target in internal drainage areas until additional tools to meet future (2019 and 2023) targets are available (consistent with recommendation 6.2.3 d).

[40] WER 2003; Hilderbrand et al. 2010; Fitzgerald et al. 2012; Chithra et al. 2015
[41] Hayashi 2004; Hayashi and Farrow 2014
[42] van Duin and Garcia 2008
[43] NCWP 2015
[44] The Internal Drainage Areas Policy was established in January 2015 by the NCWP to clarify recommendations put forward in the 2007 Nose Creek Plan. Municipalities have been incorporating the IDA policy in all submitted Master Drainage Plans.

Table 4. Recommended runoff volume control targets and maximum allowable release rates for internal drainage areas.

	Average Runoff Volume Control Target (mm)			Maximum Allowable Unit Area Release Rate (L/s/ha)
Date of Implementation	**2015**	**2019**	**2023**	**2015**
Nose Creek	16	11	6.1	1.257
West Nose Creek	26	17	9.6	0.99

The Nose Creek Internal Drainage Areas Study[45] identified that the sizing of infrastructure and the timing of discharges cannot be equated to a specific single "extreme" event as described in the NCWWMP, (e.g., a 24 hour 1:100 year event), but needs to consider the accumulation of runoff over time. Therefore, a continuous water balance simulation is the only appropriate method for the sizing of the drainage infrastructure and for demonstrating that the average annual volume control targets have been satisfied.

Refer to Appendix E for the complete Internal Drainage Area Policy.

6.2.3 n The Alberta Wetland Policy should be amended to include the consideration of wetland integration in stormwater management for urbanizing areas, and the true valuation of wetlands (refer to Section 6.4.4).

Low Impact Development

Low-impact development (LID) strategies can reduce stormwater runoff volume and improve water quality.[46] A development is considered 'low impact' when the post-development runoff conditions mimic the pre-development rates and volumes for smaller storm events and severe, infrequent events. This is typically achieved through reduction in the level of imperviousness and integration of 'green infrastructure' and stormwater capture and use in subdivision design. In some cases, precipitation captured at the source can be returned to the original, natural hydrologic pathways through infiltration and evapotranspiration. Urban design cannot rely solely on existing and traditional strategies if watershed objectives are to be achieved.

6.2.3 o Low impact development practices should be incorporated, wherever feasible, in all new developments and/or areas of redevelopment according to best available science in order to meet the runoff volume control target.

Low Impact Development practices should include, but not be limited to

- a reduction in hard surface area
- green roof systems
- stormwater capture and use
- absorbent landscaping

[45] MPE 2013
[46] Credit Valley Conservation and Toronto Region Conservation 2010

- adoption of compact development forms and alternative site development standards[47]

6.2.3 p Install rain barrels in all new developments where possible. Clear instructions on the role of rain barrels and the proper use of rain barrels should be available.

6.2.3 q Continue to work with others interested in the field of Low Impact Development (e.g., the Alberta Low Impact Development Partnership (ALIDP))[48] to promote wider adoption of LID practices in the watershed.

6.2.3 r Work to improve the timeliness and reduce the uncertainty of the approval process for LID projects under the *Water Act, Building Code,* and others that are necessary to achieve stormwater targets, by increasing flexibility.

6.2.3 s Performance monitoring should accompany the implementation of LID pilot studies. Monitoring should include the effectiveness of the practice to reduce runoff volumes and improve water quality, as well as other considerations (e.g., cost to implement, maintenance). Results of the performance monitoring should be shared with partners and the professional community to evolve and optimize the implementation of LID.

Monitoring

6.2.3 t Monitoring of stream erosion and other ecological indicators, and additional research regarding LID practices, should continue to better inform future stormwater management decisions.

Water Re-use and Stormwater Use

Municipal stormwater use, mainly for irrigation, is one way new developments in the Nose Creek watershed can meet runoff volume control targets. The quality of water for re-use and stormwater use should be "fit-for-purpose". Water quality investigations should include pH, conductivity, presence of pathogenic bacteria, and other constituents to ensure public health and minimize impacts to vegetation[49]. Provincial policy guidelines for water re-use and stormwater use are currently being developed and will be available in the next few years.

Until the water re-use and stormwater use policy is available, a licence must be granted by AEP to divert stormwater for use.

[47] Low impact development principles and practices can be found in The City of Calgary's Low Impact Development Guidelines Module 1: Geotechnical and Hydrogeological Considerations (EBA 2014); Module 2: Bioretention and Bioswales (MPE and Kerr Wood Leidal 2016); Module 3: Green Roofs (Struck et al. 2014); Module 6: Permeable Pavement (Tetra Tech EBA Inc. 2015)). Also refer to the Stormwater Source Control Practices Handbook (The City of Calgary 2007).
[48] https://alidp.org/
[49] ESRD 2014

6.3 Surface Water Quality

6.3.1 Background

Water quality is an indicator of watershed condition as it reflects local climate, geology, and land use. The accumulated impacts of point (end-of-pipe discharge) and non-point (diffuse) source pollution can contribute to water quality problems downstream.

Various water monitoring programs have documented the poor quality of water in Nose and West Nose Creek since the 1980s[50], with slightly better water quality observed in West Nose Creek. For the period 1999-2001, the percentage of Nose Creek samples that complied with water quality guidelines was low, particularly for nutrients (e.g., total phosphorus: 4% compliance; total nitrogen: 7% compliance)[51], with slightly better results for West Nose , Creek. From 2009 to 2013, the main water quality challenges were high phosphorus, salt and total suspended solids concentrations, and high fecal coliform bacteria counts. Phosphorus continues to exceed the water quality objectives, and dissolved oxygen occasionally reaches acute and chronic levels for aquatic life.[52] The City of Calgary maintains an ongoing monitoring program at Nose and West Nose creeks. For the reporting period 2012-2014, overall water quality condition was reported as "fair" at Nose Creek[53] and West Nose Creek[54] at the mouth; individually, total phosphorus and total nitrogen both rated poor.

Excessive phosphorus concentration in surface water stimulates the growth of algae and aquatic plants, ultimately degrading water quality for human use and aquatic life. Sources of phosphorus to Nose Creek and West Nose Creek include inorganic fertilizers, livestock manure, phosphate detergents, urban runoff, atmospheric deposition, and naturally occurring phosphorus in soil and creek sediment. The seasonal release of treated effluent from the Town of Crossfield also contributes a substantial phosphorus load to Nose Creek, annually.

The Bow River Phosphorus Management Plan (BR PMP or PMP)[55] outlines strategies to reduce phosphorus loading to the Bow River from multiple sources. The PMP identified Nose Creek as a tributary to the Bow River that contributes to the overall phosphorus load. To support the PMP implementation, Total Maximum Loads (TMLs) may be explored as a way to reduce phosphorus loading to surface water in the Nose Creek watershed. A TML is a limit on pollution, developed when streams or other waterbodies do not meet water quality objectives. TMLs may also be used to reduce sediment loads and other contaminants of interest in Nose and West Nose creeks.

A continued cooperative effort is needed to improve water quality in the Nose Creek watershed. The following section summarizes existing surface water quality guidelines and objectives, encourages the development of stormwater quality guidelines and recommends improved monitoring to meet water quality goals. In addition, recommendations address the need for added protection of natural features in the watershed to improve water quality conditions.

[50] Schonekess 1981
[51] Cross 2002
[52] Palliser Environmental Services Ltd. 2013
[53] Nose Creek at the mouth rated Fair with an index value of "60" using the CCME Water Quality Index.
[54] West Nose Creek at the mouth rated Fair with and index value of "67" using the CCME Water Quality Index.
[55] Government of Alberta 2014

6.3.2 Recommendations for Surface Water Quality

Water Quality Guidelines and Objectives

Surface water quality guidelines are developed by the province and local objectives for Nose and West Nose creeks were established in the Bow River Basin Watershed Management Plan, Phase I, Water Quality Objectives (updated in the Phase II Plan).[56] The City of Calgary and the NCWP have periodically monitored water quality at multiple sites in the watershed. The results of these monitoring efforts were compared to the current objectives (Table 5).

6.3.2 a Surface water quality in Nose Creek and West Nose Creek should meet water quality objectives summarized in Table 4. The water quality objectives reflect Alberta Surface Water Quality Guidelines[57] and BRBC Water Quality Objectives[58] for Nose Creek.

6.3.2 b Total Maximum Loads (TMLs) should be established for total phosphorus and sediment as a mechanism to improve surface water quality. (refer to recommendation 6.3.2 j)

6.3.2 c New recreation guidelines for fecal coliform bacteria in water will be available in 2018 to address human-health risks. The new guidelines will identify acceptable levels of the pathogen *Enterococcus* as a more representative indicator for human health risk (Dr. N. Neumann, pers. comm.). When available, these guidelines should be incorporated into the Nose Creek Watershed Water Management Plan and used to interpret the analytical results of water collected in the watershed.

Table 5. Summary of surface water quality objectives for the Nose Creek watershed identified in the Bow River Basin Watershed Management Plan (adapted from BRBC 2012).

INDICATOR	WATER QUALTIY OBJECTIVES	OPEN WATER SEASON (April-October, monthly data) (Station: Nose Creek at Mouth, unless otherwise noted)	
		BASELINE (1995-2006)[b]	CURRENT (2009 to 2015)[c]
Chlorophyll *a*, mg/m^2	150 mg/m^2 maximum value during open water season[b]	Median: 48 90th Percentile: 136 Maximum: 257 (Site DS Airdrie, 1999-2001)	Not currently monitored
Dissolved Oxygen, mg/L	Acute Daily Minimum: 5.0[a] Chronic 7-d Avg: ≥6.5[a] Spawning: ≥9.5[a]	Median: 7.1 10th Percentile: 4.8 Minimum: 2.3	Median: 8.8 10th Percentile: 6.3 Minimum: 1.6
Nitrate + Nitrite (as N), mg/L	1.5[b] Eliminate levels that cause nuisance aquatic plant growth during the open water season.	Median: 0.500 as nitrate 90th Percentile: 1.408 as nitrate	Median: 0.837 90th Percentile: 1.469
***E. coli* Bacteria, cfu/100 mL**	Meet recreational guideline.[a] No single value to exceed 400 cfu/100 mL or ≤200 cfu/100 mL (geometric mean 5 samples/30 d)	Not reported.	Median: 145 90th Percentile: 1300

[56] BRBC 2012
[57] ESRD 2014
[58] BRBC 2012

INDICATOR	WATER QUALTIY OBJECTIVES	OPEN WATER SEASON (April-October, monthly data) (Station: Nose Creek at Mouth, unless otherwise noted)	
		BASELINE (1995-2006)[b]	CURRENT (2009 to 2015)[c]
Fecal Coliform Bacteria, cfu/100 mL	100[b] No single value to exceed objective at the point of withdrawal.	Median: 350 90th Percentile: 2540	Data not collected.
Pesticides and Degradation Products	Should not exceed CCME guidelines for aquatic life in the river.[d] The CCME guideline for irrigation of sensitive crops is 0.04 µg/L for MCPA and 0.008 µg/L for Dicamba.	1999-2001 exceedence of CCME irrigation guideline (sensitive crops): MCPA: 35%[e] Dicamba: 59%[e]	2015 exceedence of CCME irrigation guideline (sensitive crops): MCPA: 20%[f] Dicamba: 80%[f]
Total Ammonia, mg/L	Should meet provincial guideline for the protection of aquatic life (varies with pH and temperature).[h]	Median: 0.250 90th Percentile: 0.500	Median: 0.450 90th Percentile: 0.450
Total Dissolved Phosphorus, mg/L	0.02[b] Eliminate levels that cause nuisance aquatic plant growth.	Median: 0.020 90th Percentile: (1999-2006 data – as DRP)	Median: 0.030 90th Percentile: 0.141
Total Phosphorus, mg/L	0.05[b] Eliminate levels that cause nuisance aquatic plant growth.	Median: 0.170 90th Percentile: 0.500	Median: 0.129 90th Percentile: 0.246
Total Suspended Solids, mg/L	No guideline.[i] Interim Objective: Improving trend in TSS concentraion through time.	Median: 19.0[g] 90th Percentile: 62.1[g]	Median: 37.8 90th Percentile: 73.8 Median: 27.1[g] 90th Percentile: 63.3[g]
Water Temperature, °C	Should not exceed 22°C at any time or a 7-day mean of 18°C to meet habitat requirements for trout (refer to Appendix I)	Median: 13.10 90th Percentile: 18.91 Maximum: 20.50 Median: 16.6 (2004, hourly) 90th Percentile: 20.9 (2004, hourly) Maximum: 26.2 (2004, hourly)	Median: 11.7 90th Percentile: 18.3 Maximum: 19.8

[a]Environmental Quality Guidelines for Alberta Surface Water (ESRD 2014)
[b]Bow River Basin Watershed Management Plan Phase II (2012)
[c]The City of Calgary data for site Nose Creek at Mouth (2009-2015)
[d]CCME 1999
[e]Cross 2002
[f]N=5, data collected by The City of Calgary
[g]Annual data (Jan-Dec)
[h]ESRD 2014; Refer to Table 1.2 Ammonia guidelines for protection of aquatic life at varying pH and temperature
[i]The instream construction guideline for TSS: **Clear Flow Period**: Max. increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Max. average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 h and 30 d). **High Flow Period**: Max. increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is ≥ 250 mg/L.

Stormwater Quality

Stormwater quality data was collected from outfalls in the Nose Creek watershed from 2014-2016 (Table 6). The study showed that stormwater quality varied by type of runoff (i.e., snowmelt, rainfall), the timing and duration of the event, and by the presence of upstream treatment infrastructure (e.g., storm ponds).[59] Generally, stormwater quality from outfalls (Table 6) is substantially higher in phosphorus and TSS compared to surface water quality objectives (Table 5).

In Alberta, stormwater management practice only began to address the presence of sediments as a contaminant in the Municipal Policies and Procedures Manual.[60] This policy outlines the requirements to prevent or control pollution, and the procedures to determine effluent limits. Generally, sediments (total suspended solids) have been viewed as a proxy for other contaminants (e.g., bacteria, phosphorus); thus, no other contaminants have historically been considered as part of stormwater management design and approval practice.

In view of the exceedance of the provincial Surface Water Quality Guidelines and BRBC Water Quality Objectives for Nose Creek, the NCWP should explore how land use practices, design and operation procedures of stormwater infrastructure should evolve to improve stormwater quality and minimize impacts to receiving waters. Properly sized and designed structural BMPs (e.g., absorbent landscaping, stormponds, cisterns and rain barrels) used to meet runoff volume control targets (Section 6.2) inherently reduce contaminant loadings and can help to attain water quality objectives.

6.3.2 d Explore opportunities to advance the development of stormwater quality guidelines and objectives beyond the current requirement to reduce total suspended solids concentration.

6.3.2 e More extensive and targeted use of LID practices and Best Management Practices (BMPs) should be used to improve stormwater quality from conditions summarized in Table 5 and protect surface water quality.[61] Each municipality should:

i. Develop a Salt Management Plan[62] that outlines key salt management practices and principles;
ii. Follow best salt management practices to prevent over use of de-icing agents;
iii. Construct indoor salt storage facilities that protect surface water and groundwater;
iv. Locate snow storage locations away from creeks, and ephemeral/intermittent streams;
v. Retrofit existing storm sewer infrastructure to include oil/grit separation and/or stormwater retention ponds;
vi. Apply LID strategies provided in Section 6.2 to minimize runoff volume and the transport of pollutants to surface water; and

[59] PESL 2014
[60] Alberta Environment 2001
[61] PESL 2015
[62] Consistent with the Code of Practice for Environmental Management of Road Salts (Environment Canada) (Transportation Association of Canada 2013)

vii. In rural areas, promote on-farm BMPs to reduce transport of nutrients and sediments into waterways.

Table 6. Summary of stormwater quality at select outfalls in the Nose Creek watershed, 2014-2016.

Parameter	Statistic	No Storm Pond		Storm Pond	
		Snowmelt (N=38)	Rainfall (N=65)	Snowmelt (N=5)	Rainfall (N=7)
Conductivity, µS/cm	Median	1155	689	1460	1270
	Minimum	354	123	702	642
	Maximum	2710	4240	2660	2370
Total Phosphorus, mg/L	Median	0.755	0.195	0.446	0.029
	Minimum	0.066	0.013	0.018	0.013
	Maximum	2.200	1.250	2.180	0.110
Total Dissolved Phosphorus, mg/L	Median	0.363	0.041	0.239	0.009
	Minimum	0.017	0.005	0.004	0.002
	Maximum	1.980	0.944	0.553	0.054
Total Nitrogen, mg/L	Median	4.510	3.450	3.390	0.940
	Minimum	2.040	0.520	1.970	0.570
	Maximum	9.300	9.730	9.400	3.950
Total Suspended Solids, mg/L	Median	93	32	22	7
	Minimum	6	2	5	2
	Maximum	926	628	207	19
Fecal Coliform Bacteria, cfu/100 mL	Median	265	1100	139	10
	Minimum	1	1	1	1
	Maximum	126,000	270,000	1040	400

[a]PESL 2017; [b]ESRD 2014

6.3.2 f Identify and upgrade infrastructure where high contaminant loads (i.e., TSS, nutrients, and indicators of human and animal waste) in stormwater is a known problem.

Discharge of Treated Effluent

6.3.2 g The Town of Crossfield releases treated effluent from lagoons to Nose Creek. While this is an approved practice under *EPEA*, the discharge adds a significant volume of poor quality water to Nose Creek and impacts downstream water users. An alternative means for treating and disposing of the effluent should be identified to minimize impacts to Nose Creek.

Monitoring

6.3.2 h Review and update the Nose Creek Long-Term Water Monitoring Strategy[63] to reflect the current water monitoring needs in the watershed. Objectives of the renewed water monitoring program should include:

i. Collection of continuous streamflow and water quality data that can be used for modeling current and future conditions in Nose and West Nose creeks (supports recommendations 6.2.2 a and 6.2.2 b). Site locations should span the watershed

[63] PESL 2009

(refer to Appendix J-2 for a map of historic and current monitoring locations);

ii. Evaluate water quality conditions with respect to established guidelines and objectives; Determine if the NCWP is meeting its goal of improved water quality;

iii. Maintain long-term records to examine trends in relationship to land cover and land use activities in the watershed; and

iv. Report and disseminate findings to the public through the website and state of the watershed reporting.

6.3.2 i Implement the standardized water monitoring program in collaboration with partners.

6.3.2 j Use the results of the long-term water monitoring program to explore Total Maximum Loads for Nose and West Nose creeks by using an appropriate hydrologic/hydraulic and water quality model for the watershed.

6.3.2 k Continue to develop and implement stormwater monitoring programs to better understand trends in quality and volume. Develop and refine stormwater objectives and evolve land use practices and stormwater infrastructure design and operation procedures as new information becomes available.

6.3.3 Recommendations to Protect Natural Features and Improve Water Quality

The preservation of natural features is critical to improving water quality in the Nose Creek watershed. Features include, but are not limited to, natural stream channel morphology, native vegetation, riparian areas (including wetlands, and ephemeral and intermittent creeks), coulees, valleys, and escarpments. Creeks that meander across a floodplain reduce the energy (velocity) of stream flows. This facilitates the attenuation of contaminants in the creek through processes such as filtration, sedimentation, and long term burial. Native vegetation, particularly on steep slopes, reduces erosion by protecting the surface of the soil from rainfall, slowing the velocity of runoff, and maintaining the soil's absorptive capacity. Natural features assist to regulate runoff volume and quality, and also serve as critical habitats for wildlife. In the following section, recommendations are made to preserve stream channel morphology, reduce erosion, and protect escarpments. Recommendations related to the protection of riparian lands, including ephemeral and intermittent watercourses, and wetlands are provided in Section 6.4. Recommendations related to biodiversity are provided in Section 6.6.

Stream Channel Morphology

Channelization of Nose Creek and West Nose Creek has occurred numerous times in the past and has resulted in a substantial loss of overall creek length. Channelization negatively impacts creek systems by simplifying habitat type, reducing riparian area, reducing stream length, and by changing flow levels, velocities and patterns. These changes ultimately result in increased erosion of downstream banks and subsequent increased sediment loading[64]. In addition, channelizing creeks degrades riparian areas when flood waters can no longer reach the floodplain due to downcutting of the channel bed. Loss of riparian function reduces the ability of a creek system to

[64] Alberta Transportation 2001

improve water quality through natural processes of nutrient attenuation, sedimentation and biological uptake.

6.3.3 a To prevent the further loss of channel length and associated ecological functions in Nose Creek and West Nose Creek, there should be no approval for development unless the following is demonstrated:

i. "No net loss" of channel length in Nose Creek, West Nose Creek and associated tributaries;
ii. No degradation of aquatic habitat or riparian areas in Nose Creek, West Nose Creek and associated tributaries; and
iii. Appropriate planning for upgrades to major infrastructure should be undertaken such that impacts to the Creeks are minimized and or mitigated to ensure no net loss.

6.3.3 b Principles of "no net loss" and "no degradation" should be achieved through project relocation and redesign.

6.3.3 c Development applications should include documentation to show how the project considered riparian areas and water quality in the planning process.

6.3.3 d Meander bends should be re-introduced, where possible, to increase riparian habitat, slow stream flows, and improve water quality and fish habitat. Existing meander bends should be protected.

6.3.3 e Restore actively eroding or slumping streambanks using appropriate bioengineering techniques. Where possible, use bioengineering techniques, as opposed to armouring (i.e., riprap) to reduce impacts on riparian health and fish habitat.[65]

Sediment, Erosion and Soils

6.3.3 f Sediment and erosion control measures should be implemented, monitored, and maintained on construction sites to prevent water quality degradation according to the Sediment and Erosion Control Manual[66], or other recognized manuals.

6.3.3 g Where possible, on all new developments and areas designated for redevelopment, effort should be made to maintain existing vegetation:

i. No earthworks should be permitted within 3-5 m of the vegetation drip line to protect root systems;
ii. Re-vegetate stripped areas as soon as feasible, according to the most recent available standards;
iii. Time stripping and grading operations to minimize potential for erosion and sedimentation;
iv. Implement erosion and sediment control measures once stripping and grading of a site has begun (e.g., using temporary seeding or mulches); and

[65] Refer to the Design Guidelines for Erosion and Flood Control for Streambank and Riparian Stability Restoration (The City of Calgary) (http://www.calgary.ca/UEP/Water/Pages/Watersheds-and-rivers/Riverbanks-and-Floodplains-in-Calgary.aspx).
[66] The City of Calgary 2017

v. Conduct clearing, stripping and grading in stages to minimize area of exposed soil.

6.3.3 h To manage soil quality and preserve agricultural lands, adhere to the Procedure for Topsoil Statutory Declaration[67] and established Development Permit processes for soil quality disposal requirements.

Escarpments

6.3.3 i On lands subject to development, regardless of proximity to the creeks, escarpments equal to 15% slope up to 30% slope should be assessed to determine suitability for development, or retained as natural area.

6.3.3 j Development of escarpment slopes equal to or greater than 30% should be avoided by dedicating these lands as environmental reserve, applying development setbacks, or by other means.

6.3.3 k Where land is situated adjacent to or includes the banks of any watercourse, including coulees, ravines, gullies, valleys and where the slope of the bank adjacent to any watercourse is in excess of 15%, buildings or other structures should not be permitted:

i. Where the height of bank is less than 6 m, within 12 m from the top of the bank;
ii. Where the height of bank is between 6 m and 23 m, within a distance that is two times the height of bank, from the top of the bank; or
iii. Where the height of bank is more than 23 m, within 46 m from the top of the bank.[68]

Restoration

6.3.3 l Effort should be made to partner with conservation groups, government agencies and watershed groups to restore the ecological function of Nose Creek, West Nose Creek and their tributaries.

6.3.3 m Restoration projects should be properly designed and allow the natural process of deposition and aggradation to occur in Nose Creek and West Nose Creek. Wherever possible, innovative bioengineering options should be employed to restore streambanks and reduce/prevent further occurrence of erosion.

6.3.3 n Priority sites that should be considered for restoration include

i. Areas that pose a safety hazard to the public due to accelerated erosion,
ii. Areas where hydraulic connectivity, that allows interaction of water between the stream and abandoned channel reaches, have been disconnected, and
iii. Areas impacted by improper management of grazing lands.

[67] Rocky View County Soil Analysis Requirements for Topsoil Statutory Declaration and Development Permit
[68] Rocky View County Land Use Bylaw Section 34 (a).

6.4 Riparian Protection

6.4.1 Background

Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent both at the ground surface and below ground, in the soil structure. These lands are influenced by and/or exert an influence on associated water bodies, which includes alluvial aquifers and floodplains, when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes[69]. In this section, riparian lands include riparian areas associated with lotic systems (flowing water, including perennial rivers and creeks, and ephemeral and intermittent watercourses), and lentic systems (i.e., lakes and wetlands).

As transition zones between the terrestrial and aquatic environment, riparian areas provide a variety of functions that benefit people living in watersheds. Riparian lands protect water quality by slowing the flow of water to facilitate trapping of sediment[70], nutrients[71] and bacteria in vegetation and soils. Riparian vegetation has deep binding roots that hold streambanks together, reducing erosion and sediment transport. Riparian areas and wetlands lessen the impacts of flood and drought by storing and releasing water slowly during the remainder of the year. Overhanging riparian vegetation can moderate water temperature, maintaining cooler water temperatures required for a variety of fish species. Finally, the riparian corridor maintains habitat diversity and allows for improved wildlife species distribution and diversity[72]. While riparian areas generally comprise less than 2 to 5% of the landscape[73] their role is essential to preserving the health of the Nose Creek watershed.

Urban developments, agricultural and recreation activity, and other human activities in the watershed tend to encroach on riparian areas, and limit or eliminate their function in the landscape. Many wetlands have been lost or impaired in the Nose Creek watershed; they are filled in, incorporated into stormwater designs, or encroached upon.

6.4.2 Riparian Health Targets and Thresholds

The Alberta Riparian Habitat Management Society (also known as Cows and Fish) established a health scoring system for Alberta that is based on criteria related to the function of the ecological components within the riparian area (i.e., hydrology, soils and vegetation)[74]. Based on these criteria, sites can be rated:

- Healthy (score 80 or above): riparian area functioning with minor impairment
- Healthy but with problems (score 60 to 79): riparian area functioning, moderate impairment
- Unhealthy (score less than 60): riparian area impaired, little ecosystem function

[69] Clare and Sass 2012
[70] Cooper et al. 1987
[71] Gilliam 1994; Vought et al. 1994; Daniels and Gilliam 1996
[72] Castelle et al. 1994
[73] Fitch et al. 2003
[74] Fitch and Ambrose 2003

At Nose Creek, 53% of riparian areas assessed since 2008 rated unhealthy and 5% of the sites rated healthy.[75] At West Nose Creek, 37% of riparian areas assessed since 2008 rated healthy and 13% of sites rated unhealthy.[76] Poor health scores are mainly attributed to invasive plants, human disturbance and human alteration (Appendix F).

The following health target and threshold apply to riparian lands in the Nose Creek watershed:

Health Target: Riparian areas score 80 or above (i.e., in the "healthy" category).[77]

Health Threshold: Riparian areas score 70-79 (i.e., upper range of the "healthy with problems" category).

Historical channelization measures in certain reaches of Nose Creek and West Nose Creek have impacted natural functions. While these reaches may receive lower riparian health scores, the desired outcome in the watershed remains the same - healthy, functioning riparian lands. Restoration efforts may be needed to achieve healthy ratings.

6.4.2 a Management actions should be taken to improve riparian conditions when scores fall below the threshold rating of 70, where practical, using a priority approach for restoration.

6.4.2 b The City of Calgary should continue to monitor riparian lands according to the Riparian Action Program[78]. Rocky View County and the City of Airdrie should develop a strategy to re-assess riparian lands systematically at benchmark sites (Refer to Appendix F). New monitoring sites should be identified in developing areas.

6.4.3 Recommendations to Protect Riparian Lands (Lotic Systems)

Riparian Setbacks

Since the Nose Creek Plan was first implemented in 2008, municipalities have established riparian setback policies[79], plans and/or land use bylaws.

6.4.3 a Riparian setbacks for permanent watercourses should be determined on a site-specific basis as the greater of the minimum setback (i.e., 30 m or 60 m) (Table 7) and the 1:100 year floodplain width (Figure 3). Additional steep slope setbacks may apply to escarpments having greater than 15% slope (Recommendation 6.3.3 i-k). The setbacks in Table 7 are considered minimum widths and may change at the discretion of municipalities, upon review of additional site information (e.g.,

[75] Cows and Fish 2009, 2014, 2015; Rangeland Conservation Services Ltd. 2014
[76] Cows and Fish 2009, 2014, 2015
[77] Aligns with municipal policies, SSRP objectives and, the Bow River Water Management Plan Phase II (BRBC 2012).
[78] The City of Calgary 2017
[79] Calgary: Wetland Conservation Plan (2004), Environmental Reserve Setback Guidelines (2007), Riparian Strategy (2014); Rocky View County: Policy 419 - Riparian Land Conservation and Management (2010), Policy 420 - Wetland Conservation and Management (2010); Airdrie: *draft* Wetland Policy

biophysical assessments). Jurisdictions without a riparian setback policy are encouraged to adopt or adapt an existing partner policy.

Redevelopment sites should adhere to the minimum setback where possible, but will be evaluated based on current site conditions.

Table 7. Minimum riparian setbacks for the Nose Creek watershed. Measurements are taken at top of bank unless otherwise specified. For riparian setbacks applied to ephemeral and intermittent watercourses, refer to recommendation 6.4.3 k. For wetland setbacks, refer to recommendation 6.4.4 b.

Waterbody	Substrate	Minimum Setback	Modifiers
Nose Creek Upstream of the confluence with West Nose Creek **West Nose Creek** **All other permanent creeks**	Glacial till	30 m	If the average cross fall slope of a defined setback area is more than 5%, increase the width of the setback by 1.5 m for every 1% of slope greater than 5%
	Coarse textured sands and gravels, alluvial sediments	60 m	None
Nose Creek Downstream of the confluence with West Nose Creek	All soil types	50 m	If the average cross fall slope of a defined setback area is more than 5%, increase the width of the setback by 1.5 m for every 1% of slope greater than 5%

6.4.3 b Relaxations of the riparian setback should not occur. When encroachment on the setback cannot be avoided through alternative design or management, mitigation measures should be applied to minimize the impact. Impacts should be addressed through restoration (refer to recommendation 6.4.3 f) or other alternative means at the discretion of partners.

6.4.3 c Future alignment of riparian setbacks among municipalities in the watershed is desired.

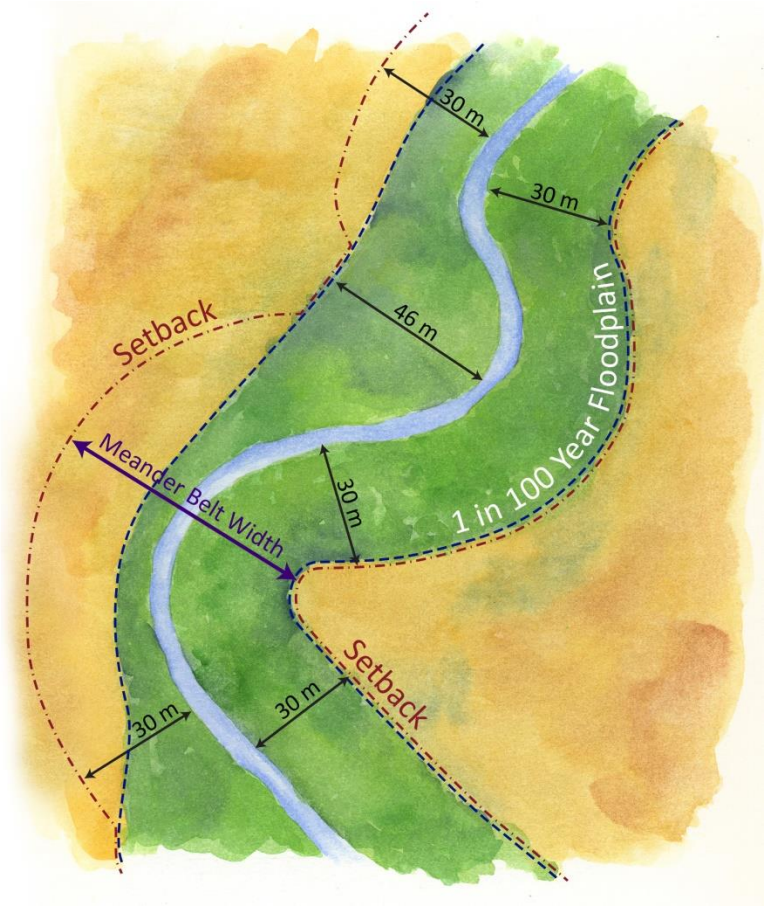

Figure 3. Schematic showing application of riparian setback.

Restricted and Permitted Activity

6.4.3 d Except for permitted activities, no further development (including stormwater ponds) or site alteration should be permitted within the riparian setback, thus maintaining riparian lands in their natural state. In a natural state, riparian functions are preserved (e.g., streambank stability, meander belt, pollution prevention, biodiversity corridors, and connection of landscape).

The following activities may be permitted in the riparian setback[80]

- Existing uses, buildings and structures
- Existing roads and pathways
- Public utility installations and facilities
- Maintenance and repair of existing infrastructure
- Existing recreational facilities and associated surface parking
- Existing parks and playgrounds
- Passive recreational uses (e.g. walking); pathways constructed from hard surfaces should be avoided where possible
- Natural areas
- Interpretive signage

[80] Adapted from the Town Cochrane's Watershed Protection and Water Management Bylaw 2005

- Existing agricultural operations, provided they comply with existing regulations (e.g. runoff regulations)
- Approved water supply wells or wells and associated technology used for the purpose of livestock watering

6.4.3 e Public access to Nose Creek, West Nose Creek and associated tributaries should be maintained in a manner that will not compromise riparian function or water quality**.** Appropriate measures to minimize impact should include

- Construction of pathways consisting of impervious materials limited to above the 1:100 year floodplain
- The use of bridges should be avoided where the stream channel is actively moving; when avoidance is not possible, bridges that span the riparian area are recommended. The use of culverts are discouraged in all cases (e.g., vehicle, pedestrian)
- Provision of signs in public areas that describe the ecological significance of riparian areas
- Provision of bioengineered access points for dogs and signs that will educate dog owners of potential ecological impacts
- Provision of garbage cans and animal waste bags in parks
- Control of invasive weeds in riparian areas through the adoption of integrated pest management

6.4.3 f Pathways in proximity of bridge crossings should be reviewed on a case by case basis to ensure continued provision of public safety.

Avoid and Mitigate

6.4.3 g BMPs should be prescribed during detailed design and used routinely when working in and around riparian areas and watercourses. Specific mitigation measures should be included in the detailed design, and account for construction and maintenance activities as well as the expected effects of the completed structure on riparian areas and water quality.

Development plans that may impact Nose Creek, West Nose Creek or an associated tributary should demonstrate why disturbance cannot be avoided through either relocation or redesign and how impacts will be mitigated.

6.4.3 h Offsets may be explored when all other options (i.e., avoid, mitigate and redesign) have been considered (refer to recommendation 6.4.3 e). Depending on the severity of the disturbance, offsets may be achieved through:

i. Replacement of riparian area at or near the site;
ii. Enhancement or improvement of existing riparian area near the site or away from the site on the same watercourse; and
iii. Maintenance or restoration of hydraulic connectivity to allow interaction of water between the creek and abandoned channel reaches**.**

Ephemeral and Intermittent Watercourses

Ephemeral and intermittent watercourses provide similar ecological and hydrological functions as perennial watercourses by moving water, nutrients, and sediment throughout the watershed.[81] When functioning properly, these watercourses provide continuous landscape hydrologic connections and stream energy dissipation during high-water flows to minimize erosion, and improve water quality. These watercourses may also serve as important emergency spillways that mitigate impacts of flood in developed areas. Recently, the loss of ephemeral and intermittent watercourses draining to Nose Creek was estimated to be 57% within Calgary's city limits.[82] Refer to Appendix G for more information regarding the role of ephemeral and intermittent watercourses in watersheds.

6.4.3 i Buildings, roads, and structures should be strategically located to preserve existing topography and the natural hydrology of ephemeral and intermittent watercourses.

6.4.3 j Ephemeral and intermittent watercourses should be preserved in new developments, where possible, to moderate runoff volume (Section 6.2) and quality (Section 6.3). These headwater streams (sometimes referred to as natural drainage swales) should be used to convey runoff from new developments to the receiving waters at an appropriate volume and rate so as not to alter the native vegetation community or induce soil erosion.

6.4.3 k The width of the riparian setback for ephemeral and intermittent watercourses should not be less than 6 m in width (Figure 5).[83] The setback should include the flood prone area as indicated by soils and vegetation. The setback should be measured from either side of the stream channel crest (edge of flow path), or from the lowest elevation (centre-line) when the width of the flow path is not clear.

6.4.3 l The following activities may be permitted in the riparian setback established for ephemeral and intermittent watercourses (Figure 5):

- Tree and shrub plantings
- Overland spillways between ponds or other green infrastructure
- Emergency spillways for unique and infrequent storm events

A buffer extending at least four metres from the outer edge of the ephemeral and intermittent watercourses setback (Figure 5) should be established and used for critical infrastructure or pathways, and include but are not limited to:

- Existing uses, buildings and structures
- Existing roads and pathways
- Public utility installations and facilities
- Maintenance and repair of existing infrastructure and riparian area
- Existing recreational facilities and associated surface parking
- Existing parks and playgrounds

[81] Levick et al. 2008
[82] AMEC Foster Wheeler and Tannas Conservation Services Ltd. 2017
[83] A minimum 6 m setback adjacent to watercourses for pollution prevention is consistent with the *MGA*.

- Passive recreational uses (e.g. walking); pathways constructed from hard surfaces should be avoided where possible
- Natural areas
- Interpretive signage
- Existing agricultural operations, provided they comply with existing regulations (e.g. runoff regulations)
- Approved water supply wells or wells and associated technology used for the purpose of livestock watering

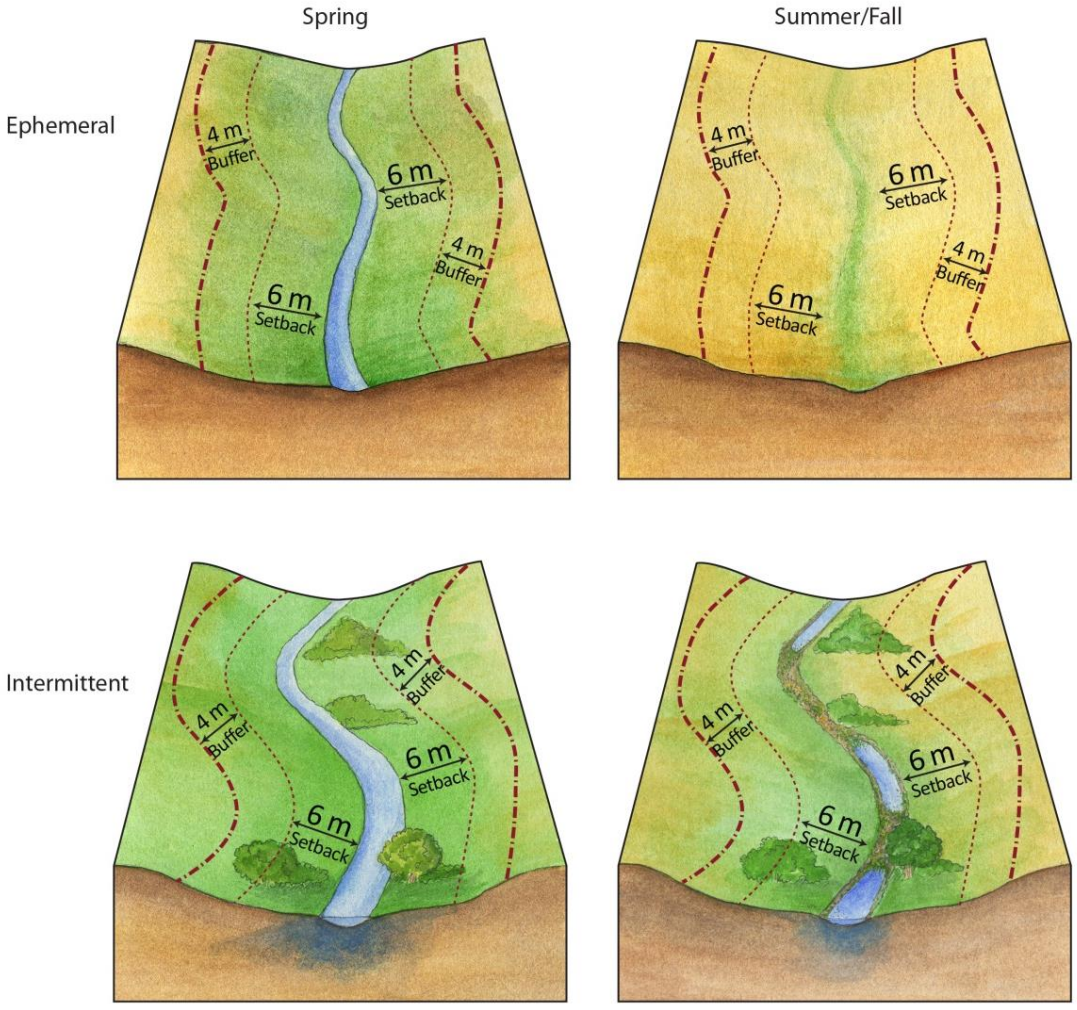

Figure 5. Schematic showing the application of the ephemeral and intermittent watercourse 6 m setback and 4 m buffer. Surface flow in ephemeral and intermittent watercourses may or may not be visible at time of field reconnaissance as surface flow depends on season and local precipitation. For intermittent watercourses, streamflow may not be observed aboveground, but may occur below surface. Other indicators, including soil and vegetation, should be used to help delineate these systems.

6.4.4 Recommendations to Protect Wetlands (Lentic Systems)

Wetlands continue to be lost in urbanizing areas in spite of the avoidance, mitigation, and replacement approach outlined in the Alberta Wetland Policy. Wetland loss in the Calgary area was estimated to be 80-90%.[84] Remaining wetlands are at risk from development and agricultural activity.

6.4.4 a Update the wetland inventory for the watershed using Alberta's Merged Wetland Inventory data layer (refer to Appendix J-3) in conjunction with field-truthing. Create a map tool to support wetland management.

6.4.4 b Setbacks should be applied to wetlands[85] (including stormwater wetlands[86]) to preserve or maintain them in the watershed according to Table 8.[87]

Table 8. Recommended minimum setbacks for wetlands.

Waterbody	Substrate	Minimum Setback	Modifiers	Notes
Temporary Wetlands[88] **(Class I & II[89])**	Not specified	10 m	None	Maintain and conserve native wetland vegetation
Seasonal, semi-permanent, permanent, and alkali wetlands[87]; stormwater wetlands[86] **(Class III – VI[87])**	Glacial till	30 m	If the average cross fall slope of a defined setback area is more than 5%, increase the width of the setback by 1.5 m for every 1% of slope greater than 5%	Conserve native riparian vegetation and natural flood regimes
	Coarse textured sands and gravels, alluvial sediments	50 m	None	

6.4.4 c Effort should be made to prevent loss of high-valued wetlands in the watershed. Assign values to wetlands, considering wetland value functional groups outlined in

[84] Parks Foundation Calgary 2003
[85] Natural wetlands considered to be Environmental Reserve Wetlands under the Wetland Conservation Plan (The City of Calgary 2004)
[86] Wetlands that are engineered to serve as stormwater management facilities
[87] A discretionary reduction of ER setback may apply if the primary function of the wetland is for the provision of stormwater treatment rather than functioning as a natural wetland. Appropriate design elements (e.g., oil and grit separation, buffer strips, treatment swales, or site grading) would be required to demonstrate that the water body would not be subject to surface or subsurface pollutant loading.
[88] ESRD 2015
[89] Stewart and Kantrud 1971

the Alberta Wetland Policy and criteria established in the Alberta Wetland Rapid Evaluation Tool (ABWRET-A) Manual.[90] Consider the wetlands contribution to broader, regional open space and landscape connectivity goals.

6.4.4 d Integrate wetland management into urban planning. Urban development should avoid wetland loss or incorporate land use zoning to protect wetlands.

6.4.4 e Urban planning should identify wetlands as natural infrastructure that supports biodiversity, landscape planning (e.g., connectivity and open spaces), and water management (e.g., stormwater management, water supply and water treatment).

6.4.4 f Adopt the following strategies to prevent wetland loss in urban areas.

i. Identify wetlands to be retained early in the planning process, using results of biophysical assessments, and the wetland value criteria and map tool (refer to recommendations 6.4.4 a and 6.4.4 c).[91]
ii. Apply land use zoning: Environmental Reserve, Public Utility Lot or Conservation Reserve to retain wetlands.
iii. Clarify the approval process for urban development plans that integrate wetlands and water management to prevent delays in the approval process.
    - Establish criteria for wetland integration that includes the risk of interaction with other water (surface water or groundwater), and water quality and hydrological requirements (e.g., pre- and post-development hydro-periods) to maintain all or some valued wetland functions.
iv. Review and update expectations to address impacts that better reflect the true cost of wetland loss (e.g., to biodiversity, water quality, flood and drought protection and human uses, as well as the cost to restore damaged systems) and deter further loss.
v. Address timing issues that result from multi-staff review of applications under the *Water Act* and the Alberta Wetland Policy for wetland restoration projects. A streamlined approach for wetland restoration project applications should be developed where clear watershed benefits are identified.

6.4.4 g Where loss is unavoidable, wetland impacts should be mitigated, or wetlands should be restored and/or created in urban areas as part of water management infrastructure, provided that the criteria for wetland integration is met (Recommendation 6.4.4 f iii). Priority areas for wetland restoration and creation should be identified.

6.4.4 h Land planners and approvals staff should establish a decision tracking system to support wetland management. Track decisions regarding design modifications applied to developments that lead to successful impact avoidance to wetlands, or to the integration of wetlands into overall site plans. The tracking system should help managers understand the rate of wetland loss in the watershed and the steps that were taken to avoid or mitigate wetland loss through project re-design.

[90] GOA 2013; GOA 2015c
[91] Refer to the glossary for the definition of wetland retention.

6.4.4 i Collaborate with organizations to identify opportunities to retain wetlands in their natural state in country-residential developments or in rural areas through conservation easement or ecological gifting.

6.4.4 j Develop a guide to wetland integration for new developments and areas of re-development that reflects the Plan and that provides examples of urban designs that support wetland retention and integration in the watershed.

6.4.5 Recommendations to Protect Riparian Lands in Agricultural Areas

6.4.5 a The application of manure and fertilizer on agricultural lands should be consistent with the standards outlined in the *Agricultural Operations Practices Act* (AOPA) for manure and fertilizer application on forages or direct seeded crops.[92]

- Manure and fertilizer should be applied at an appropriate rate so as not to accumulate in the soil or leach into groundwater.
- Regular soil testing should be conducted to prevent over application of fertilizer and manure.
- Vegetative buffers should be established and protected adjacent to riparian areas at widths of 6 m on slopes less than 6%, and 30 m on slopes greater than 6%.
- Vegetative buffer strips should be seeded using a mixture suitable for forage so to preserve the utility of the land for agriculture.
- Vegetative buffer strips should be maintained by mowing, to not less than 15 cm in height. The forage produced may be used for livestock.

6.4.5 b Land that is marginally productive for annual crops should be converted into long-term forage production or retained in its natural state (e.g., ephemeral wetlands).

6.4.5 c Wetlands should be retained or reclaimed to allow for the process of groundwater recharge and water quality protection.

6.4.5 d Riparian vegetation (i.e., trees, shrubs and grasses) should be maintained, protected, restored and/or enhanced.

6.4.5 e Livestock grazing should only be permitted in the riparian area if best management practices (BMPs) are implemented, including, but not limited to:

- Livestock should not be grazed in riparian areas during the spring thaw or when soils are moist. Most appropriate grazing periods are summer and/or winter;
- Livestock should be grazed at the appropriate stocking rate for pastures bisected by a watercourse; and
- Offstream watering systems should be used to water livestock.

6.4.5 f When timing restrictions and stocking rates cannot match a pasture's carrying capacity, temporary or permanent fencing should be used to protect water bodies.

[92] *Agricultural Operations Practices Act* (*AOPA*)

6.4.5 g Tools, such as salt, artificial windbreaks, temporary or permanent fencing and water should be used to promote even distribution of grazing and manure throughout the entire pasture and discourage use around watercourses.

6.4.5 h Seasonal feeding and bedding sites should be located at least 30 m from a common body of water. Where sites are less than 30 m from a common body of water, an engineered berm between the site and the water should be constructed to divert runoff away from the site. Accumulations of manure and bedding should be removed before runoff occurs. An engineered berm upslope of the wintering area will also divert clean water away from the site, reducing the volume of runoff that comes in contact with manure.

6.4.5 i Short-term storage of solid manure should be located

i. More than 1 m above the water table;
ii. Above the 1:25 year floodplain;
iii. 100 m from springs or water wells; and
iv. 30 m from a common body of water.[93]

6.4.6 Recommendations for Riparian Restoration and Stewardship

For additional guidance related to restoration approach and priorities, refer to Section 6.3.3, recommendations 6.3.3 l, m and n.

Vegetation

6.4.6 a Protect and maintain existing native riparian plant communities. Continue to avoid and minimize new disturbance or clearing of native vegetation in the riparian zone.

6.4.6 b Urban parks and golf courses should be restored by replacing tame species with native species that are naturally present in the local vicinity, where possible. Mowing should not occur in the riparian setback, except in the immediate vicinity of pathways if necessary.

6.4.6 c Clustered plantings of native trees and shrubs should be used in future landscaping or restoration projects to improve woody cover in the riparian area. Suitable native shrubs include sandbar willow, red-osier dogwood, silverberry, and choke cherry.

6.4.6 d To maintain bank stability, plant sedges and non-suckering native shrubs tolerant to saturated soils in areas where reed canary grass is routinely mowed (e.g., at golf courses, in manicured Environmental Reserves). Although reed canary grass has deep binding roots that stabilize streambanks, it may encroach into adjacent areas where shorter grass is preferred.

6.4.6 e Maintain and monitor new soil bioengineering and riparian planting projects to assess survival and improve the overall success of the projects. Monitoring and maintenance guidance is provided in Appendix H.

[93] *AOPA* 2003

Stewardship

6.4.6 f Continue to encourage community and resident stewardship of water and riparian lands in the watershed, including:

i. Encourage use of designated pathways. Sign and close undesignated trails that contribute to bank erosion and slumping. Install educational signage in conjunction with restoration projects and trail closures;
ii. Encourage community involvement in creek clean-up events, weed pulls, and other restoration projects when possible. Community involvement may come from community associations, golf clubs, commercial and industrial landscaping managers, or other;
iii. Enforce no dumping of grass clippings or other landscaping debris into the Nose Creek riparian corridor to prevent the spread of weeds;[94] and
iv. Continue to educate dog-owners about existing on and off-leash regulations, and the potential impacts dogs can have on sensitive riparian areas, fish habitat, and water quality.

[94] Observed at site NOS8 during the riparian health inventory.

6.5 Groundwater

6.5.1 Background

Groundwater studies in the Nose Creek watershed showed that infiltration capacity or groundwater recharge is a function of biophysical conditions including topography, soil, vegetation and geology. Hayashi (2004) divided the northern reaches of the West Nose Creek watershed into eight sub-basins. They recorded change in base flow during one month in 2003. With no significant precipitation events occurring during the course of their study, they found that Big Spring Creek contributed 64% of the flow in West Nose Creek, while occupying only 15% of the area. The headwaters of the Big Spring Creek are comprised of a group of springs discharging from the contact zone between the Paskapoo Formation and the overlying gravel layer. Best management practices (BMPs) for runoff volume control such as porous pavement and other infiltration structures should be implemented to maintain groundwater and base flows in this region.

Source water protection initiatives focused on the groundwater resource should be implemented in internal drainage areas (see map in Appendix J). These areas have unique drainage characteristics that are important for groundwater quality and recharge. Allowing rainfall to infiltrate into the soil replenishes groundwater to maintain groundwater reserves and provide base flow to streams.

6.5.2 Recommendations for Groundwater Protection

6.5.2 a A comprehensive source water protection plan should be developed that focuses on groundwater in the Nose Creek watershed and the specific protection and management strategies required for high, medium and low risk areas.

6.5.2 b Measures should be taken to protect groundwater supplies. Abandoned water wells should be identified by each municipal jurisdiction and sealed by qualified professionals to prevent contamination of groundwater.

6.5.2 c Landowners should apply BMPs for groundwater protection including appropriate disposal of harmful materials and proper use of pesticides and fertilizers.

Future Research and Monitoring

6.5.2 d Increase understanding of springs and seeps in headwater areas.

6.5.2 e Increase knowledge regarding the role of groundwater in the watershed's water balance. Consider investigating groundwater-surface water interactions in the hydrologic/hydraulic and water quality model (refer to recommendation 6.2.2 a).

6.5.2 f Continue with community-based groundwater monitoring programs.

6.6 Biodiversity

6.6.1 Background

Biodiversity refers to the variety and variability of all living things. Biodiversity is important to maintaining a resilient environment that can recover from episodes of disaster (e.g., contaminants spill, fire, and flood). Habitats that are highly impacted and are simplified tend to support fewer species and are often numerically dominated by a few species. Society's success in conserving biodiversity depends on the retention of key elements in watersheds. While all aspects of biodiversity are important, in the Nose Creek Plan emphasis is placed on aquatic life and native plant communities that indicate a measure of health and resiliency in the watershed.

Many of the recommendations in this Plan are integrated, and when implemented will support biodiversity in the watershed. Biodiversity is supported when the cumulative effects of land use activities is minimized, native vegetation and diversity is conserved, and landscape features are connected to minimize habitat fragmentation and isolation of species.[95]

6.6.2 Recommendations to Preserve Biodiversity

Fish

The class structure for water bodies in Alberta is outlined in the Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body (the Code).[96] The class designation of a water body is determined based on the sensitivity of fish habitats and their known distribution. Class C is described as having moderately sensitive habitat areas that are sensitive enough to be potentially damaged by unconfined or unrestricted activities in a water body. Class C is further described as having broadly distributed habitats that support local fish species populations.

Restricted Activity Periods (RAP) are time periods when works that disrupt the bed or banks of a water body are not permitted. The restricted time period aims to minimize the potential to impact spawning fish, incubating eggs and newly-emerged fry. Maps under the Code identify restricted activity periods for mapped Class A to Class C water bodies.

Currently, Nose Creek and West Nose Creek are designated Class C watercourses, and have a RAP from April 1 to May 31 (mouth to headwaters). This RAP aims to protect spring-spawning fish such as Northern Pike and Yellow Perch. Nose and West Nose creeks were classified as Class C waterbodies on the Code of Practice maps[97] following a recommendation from the NCWP to the Province to increase the level of protection for aquatic life[98]. The provincial fisheries biologist is responsible for identifying RAP periods and the reaches to which they apply.

Eleven fish species have been confirmed in Nose Creek and/or West Nose Creek (Appendix I). Brown Trout were observed in 2007, 2009 and 2010 at Nose Creek and in 2010 and 2012 at West Nose Creek within The City of Calgary's City Limits (FWMIS Database 2015). A recent angling and

[95] These objectives align with biodiversity outcomes in the South Saskatchewan Region Biodiversity Framework.
[96] ESRD 2013
[97] ESRD 2012b
[98] PESL 2008

spawning survey at West Nose Creek confirmed spawning activity up to 5,800 m upstream of the confluence with Nose Creek (at Country Hills Blvd).[99] The current RAP is not biologically relevant to Brown Trout as they spawn in the fall with eggs incubating in the substrate over the winter.

6.6.2 a The RAP for West Nose Creek should be made biologically relevant for Brown Trout that spawn in the fall to protect important spawning areas. This fall/winter RAP would also protect spawning Brook Trout and Mountain Whitefish should these two species spawn in Nose or West Nose creeks.[100]

6.6.2 b The area appropriate for a fall/winter RAP should be identified on the Code of Practice maps.

6.6.2 c Protect and maintain spawning and rearing areas for Brown Trout in West Nose Creek:

i. Adhere to the appropriate RAP as established by the Provincial Biologist;
ii. Maintain appropriate water quality (including temperature (Appendix I)) and overall habitat condition by implementing the riparian recommendations (Section 6.4); and
iii. Prohibit riparian and stream channel alterations in areas identified as Brown Trout spawning habitat.

6.6.2 d Partner with Fisheries and Oceans Canada, Trout Unlimited Canada and Alberta Environment and Parks to conduct a comprehensive study that identifies the fishery potential of Nose Creek and West Nose Creek, and determine the creek's suitability and importance to maintaining a fishery in the Bow River.

Wildlife

About 80% of Alberta's wildlife relies on riparian areas and wetlands for all or part of their lifecycle.[101] Riparian areas and wetlands provide connectivity in the landscape and movement corridors for wildlife. Wildlife is regulated under the federal *Migratory Birds Convention Act*[102] and *Species at Risk Act*[103]. Municipalities must abide by provincial and federal regulations. One of the key objectives of the Biodiversity Management Framework, developed as part of the South Saskatchewan Regional Plan (SSRP)[104], is to maintain terrestrial and aquatic biodiversity.

6.6.2 e Consider wildlife habitat sensitivities (e.g., secure nesting habitat for waterfowl and other grassland nesting passerines) in future land use plans.

Invasive Species

6.6.2 f A study should be undertaken to document the occurrence of invasive species[105] (e.g., Prussian carp, crayfish) in the watershed to support future Plan recommendations and a detection program for aquatic invasive species.

[99] Bow Valley Habitat Development 2015
[100] A Provincial Biologist is responsible for assigning the appropriate RAP to West Nose Creek.
[101] Fitch et al. 2003
[102] Government of Canada 1994
[103] Government of Canada 2002
[104] GOA 2015
[105] Note that crayfish were observed at the Cross Iron Mills stormpond outfall (Balzac 3) in 2016, as well as at outfalls in Airdrie.

6.6.2 g Partner with other organizations to implement existing Early Detection and Rapid Response (EDRR) plans for aquatic invasive species.[106]

6.6.2 h Educational resources should be developed for public users of Nose and West Nose creeks that highlight the threat of aquatic invasive species:

i. Crayfish captured in Nose and West Nose creek should not be consumed by humans. Crayfish are filter feeders and can bioaccumulate metals and other toxins in tissue.
ii. Release of fish (e.g., goldfish, carp) is prohibited. These fish compete with native fish for food and can displace native species, simplifying aquatic systems.

6.6.2 i Anglers and contractors should take measures to prevent the spread of Whirling disease (e.g., cleaning, draining and drying all aquatic equipment including watercraft, waders, nets and all fishing gear). Mud, plants and fish should not be transported from Nose Creek or West Nose Creek to other waterbodies.[107]

Invasive Plants

Invasive plants are regulated by the *Alberta Weed Control Act*, administered by municipalities.

6.6.2 j Continue annual efforts to control and monitor invasive plant species with due care to native plants and water resources. Weed control efforts should first focus on removing new invasive plant species infestations that are not yet widespread (e.g., yellow clematis, nodding thistle, scentless chamomile, ornamental geranium).

6.6.2 k Invasive aquatic plants observed in the watershed should be reported to municipal staff. Plants that are provincially listed as invasive include flowering rush, purple loosestrife, and pale yellow iris.

6.6.2 l Select the mix and source of plants used for landscaping to prevent unintentional introduction of invasive ornamental species (e.g., creeping bellflower, Dame's rocket, yellow clematis, caragana, or Russian olive).

6.6.2 m Weed control efforts should be coordinated with the Canadian Pacific Railway (CPR), adjacent jurisdictions, and adjacent residential community associations. Weed prevention programs should educate the public about the harms of planting invasive ornamental species in private yards or public open spaces.

6.6.2 n Avoid caragana root removal that may cause soil disturbance or undesirable impacts to bank or slope stability. The priority for caragana management should be to prevent its spread into intact native riparian plant communities.

[106] Calgary and Area Governmental Weed Control Committee; Flowering Rush Task Force

[107] In August 2016, Whirling disease (a parasite that affects juvenile trout and whitefish) was detected in Alberta at Banff National Park and has since been confirmed throughout the Bow River watershed. In the Nose Creek watershed, fish susceptible to whirling disease would include Rainbow Trout (highly susceptible), Brook Trout (susceptible), Mountain Whitefish (susceptible) and Brown Trout (low susceptibility) (MacConnell and Vincent 2002). Precautions should be taken to prevent the spread of this disease.

6.7 Nose Creek Watershed Partnership Priorities

The following provides a preliminary assessment of NCWP priorities, with emphasis on continued collaboration to achieve common goals.

6.7.1 Priorities

The Nose Creek Plan Implementation Guide[108] was developed to support the implementation of recommendations presented in the Plan. The guide summarizes implementation actions, identifies roles and responsibilities, and suggests a preliminary timeline in a series of tables related to each of the five main themes presented in the Plan. The NCWP and Technical Team identified actions that should be implemented by the NCWP in the short-, medium-, and long-term to achieve desired outcomes. Criteria in Table 9 were then used to rank 14 primary actions in order of priority. A list of the top five priorities determined by the Partnership is provided in Appendix K.

Table 9. Criteria used to identify priority recommendations and actions for the NCWP. See Appendix K.

Number	Description
1	NCWP has a leading or unique role in the implementation action (recommendation is not regulated by municipal or provincial legislation; action not likely to be implemented by another jurisdiction/organization
2	Recommendation provides watershed-wide benefits and/or may benefit all partners.
3	Recommendation addresses current knowledge gaps (urgent need to fill gap vs. interesting information that contributes to general scientific understanding)
4	Aligns with partner's current work and priorities
5	Significant interest in the action as expressed by partners

The top three NCWP priorities identified were:

1. Develop a hydrologic/hydraulic and water quality watershed-scale model;
2. Design and implement a standardized water monitoring program; and
3. Initiate streambank erosion monitoring.

The development of the watershed-scale hydrologic/hydraulic and water quality model and the implementation of the standardized water monitoring program are deemed the highest priorities and should be implemented concurrently. Model development is contingent on the availability of data collected in the standardized water monitoring program. Watershed condition reporting also ranked as a top priority (tied as third priority), but was considered a recommendation that should be implemented following data collection (e.g., water quality, riparian health, fisheries).

6.7.2 Staged Work Plan

A preliminary work plan was created considering the actions and timelines detailed in the Nose Creek Plan Implementation Guide and the priorities established by the NCWP (Appendix K). Tasks and timelines are summarized in Table 10. The timeline outlined in the preliminary work plan are approximate and may change according to further discussion, individual jurisdiction priorities, and

[108] PESL 2018

resource availability (e.g., personnel and financial resources). Details will be further refined in discussion with Sub-Committee members assigned to individual projects.

Table 10. Preliminary staged work plan for the NCWP – priorities and timelines.

Approximate Timeline							
Immediate		Short-term		Medium-term		Long-term	

Activity	Plan Ref.	Preliminary Work Plan	2018	2019	2020-2021	2022-2024	2025-2027
			Annual		Multi-year		
Core: Capacity (human resources and funding)	6.1.1 j, k, l	Maintain NCWP capacity (i.e., board participation, administration, annual funding)					
		Identify and seek external funding sources					
Project: Hydrologic/ hydraulic/ water quality modelling tool	6.2.2 a	Determine interest and establish sub-committee to oversee project					
		Develop detailed proposal and budget; seek funding					
		Work with consultant to develop and calibrate model					
Project: Monitoring (water, erosion)	6.2.2 b, c 6.2.3 b, s, t 6.3.2 h, i	Determine interest and establish sub-committee to oversee project					
		Develop detailed monitoring proposal; seek funding					
		Implement monitoring program					
Project: Wetland inventory/ valuation	6.4.4 c	Determine interest and establish sub-committee to oversee the project					
		Develop detailed wetland inventory/valuation proposal; seek funding					
		Work with consultant to complete project					
Core: Watershed condition reporting	6.1.1 i	Determine interest and establish sub-committee to oversee the project					
		Develop Terms of Reference; Seek funding					
		Work with consultant to complete project					
Staged implementation of remaining priorities	6.1.1 e, f	Annual review of Plan implementation progress					
		Five year work plan review					

7.0 GLOSSARY

Abandoned project area Any site where work (i.e., construction, development, soil disturbance) was progressing, but has since been stopped indefinitely, and there is no plan for re-starting the project (A. Phelps, Calgary).

Accelerated erosion Rate of erosion that is much more rapid than normal, natural or geologic erosion, due primarily to human activities (Armantrout 1998).

Baseflow Portion of the stream discharge that is derived from natural storage (i.e., outflow from groundwater, large lakes or swamps), or sources other than rainfall that creates surface runoff; discharge sustained in a stream channel, not a result of direct runoff and without regulation, diversion, or other human effects. Also referred to as sustaining, normal, dry-weather, ordinary or groundwater flow (Armantrout 1998).

Buffer A strip of land managed to maintain desired ecological processes, and provide economic and societal benefits.

Channelization The mechanical alteration of a stream usually by deepening and straightening an existing stream channel or creating new channel to facilitate the movement of water (Armantrout 1998).

Common body of water The bed and shore of an irrigation canal, drainage canal, reservoir, river, stream, creek, lake, marsh, slough or other exposed body of water (AOPA Standards and Administration Regulation, Section 1), not including:

a) A water works system as defined by EPEA,
b) A reservoir, lake, marsh or slough that is completely surrounded by private land controlled by the owner or operator and has no outflow going directly beyond the private land to a drainage canal, reservoir, river, permanent stream or creek, lake or potable water source that is being used for human or livestock consumption,
c) An irrigation canal or a drainage canal that is completely surrounded by private land controlled by the owner or operator and has no outflow going directly beyond the private land,
d) A roadside ditch,
e) A wastewater system as defined by EPEA,
f) A storm drainage system as defined by EPEA, or
g) An ephemeral stream on private land controlled by the owner or operator that has no outflow going beyond the private land directly to a drainage canal, reservoir, river, permanent stream or creek, lake or potable water source that is being used for human or livestock consumption.

Conventional infrastructure Single-purpose grey stormwater infrastructure that is largely designed to transport urban stormwater away from the built environment (EPA).

Coulee i) a deep, steep-sided gulch or valley that is often dry during the summer months (Canadian Dictionary of the English Language); ii) a dry stream valley, especially a long steep-sided ravine that once carried melt water (Alberta EAP Integrated Standards and Guidelines).

Corridor A corridor is a strip of a particular type that differs from the adjacent land on both sides. Corridors have several important functions, including conduit, barrier and habitat.

Criteria Scientific data evaluated to derive recommended limits of parameters for water use.

Cumulative effects Refers to the combined effects of past, present and reasonably foreseeable future land-use activities over time on economic, social and environmental values (BRBC 2012).

Ecosystem services Ecosystem services are the benefits that nature provides to people. Examples include the ability of forest to regulate carbon and mitigate climate change, or the filtration and purification of water by wetlands. Ecosystem services are crucial to long-term, human well-being and economic success.

Effective area That area where surface runoff water reaches Nose Creek, West Nose Creek or one of their tributaries

Environmental Reserve Land designated as Environmental Reserve by a subdivision authority under Section 664 of the *Municipal Government Act*.

Ephemeral watercourse i) watercourse that flows briefly in direct response to precipitation or snowmelt; these channels are always above the water table (USEPA 2015). ii) A watercourse that flows only during and immediately after snowmelt or heavy rainfall (<10% of the time) (Hedman & Osterkamp 1982). Ephemeral drainages are often identified as grass swales and typically do not have an exposed bottom substrate from the erosive action of water.

Escarpment A steeply sloping area associated with a slope of 15% or greater that is separating two comparatively level or more gently sloping areas, and may contain isolated pockets of lesser sloped terrain. Escarpments include ravines, gullies, coulees, side draws, and other similar features (Adapted from the Town of Cochrane's Land Use Bylaw 1/99).

Evapotranspiration The combined action of evaporation (a physical process that converts liquid water to a gas) and transpiration (the loss of water vapor from plants) (Stevenson and Wyman 1991).

Fit-for-Purpose Water treated to a quality matching the quality requirements for the intended use of that water (WERF 2017).

Flood fringe The portion of the flood hazard area outside of the floodway. Water in the flood fringe is generally shallower and flows more slowly than in the floodway.

Floodplain An area adjoining a body of water that has been or may be covered by flood water.

Floodway The portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area.

Green infrastructure Green infrastructure is network of small-scale infrastructure interventions, such as tree planting, trenches, swales, rain gardens, and permeable pavement, that help to manage runoff as close to the source as possible. Application of green infrastructure aims to mimic natural

hydrological functions by facilitating infiltration, evapotranspiration, harvesting, filtration, and detention of stormwater.

Gross area The area that makes up the entire Nose Creek watershed. Compare to "effective area".

Groundwater recharge Inflow of water to a ground water reservoir from the surface (Alberta Environment 2008)

Guidelines Recommended limits of parameters that will support and maintain a designated water use. They are given as numerical concentrations or narrative statements.

Hydraulic(s) The science concerned with water and other fluids at rest or in motion (Stevenson and Wyman 1991).

Hydrologic From the word hydrology. The study of the distribution, movement and chemical makeup of surface and underground waters (Stevenson and Wyman 1991).

Instream needs Instream needs are defined as the quantity and quality of water required to satisfy hydrological process demands instream and to protect river ecology and riparian environments. Instream needs include fish habitat, water quality, riparian vegetation, channel structure, human safety and recreational uses. Instream flow needs differ from water conservation objectives in that they are strictly a scientific assessment. Water conservation objectives, on the other hand, refer to the quantity of water that should be present in a stream to meet instream needs and socio-economic factors.

Intermittent watercourse i) A watercourse or portion of a watercourse that flows continuously only at certain times of year. At low flow, dry segments alternating with flowing segments can be present (USEPA 2015). ii) A watercourse that flows for part of each year (e.g., flow occurs 10 to 80% of the time) (Hedman & Osterkamp 1982). The extended period of flow in intermittent streams typically results in a scoured or non-vegetated channel bottom.

Low impact development A land planning and engineering design approach to managing stormwater runoff. The approach includes land use planning and conservation, as well as engineered hydrologic controls to replicate the pre-development hydrologic regime of watersheds by infiltrating, filtering, storing, evaporating, and detaining runoff close to its source.

Meander belt The land area on either side of a watercourse representing the farthest potential limit of channel migration. Areas within the meander belt may someday be occupied by the watercourse; areas outside the meander belt will not (Parish Geomorphic 2004).

Meander belt-width Normal width or distance between tangents drawn on the convex sides of successive belts (Armantrout 1998).

Minimum Disturbance Practice Practices that minimize disturbance and adverse environmental effects.

Morphology From the Greek morphe, meaning 'form', a prefix meaning pertaining to form or shape (Allaby 1994).

Municipal water use Purposes usually served by potable water within a city, town, or village, including but not limited to household and sanitary purposes, watering of lawns and gardens, fire protection, including commercial and industrial purposes within a municipal boundary (*draft* Alberta Wastewater Re-use and Stormwater Use Guidebook, September 2017).

Objectives Numerical concentrations or narrative statements that have been established to support and protect the designated uses of water at a specific site.

Peak flow Highest discharge recorded within a specified period of time that is often related to spring snowmelt, summer, fall, or winter flows. Also referred to as maximum flow (Armantrout 1998).

Perennial river/stream A watercourse or portion of a watercourse that flows year-round (USEPA 2015); ii) A watercourse that generally flows continuously year-round (e.g., flow greater than 80% of the time) (Hedman & Osterkamp 1982); iii) watercourses where base flow is dependably generated from the movement of groundwater into the channel (USEPA 1998); iv) perennial channels that convey water throughout the year (ESRD 1998).

Redevelopment The act of developing something again. According to the *Municipal Government Act*, redevelopment means an area of land that is the subject of an area redevelopment plan (Alberta Queen's Printer 2015). Municipalities may designate an area as a redevelopment area for the purpose of any or all of the following:

i. preserving or improving land and buildings in the area;
ii. rehabilitating buildings in the area;
iii. removing buildings from the area;
iv. constructing or replacing buildings in the area;
v. establishing, improving or relocating roads, public utilities or other services in the area;
vi. facilitating any other development in the area.

Riparian Riparian lands are transitional areas between upland[109] and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated water bodies[110], which includes alluvial aquifers[111] and floodplains[112], when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes (Clare and Sass 2012).

Riparian vegetation Vegetation growing on or near the banks of a stream or other water body that is more dependent on water than vegetation that is found further up slope (Armantrout 1998).

Runoff (1) Natural drainage of water away from an area. (2) Precipitation that flows overland before entering a defined stream channel (Armantrout 1998).

[109] For the purpose of this definition, "upland" is considered to be the land that is at a higher elevation than the alluvial plain or stream terrace or similar areas next to still water bodies, which are considered to be "lowlands."
[110] A water body is any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood, and includes but is not limited to wetlands and aquifers (generally excludes irrigation works). Source: *Water Act*.
[111] For the purpose of this definition, alluvial aquifers are defined as groundwater under the direct influence of surface water (GUDI).
[112] For the purpose of this definition, floodplain is synonymous with flood risk area. The flood risk area is the area that would be affected by a 100-year flood. This event has a one percent chance of being equaled or exceeded in any year.

Seasonal feeding and bedding site An overwintering site where livestock are fed and sheltered.

Sedimentation (1) Action or process of forming and depositing sediments. (2) Deposition of suspended matter by gravity hen water velocity cannot transport the bed load (Armantrout 1998).

Setback For the purposes of this document, a setback is a minimum distance that must be maintained between a land use or development and a water body. The distance is measured from the legal bank of the water body to the boundary line of the adjacent development.

Stakeholder Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity.

Standards Enforceable environmental control laws, set by a level of government. Standards are typically applied to effluent or emissions by industry to maintain a level of environmental quality.

Stormwater use The use of collected stormwater for various purposes. When the source water for re-use is stormwater as defined under the *Environmental Protection Act*, authorization/Approval from AEP for the use of the storm water in accordance with *Water Act* may be required.[113]

Surface water Water bodies such as lakes, ponds, wetlands, rivers and streams, as well as groundwater with a direct and immediate hydrological connection to surface water (Alberta Environment 2008)

Target An indicator value that reflects a desirable environmental outcome.

Technical Team The sub-committee appointed by the Nose Creek Watershed Partnership to undertake the update of the Nose Creek Watershed Water Management Plan. Members include representatives from the City of Airdrie, City of Calgary, Rocky View County, and the Bow River Basin Council.

Total maximum load A calculation of the maximum amount of pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TML is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality (https://www3.epa.gov/region6/water/npdes/tmdl/).

Water conservation objective The amount and quality of water established by the Director, based on information available to the Director, to be necessary for the (i) protection of a natural water body or its aquatic environment, or for the (ii) protection of tourism, recreational, transportation or waste assimilation uses of water, or (iii) management of fish or wildlife, and may include water necessary for the rate of flow of water or water level requirements (adapted from the *Water Act*).

Water re-use When water is used again after its original intended (licenced) purposes. The re-use can be for the same or a new purpose, and includes the use of return flow, wastewater, treated wastewater, reclaimed water, or any type of water recycling (DRAFT Alberta Wastewater Re-use and Stormwater Use Guidebook, Sep 2017).

[113] Alberta Government 2017

Reclaimed wastewater or stormwater, which has been treated to a quality suitable for specific non-potable uses. Water re-use systems fall under the mandate of Alberta Municipal Affairs and the *Safety Codes Act*. These systems require an approved alternative solution as defined by the National Plumbing Code and can be accepted by a variance under the *Safety Codes Act*. The source water (i.e., wastewater or stormwater) and intended end-uses of treated water must be clearly identified.[114]

Watershed All lands enclosed by a continuous hydrologic-surface drainage divide and lying upslope from a specified point on a stream (SSRP 2014).

Wetland retention Wetlands are retained in the Nose Creek watershed in either a natural or altered state. Wetland retention in rural settings may preserve the natural characteristics of the wetland, including hydrology and vegetation community. Wetland characteristics and functions are presumed to be the same pre-and post-development.

In urbanizing areas, the original hydrology and vegetation characteristics of a wetland may be altered, and only some of the natural functions (i.e., water quality improvement, flood mitigation, and biodiversity values) may be retained. Hydrology may be altered by a change in drainage area contributing to the wetland (resulting in a lowering of water levels) or by the influx of *treated* stormwater that may increase water levels above natural, thereby altering natural vegetation communities and soils (PESL 2018, this document).

[114] Alberta Government 2017

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APPENDIX A. Relevant legislation, policy, plans, guidance documents and programs.

Bow River Basin Council

- Bow River Basin Watershed Management Plan Phase I (2008). Water Quality Objectives
- Bow River Basin Watershed Management Plan Phase II (2012)
- Dissolved phosphorus and pathogen water quality targets/objectives were updated in 2011

Calgary Airport Authority

- Runoff Volume and Release Rate Control Strategy (implement metering system to catchment ponds and measure release volumes for glycol treatment ponds)
- Improvements to glycol ponds that include the recycling of glycol from runoff water

City of Airdrie

- AirdrieOne Sustainability Plan (2012)
- Municipal Development Plan (2014, City Plan)
- Master Stormwater Drainage Plan
- Great Places Plan (2016)
- Natural Areas Management Plan (Pending)
- Community Structure Plans
- Neighbourhood Structure Plans
- Salt Management Plan (Pending)
- Ecological Inventory (completed 2013 to identify ESA's)
- Street Sweeping Program implemented to remove 600-700 tonnes of winter road sediments and other debris annually
- A minimum 300 mm top soil depth required in the Standard Landscape Guidelines and Specifications
- Annual Stamp Out Poo Shoe event
- Annual Creek Clean Up event
- Rain Barrel sales
- Annual Toxic Roundup
- Stormwater Infrastructure Maintenance Program

Rocky View County

- Riparian Policy
    - Land Use Bylaw Updated (2015)
- Municipal Development Plan (Updated 2012)
- Agriculture Master Plan (2011)
- County Servicing Standards (2013)
- Balzac West Area Structure Plan (2014)
- Land Use Bylaw Update – Placement of topsoil and fill

The City of Calgary

- Municipal Development Plan (2009)
- Calgary Transportation Plan (2009)
- Calgary Parks Natural Areas Management Plan (1994)
- Open Space Plan (2003)

- Calgary Wetland Conservation Plan (2004)
- Environmental Reserve Setback Policy (2007)
- Wetland Conservation Policy (2007)
- Stormwater Management Strategy (2005)
- Streambank Slope Stability and Riparian Assessment Study (2012)
- Design Guidelines for Erosion and Flood Control Projects for Streambank and Riparian Stability Restoration (2012)
- Riparian Strategy: Sustaining Healthy Rivers and Communities (2014)
- Source Water Protection Plan (*draft* 2018)

Town of Crossfield

- Crossfield Sustainability Plan (2009)
- Crossfield Biophysical Overview (2010)
- Crossfield Downtown and Entrance Area Redevelopment Plan (2010)
- Municipal Development Plan (2010)
- Rocky View County/Town of Crossfield Intermunicipal Development Plan (2013)

Provincial

- Bow River Phosphorus Management Plan (2014)
- South Saskatchewan Regional Plan (Amended 2017)
- Alberta Wetland Policy (2013)
- Stepping Back from the Water (2012)
- *Alberta Land Stewardship Act* (2009)
- *Environmental Protection and Enhancement Act*
- *Agricultural Operations Practices Act*
- *Fisheries (Alberta) Act*
- *Municipal Government Act*
- *Public Lands Act*
- *Safety Codes Act*
- *Regional Health Authorities Act*
- *Weed Control Act*
- *Wildlife Act*

Federal Legislation

- *Fisheries Act*
- *Canada Water Act*
- *Migratory Birds Convention Act*
- *Species At Risk Act*

APPENDIX B. Summary of new and emerging issues in the Nose Creek watershed.

Current implementation issues regarding the Nose Creek Watershed Water Management Plan (2008) and, new and emerging watershed issues were identified through Stakeholder Engagement (Section 4.0).

Water Quantity

- Challenges implementing the 2013 runoff volume control targets for certain types of development, and concern regarding the implementation of the more stringent 2017 targets
- Lack of tools at the municipal level to implement stormwater targets
- Lack of provincial guidance on water re-use and stormwater use
- Lack of guidance for managing stormwater in areas proposed for redevelopment
- Low Impact Development (LID) challenges:
    - Limited uptake of LID practices by industry
    - Questions about cold-climate LID practice implementation and experience
    - Regulatory approval for some LID practices (e.g., wetland retention, water re-use, stormwater use) is difficult to obtain, creates uncertainty in process, and may result in costly delays.
- Need to integrate Internal Drainage Areas into existing and future policies to minimize discharge and protect property
- Lack of ability to maintain ephemeral and intermittent streams as important ecological features
- Lack of knowledge regarding springs and seeps in the headwaters

Water Quality

- High nutrient concentrations in Nose and West Nose creeks that contribute to algal growth and poor water quality downstream
- Channelization (straightening) of Nose and West Nose creeks that reduces channel length, accelerates streamflow, increases erosion, and decreases sediment deposition in the floodplain
- Discharge of treated effluent to Nose Creek from the Town of Crossfield, and the subsequent impacts to water quality and downstream users
- Limited monitoring to measure improvements in water quality, streamflow, and channel morphology
- Delayed uptake of best management practices to achieve goals for water quantity, water quality and riparian health

Riparian Areas

- Lack of understanding costs and benefits of implementing strategies to protect riparian areas and improve water quality
- Concerns regarding the implementation of riparian setbacks and over-interpretation of maps, particularly for ephemeral streams with poorly defined channels
- Encroachment of development into riparian areas and relaxations of setbacks

Wetlands

- Continuing loss of wetlands using the avoidance, mitigation, and compensation approach, despite the implementation of Alberta's Wetland Policy
- The lack of knowledge about the rate of loss of wetlands and the impact of that loss
- Challenges with wetland integration in development; lack of guidance on how to protect and mitigate impacts on wetlands in new developments, or how to integrate water management and wetlands in developments without creating delays in the approval process

Biodiversity

- Need for the protection of Brown Trout spawning habitat in West Nose Creek
- Presence of invasive species (e.g., Prussian carp, crayfish) in storm ponds, creeks, and tributaries
- Prevention of new threats (e.g., zebra/quagga mussels, whirling disease, invasive plants)

Administration

- Discretionary decision-making that supersedes policy and deviates from the intent of the Plan
- Greater consideration of Public Utility Lands and Municipal Reserve Lands to conserve natural features and augment environmental reserve
- Need to plan to meet recommendations/targets earlier in the planning process (e.g., ASPs should show tributaries, wetlands, green space)
- Difficult to measure Plan implementation progress (e.g., wetland loss)
- Lack of enforcement of existing policies (e.g., erosion and sediment control)
- Approval framework can lead to lengthy timelines for applications under the Water Act, Alberta Wetland Policy, etc.
- Regulatory approvals for wetland relocation or restoration are complicated and time-consuming. Developers then opt to compensate for wetland removal (loss).
- Need for greater consideration of incentives for the uptake of new practices to achieve goals for water quantity, water quality and riparian health

APPENDIX C. History of stakeholder engagement in the Nose Creek Watershed Water Management Plan planning process.

Guiding Principles for Stakeholder Engagement

- The NCWP is committed to open communication that fosters trust, credibility and integrity.
- The NCWP will engage in a timely manner, and will provide stakeholders with sufficient time to respond. The NCWP expects stakeholders to also respond in a timely manner.
- The Partnership fosters a diversity of knowledge, interests and values. The Partnership will consider input provided by stakeholders along with technical information on Nose Creek and West Nose Creek.

From 2004 through 2006, the Nose Creek Watershed Partnership engaged with stakeholders in accordance with the *Framework*[115] to ensure the long-term viability of the Nose Creek Watershed Water Management Plan. Throughout the engagement process, stakeholders provided valuable insight, ideas and advice that was considered by the Technical Team and incorporated into the Water Management Plan where appropriate. Methods of engagement included focus group meetings, open houses, newspaper releases, public presentations, and reports to Council.

The 2004 focus group meetings were attended by representatives from regulatory agencies, environmental groups, and the agricultural and development industry. Two Open Houses, one in Calgary and the other in the Rocky View County, were held in the spring and the fall of 2005 to provide progress updates to urban and rural watershed stakeholders and to solicit input. In total, approximately 100 people attended each series of Open Houses. Meetings were also held with specific interest groups following the release of the draft Water Management Plan in November 2005.

[115] For the original Plan (2008), the Framework for Water Management Planning, Government of Alberta was consulted. For the update of the Plan, the Framework for Watershed Management Planning was followed.

APPENDIX D. Indicators and performance measures for the Nose Creek watershed.

Theme	Indicator	Measure	Significance
Water Quantity	Deviation from predevelopment conditions (IFN Study)	Monthly streamflow (cumulative amount of flow in the creek)	Streamflows should reflect a normal range of condition and support channel processes (erosion/building), aquatic life, the riparian environment and communities.
		Runoff Volume	
		% Impervious Area	Increasing percentage of impervious surface area in watersheds may degrade stream quality (e.g., decreased baseflow, aquatic biodiversity (fish and macroinvertebrate diversity), and water quality; increases streambank erosion and signifies the need for stormwater Best Management Practices (BMPs).
		Stream channel morphology	Indicates the physical condition of streams, including stability.
Water Quality	Deviation from baseline/normal concentration or load	Stormwater quality guidelines	Deviation of quality from baseline condition suggests a degrading (or improving) trend. Surface water quality should support designated or desired end uses.
		Surface Water Quality Objectives for nutrients, sediment, bacteria, and other parameters as data allows	
Riparian Areas	Riparian Function	Riparian Health Scores[116]	Functioning riparian areas contribute to water supply, water quality, river channel stability, and biodiversity.
Wetlands	Wetland Cover	Percentage of watershed area	
		Tracking wetland loss	
Biodiversity	Fish, Wildlife and Vegetation	Species composition No. of Trout redds	Aquatic and upland systems that support a diverse group of fish, wildlife, and plant species are more resilient to ecological adversity or changes to environmental condition.
		Regulated invasive plants[117], disturbance and rare plants	
		Land cover (anthropogenic footprint, linear disturbance, critical habitat)	
		Riparian Health Scores	
Land Use	Developed/ Undeveloped Land Cover	Percentage land use cover: Agriculture – cropped and pasture, native grassland, developed area, wetlands, etc.	Monitor land use changes in the watershed.

[116] As per Cows and Fish riparian health assessment methods
[117] As identified by the *Alberta Weed Control Act*

APPENDIX E. Internal Drainage Area Policy (NCWP 2015).

POLICY STATEMENT

This Internal Drainage Areas policy statement applies to undeveloped areas that are currently not serviced by stormwater infrastructure. The policy statement has been developed to clarify the required runoff volume control targets and maximum allowable unit area release rates in internal drainage areas at a time when development occurs. These requirements allow a discharge to Nose Creek and West Nose Creek during prolonged rainfall or snow melt events and thus minimize the need for evaporation ponds in these areas.

***Table 1** below provides the recommended runoff volume control target and the maximum allowable release rates for Nose Creek and West Nose Creek based on a phased implementation approach. The average annual runoff volume control targets will ultimately be equal to the predevelopment runoff volumes for Nose Creek and West Nose Creek as given in the NCWWMP. The maximum allowable unit area release rates have been set at the same rate as development that contributes directly to Nose Creek or West Nose Creek to provide consistency across the catchment.*

Table 1. Recommended runoff volume control targets and maximum allowable release rates for internal drainage areas.

	Average Runoff Volume Control Target (mm)			Maximum Allowable Unit Area Release Rate (L/s/ha)
Date of Implementation	**2015**	**2019**	**2023**	**2015**
Nose Creek	16	11	6.1	1.257
West Nose Creek	26	17	9.6	0.99

Prior to commencing the preparation of Master Drainage Plans for proposed development within the internal drainage areas, a Lake or Wetland Management Plan shall be prepared to provide guidance on the expected water levels and operation of the ponds, lakes or wetlands that are the terminus of the drainage within internal drainage areas and from where excess runoff is directed to Nose Creek and West Nose Creek. The required content of these plans is summarized in Section 4.0 of the Nose Creek Internal Drainage Areas Study (MPE, 2013). In preparing Master Drainage Plans and any related Lake or Wetland Management Plans, consideration of provincial regulatory requirements needs to be made.

For areas upstream of Airdrie, the option of discharge from the lake, pond or wetland, during low-flow periods in Nose Creek shall be considered during the preparation of the Lake or Wetland Management Plan.

The Nose Creek Internal Drainage Areas Study (MPE, 2013) identified that the sizing of infrastructure and the timing of discharges cannot be equated to a specific single "extreme" event as described in the NCWWMP, (e.g., a 24 hour 1:100 year event), but needs to consider the accumulation of runoff over time. Therefore, a continuous water balance simulation is the only appropriate method for the sizing of the drainage infrastructure and for demonstrating that the average annual volume control targets have been satisfied.

Alberta's Water Act requires that an approval be obtained before undertaking an activity which may directly or indirectly impact a water body or cause a change in the flow, level, direction, or level of water

or a license before diverting and using water from a water body. An example of an activity is a disturbance to a wetland, and an example of a diversion of water is diverting and using water for industrial purposes. Development projects that affect wetlands must comply with the Water Act and other current Provincial policies such as the Alberta Wetland Policy (2013) and the Interim Accepted Practice (Authorizations required under the Water Act for the Diversion of Stormwater Drainage).

Generally, an Environmental Protection and Enhancement Act (EPEA) registration is required for most stormwater projects to ensure the works meet Provincial standards for storm design, capacity, timing, quantity, and quality of storm water runoff release.

A Public Lands Act authorization is required where the proposed construction is on Crown land or a water body that is claimed by the Crown. Bed and shores of semi-permanent and permanent water bodies/wetlands may be claimed by the Crown under the Public Lands Act.

APPENDIX F. Summary of current riparian condition at Nose Creek (Table A) and West Nose Creek (Table B).

Green represents a "healthy" rating, yellow a "healthy but with problems" rating, and red represents an "unhealthy" rating. A "+" symbol indicates an improving trend, a "/" symbol indicates unchanged conditions, and a "-" indicates a degrading trend.

Table A. Nose Creek

Site: Nose Creek	Most Recent Assessment Year	Vegetation cover of floodplain and bank	Invasive plant spp. cover	Invasive plant spp. density distribution	Disturbance-caused undesirable herb spp.	Preferred tree and shrub establishment and regen.	Utilization of preferred trees/ shrubs	Woody veg. removal other than browse	Decadent and dead woody material	Vegetation Score	Bank root mass protection	Human-caused bare ground	Bank structurally altered	Human physical alteration to site (polygon)	Channel incisement	Soil/ Hydrology Sub-score	Overall Score	Trend
BED 1-Cal	2015									77						83	80	+
NOS1-RVC	2000									67						50	56	
NOS2-RVC	2000									67						63	65	
NOS3-RVC	2000									48						37	41	
NOS4-Air	2009									70						80	75	+
NOS5-Cal	2014									73						30	52	/
NOS6-RVC	2000									27						37	33	
NOS7-RVC	2000									44						50	47	
NOS8-Cal	2015									73						37	55	/
NOS9-Cal	2015									67						43	55	/
NOS10-Cal	2015									73						53	63	/
NOS11-RVC	2000									63						43	53	
NOS12-RVC	2000									56						37	46	
NOS13-RVC	2000									40						43	42	
NOS14-RVC	2000									62						57	59	
NOS15-Cros	2009									57						57	57	-
NOS16-RVC	2000									48						50	49	
NOS17-Air	2009									70						37	53	/
NOS19-RVC	2005									63						87	75	

Site: Nose Creek	Most Recent Assessment Year	Vegetation cover of floodplain and bank	Invasive plant spp. cover	Invasive plant spp. density distribution	Disturbance-caused undesirable herb spp.	Preferred tree and shrub establishment and regen.	Utilization of preferred trees/ shrubs	Woody veg. removal other than browse	Decadent and dead woody material	Vegetation Score	Bank root mass protection	Human-caused bare ground	Bank structurally altered	Human physical alteration to site (polygon)	Channel incisement	Soil/ Hydrology Sub-score	Overall Score	Trend
NOS20-Cal	2014									73						40	57	/
NOS21-Cal	2014									73						50	62	/
NOY1 - trib - Cal	2016									60						44	56	
TR-A1 - Air	2014																79	
TR-A2 - Air	2014																57	
TR-A3 - Air	2014																72	
TR-A4 - Air	2014																55	
TR-A5 - Air	2014																73	
TR-A6 - Air	2014																60	
TR-A7 - Air	2014																63	
TR-A8 - Air	2014																41	

Table B. West Nose Creek

Site: West Nose Creek	Most Recent Assessment Year	Veg. cover of floodplain and bank	Invasive plant spp. cover	Invasive plant spp. density distribution	Disturbance-caused undesirable herb spp.	Preferred tree and shrub establishment and regeneration	Utilization of preferred trees and shrubs (browse)	Woody vegetation removal other than browse	Decadent and dead woody material	Vegetation Score	Bank root mass protection	Human-caused bare ground	Bank structurally altered	Human physical alteration to site (polygon)	Channel incisement	Soil/ Hydrology Sub-score	Overall Score	Trend
WNO1 - RVC	2000									67						50	58	
WNO2 - RVC	2000									52						50	51	
WNO3 - RVC	2000									48						50	49	
WNO4 - RVC	2000									59						50	54	
WNO5 - RVC	2000									63						40	51	
WNO6 - RVC	2000									56						63	60	

Site: West Nose Creek	Most Recent Assessment Year	Veg. cover of floodplain and bank	Invasive plant spp. cover	Invasive plant spp. density distribution	Disturbance-caused undesirable herb spp.	Preferred tree and shrub establishment and regeneration	Utilization of preferred trees and shrubs (browse)	Woody vegetation removal other than browse	Decadent and dead woody material	Vegetation Score	Bank root mass protection	Human-caused bare ground	Bank structurally altered	Human physical alteration to site (polygon)	Channel incisement	Soil/ Hydrology Sub-score	Overall Score	Trend
WNO7 - RVC	2009 (2000)									77	NA		NA		NA	67	74	NC
WNO8 - RVC	2000									59						67	61	
WNO9 - RVC	2000									74						63	68	
WNO10 - RVC	2000									74						63	68	
WNO11 - RVC	2000									48						50	49	
WNO12 - RVC	2000									56						63	60	
WNO13 - RVC	2000									89						83	86	
WNO14 - RVC	2000									59						50	54	
WNO15 - RVC	2000									63						47	54	
WNO16 - RVC	2000									37						40	39	
WNO17 - RVC	2000									44						50	47	
WNO18 - Cal	2015 (2007)									77						93	85	+
WNO19 - Cal	2014 (2008)									73						70	72	/
WNO20 - Cal	2015 (2007)									70						70	70	/
WNO21 - Cal	2014 (2007)									73						97	85	+
WNO22 - Cal	2015 (2008)									77						77	77	/
WNO26 - Cal	2015 (2010)									70						93	82	/
WNX-1 - trib - Cal	2016									60						44	56	

APPENDIX G. The role of ephemeral and intermittent watercourses in watersheds.

Ephemeral and intermittent watercourses with vegetated buffers provide *sediment control* and reduce sediment delivery to larger streams. An intact network of functioning ephemeral and intermittent watercourses can reduce downstream sediment transport and reduce dredging costs, flood frequency, reduce water treatment costs, and reduce siltation of larger stream habitats (Ohio EPA 2015).

The associated riparian areas of ephemeral and intermittent watercourses and the instream vegetation (grasses, sedges) provide *nutrient control* by reducing the amount of nutrients reaching larger streams through plant uptake of nutrients and the retention of sediment. Excess nutrients are a common cause of stream pollution and often lead to excessive algae and aquatic plants in waterways. Ephemeral and intermittent watercourses also reduce amounts of other pollutants, such as herbicides. By reducing the amount of nutrients, an intact network of functioning ephemeral and intermittent streams can improve recreational opportunities and reduce water treatment costs, human health risks and degradation of downstream waters (Ohio EPA 2015).

Ephemeral and intermittent watercourses provide *flood control* because of their close connection to groundwater, wetlands, and subsurface water flows. Ephemeral and intermittent streams are important in controlling the flow of water to larger streams. By controlling the flow of water to larger streams, an intact network of functioning ephemeral and intermittent watercourses can reduce local and downstream flooding and prevent excess erosion (Ohio EPA 2015).

There are numerous biological benefits of ephemeral and intermittent watercourses. The cooler groundwater discharge from intermittent streams may help to provide areas of thermal refuge in Nose Creek watershed during periods of drought and/or extremely warm air temperatures. This is particularly important as salmonids such as brown trout and brook trout continue to expand their range in the watershed. Intermittent streams may provide habitat for fish and the contributions of coarse particulate organic matter (CPOM) (i.e., allocthonous inputs[118]) and production of macroinvertebrates provides components of downstream fish habitat (Reid and Ziemer 1994). The seasonally wet conditions of ephemeral and intermittent watercourses and the associated riparian area provide wildlife habitat and corridors for amphibians, reptiles, birds and small and large-mammals (Reid and Ziemer 1994; McDonough *et al.* 2011).

In urban areas, ephemeral and intermittent watercourses provide additional functions. Ephemeral and intermittent watercourses maintained in urban developments may serve as emergency spillways to minimize the impact of flooding during extreme rainfall events. These systems may also maintain and improve water quality for downstream water users.

[118] Allocthonous Inputs: Energy sources derived from outside the stream system from the terrestrial environment. Leaves, twigs, fruit and seeds etc. are typical forms of terrestrial CPOM that enter the water by direct litterfall. Long-term sources of allochthonous inputs are important as a source of habitat and food for benthic invertebrates, the main food source for trout.

APPENDIX H. Maintenance and monitoring of bioengineering and restoration projects.

The success of new bioengineering and riparian planting projects will depend on how well the site is maintained and monitored. The following provides some guidance to improve success. Additional guidance can be found in The Design Guidelines for Erosion and Flood Control for Streambank and Riparian Stability Restoration (AMEC Environment and Infrastructure 2012).

Maintain new soil bioengineering and riparian planting projects:

a. Water new plantings frequently until they are established.
b. Apply cardboard and wood chip mulch around new plantings, where necessary, to reduce potential for competition with disturbance-caused non-native grasses.
c. Replace dead plantings as needed.
d. Install beaver and wildlife fencing (where necessary) to protect new plantings.
e. Minimise the use of chemical herbicides and fertilizers.

Monitor new soil bioengineering and riparian planting projects to assess survival and inform future projects. Monitoring and record keeping efforts should include:

a. Source and type of plant materials used,
b. Planting methods used,
c. Assessment of survival rates of native plants by species,
d. Site maintenance effort and cost (e.g. weed removal and watering costs)
e. A photo journal documenting before, during, and after conditions of the project
f. Evaluate success and failure and use the findings to improve future riparian enhancement projects.

Protect mature trees from beaver use with appropriate 2” x 4” wire mesh cylinders to a minimum height of 1.0 m (or taller depending on average snow depth). Avoid using chicken wire as this typically rusts out quickly. Alternatively, mature trees can be protected from beaver damage by brushing them with a pre-mixed coating of 6 cups of coarse sand mixed with one gallon of exterior latex paint. The coarse sand/paint mix should also be applied to a minimum height of 1 m (or taller depending on average snow depth).[119]

[119] Adapted from Cows and Fish Riparian Health Inventories for Nose and West Nose creeks, 2014 and 2015.

APPENDIX I. Summary of fish species utilizing Nose and West Nose creeks, and temperature requirements.

At Nose Creek, as a percent of total catch (11 species, n=1712) from May 2004 to October 2014, the fish community was dominated by three species: Brook Stickleback (42%), White Sucker (17%), and Lake Chub (16%). Other less common species included Fathead Minnow (10%), Longnose Dace (7%) and Longnose Sucker (5%). Mountain Whitefish, Brown Trout, Brook Trout, Trout-Perch and Prussian Carp made up the remaining 3% of the total catch (FWMIS online database, accessed March 1, 2016). Upstream of the confluence with West Nose Creek (i.e., Balzac, Airdrie and Crossfield area), 98% of the fish catch was provided by four species: Brook Stickleback (60%), Lake Chub (14%), White Sucker (13%) and Fathead Minnow (11%) out of a total of six fish species. From the mouth of Nose Creek to the confluence with West Nose Creek, 98% of the fish catch was provided by seven species: White Sucker (26%), Lake Chub (21%), Longnose Dace (17%), Longnose Sucker (14%), Fathead Minnow (8%), Brook Stickleback (7%) and Mountain Whitefish (5%) out of a total of 11 fish species.

Table I.1. Summary of fish species utilizing Nose Creek and West Nose Creek.

Creek	Species
Nose Creek	Brook Stickleback, White Sucker, Lake Chub, Longnose Dace, Longnose Sucker, Fathead Minnow, Mountain Whitefish, Brown Trout, Brook Trout, Northern Pike, Trout-Perch, Prussian Carp
West Nose Creek	Lake Chub, Brook Stickleback, White Sucker, Longnose Dace, Longnose Sucker, Fathead Minnow, Brown Trout, Mountain Whitefish

At West Nose Creek, as a percent of total catch (8 species, n=893) from March 2006 to May 2012, the fish community was dominated by three species: Lake Chub (30%), Brook Stickleback (28%) and White Sucker (28%). Other less common species included Longnose Dace (9%) and Longnose Sucker (4%). Fathead Minnow, Brown Trout and Mountain Whitefish made up the remaining 1% of the total catch (FWMIS online database, accessed March 1, 2016). Two Brown Trout and a single Mountain Whitefish were captured at West Nose Creek in 2010. During October 2015, Bow Valley Habitat Development undertook angling and spawning surveys at West Nose Creek. Five Brown Trout (10 to 48 cm in length) were captured in a 1200 m reach of the creek downstream of the Harvest Hills Blvd bridge on October 9, 2015 for a catch per unit effort of 1.2 trout per hour (BVHD 2015). Between October 6th and 10th, 2015, five trout redds were identified in a 1100 m reach of West Nose Creek from 400 m upstream to 700 m downstream of the Harvest Hills Blvd bridge. Between October 14th and 16th, 2015, 10 trout redds were identified in a 120 m reach of West Nose Creek immediately underneath and downstream Country Hills Blvd bridge. Visual observations were made of some Brown Trout over the redds (BVHD 2015). In the fall of 2016, spawning surveys by Bow Valley Habitat Development documented 31 trout redds, with some occurring 10 km upstream from the mouth (between Stoney Trail and Panorama Rd NW) (BVHD 2016).

The Province of Alberta has developed Restricted Activity Periods (RAPs) for watercourses throughout Alberta. During the RAP, instream construction activities are typically prohibited. RAPS were developed to protect sportfish during the period of pre-spawning, spawning, egg incubation and fry emergence. Currently Nose Creek and West Nose Creek are designated Class C watercourses with a Restricted Activity Period (RAP) from April 1 to May 31 (mouth to headwaters). This is a RAP to protect spring-spawning fish such as Northern Pike and Yellow Perch but is not biologically relevant as Brown Trout spawn in the fall with eggs incubating in the substrate over the winter. A more appropriate RAP would be September 16 to April 5 to protect brown trout which are known to spawn in West Nose Creek. This fall/winter RAP would also protect spawning brook trout and mountain whitefish should these two species spawn in Nose or West Nose creeks.

Table I-2. Summary of water temperatures (°C) required for sport fish species in Nose Creek and West Nose Creek. Temperatures in **green** are optimum temperatures for growth and health. Temperatures in **black** are the tolerance range (sub-optimum growth and health at the lower and upper extreme temperature). This is important because temperatures higher than the upper tolerance range may result in mortality for all life history components and cessation of spawning. Temperatures lower than lower tolerance range may result in reduced growth for all components, cessation of spawning and increased mortality for incubating eggs and newly-emerged fry.

Species	Waterbody	Egg Incubation	Egg Incubation Timing	Fry	Juvenile	Adult	Spawning	Spawning Timing	Reference[120]
Brown Trout (*Salmo trutta*)	Nose Creek, West Nose Creek	3 - 8 0 - 12	148 days at 2°C: Oct to late-Mar	14 - 17 5 - 24	7 - 19 0 - 27	12 - 19 0 - 27	7 - 9 5.5 - 10	Oct to Dec	3, 6, 9, 10, 14, 15, 16
Brook Trout (*Salvelinus fontinalis*)	Nose Creek	6 <12	100 days at 6°C: late-Sep to Feb	12 - 15 0 - 19	11 - 16 0 - 24	14 - 18 0 - 25	9 6 - 11	late-Sep to Nov	2, 3, 6, 7, 8, 13
Mountain Whitefish (*Prosopium williamsoni*)	Nose Creek, West Nose Creek	<7 <9	180 - 220 days at 0°C: late-Sep to Apr	14 <17	9 - 12 0 - 20.6	13 - 18 0 - 20.6	3 - 9 <10	late-Sep to Nov	1, 2, 3, 4, 5, 11, 12, 14, 15

[120] **Reference list for Table I-2**

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13 - Blanchfield, P.J., and M.S. Ridgway. 1997. Reproductive timing and use of red sites by lake-spawning brook trout (*Salvelinus fontinalis*). Canadian Journal of Fisheries and Aquatic Science 54: 747-756.

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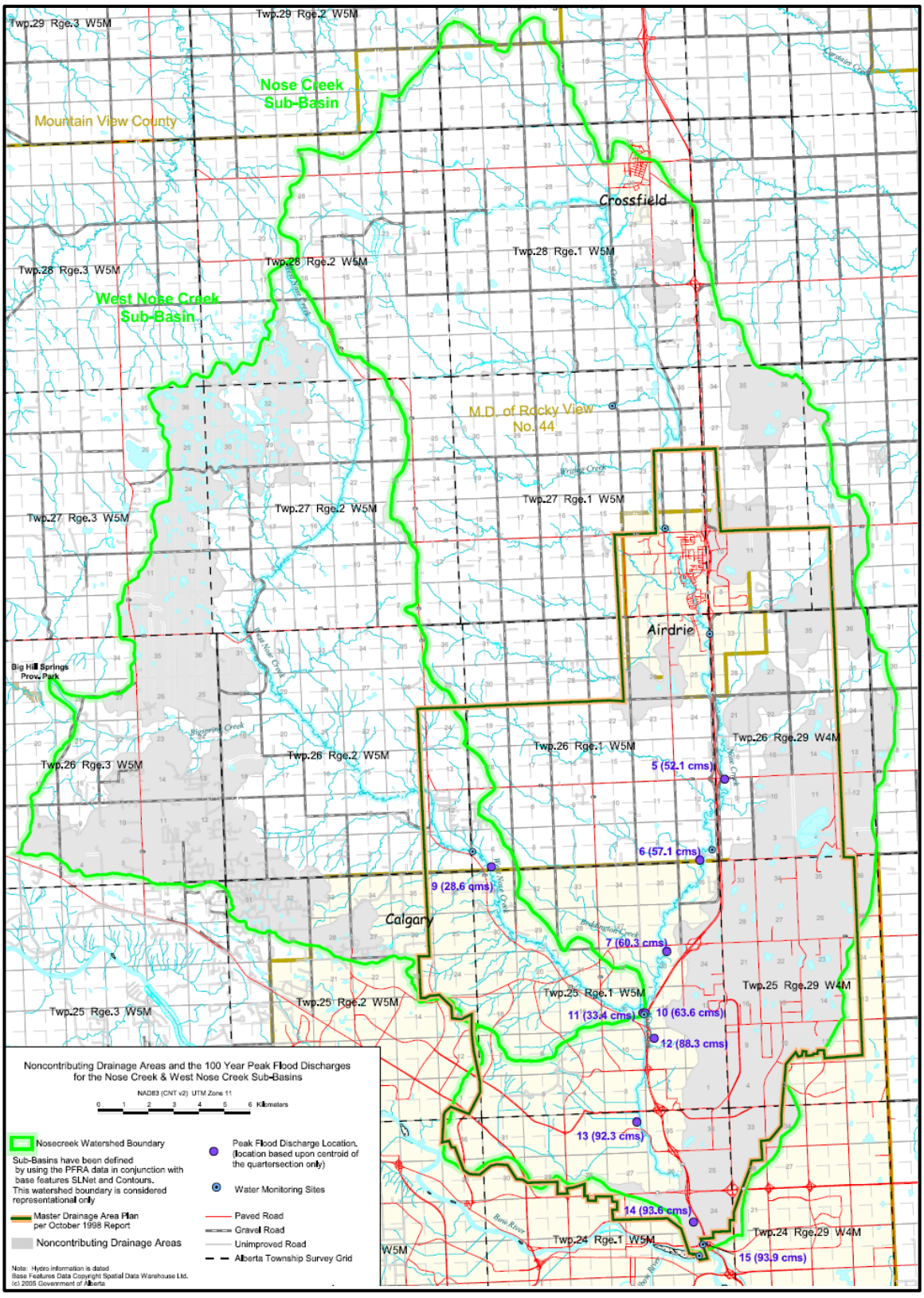
APPENDIX J. Key reference maps supporting the Nose Creek Watershed Water Management Plan.

Maps included in this appendix are intended to provide cursory information regarding watershed hydrology, important natural features, and land use in the watershed. The maps provide a general overview of the watershed and do not replace responsibilities of detailed assessment or investigation when required (e.g., biophysical impact assessment, environmental impact assessment).

Included in this series:

- J-1. Internal drainage areas (non-contributing areas)
- J-2. Water monitoring locations
- J-3. Alberta merged wetland inventory
- J-4. Groundwater quality risk
- J-5. Human footprint

J-1. Internal drainage areas (non-contributing areas) (shaded grey).



J-2. Historic and current water monitoring locations.

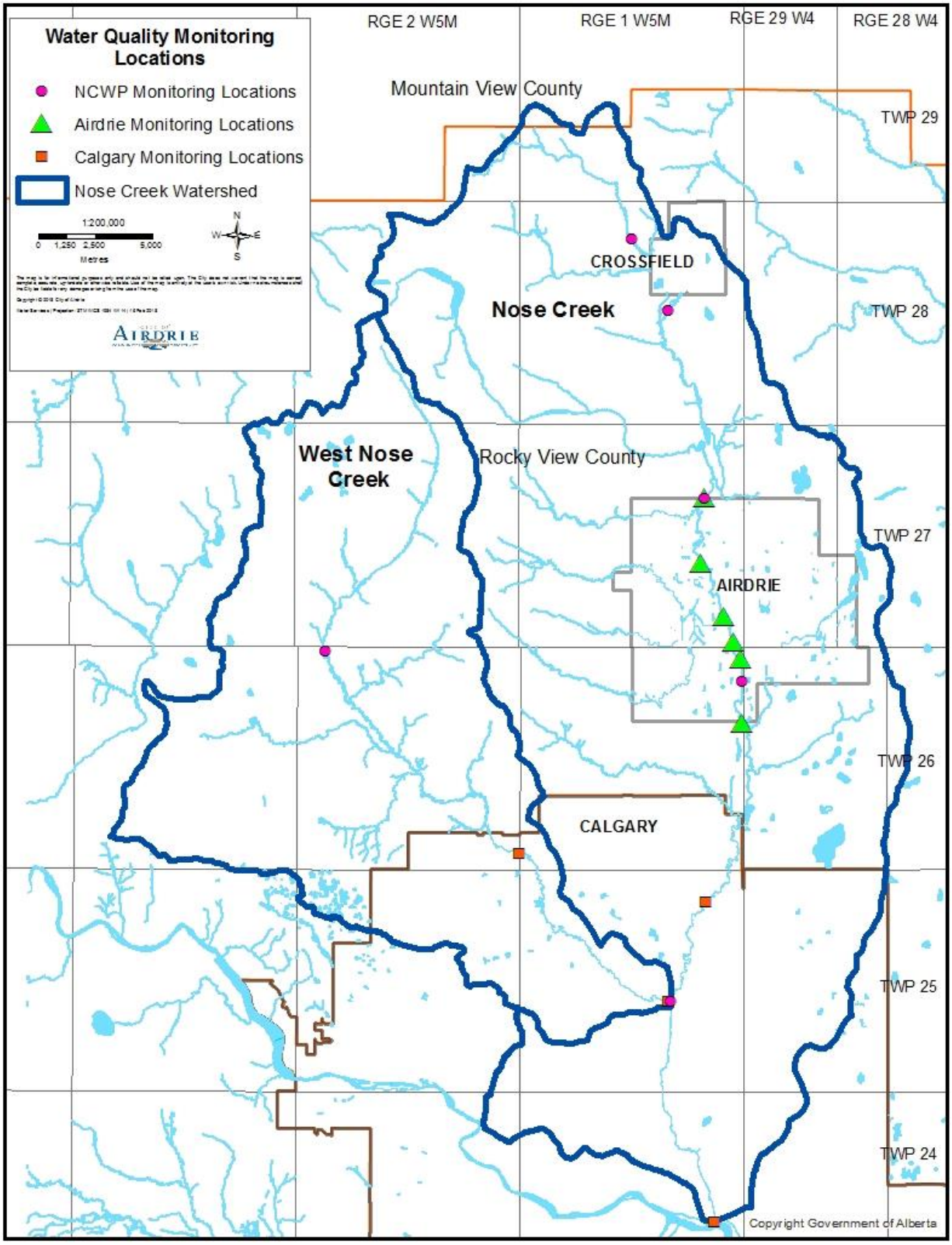


Table J-2.1. Historical monitoring locations.

Site Name	UTM Coordinates	
Site 1 – NC U/S Crossfield (NEW)	11U703543	5701784
Site 2 – NC D/S Crossfield (NEW)	11U705270	5698762
Site 3 – NC U/S Airdrie (Existing - AB05BH0300)	11U707182	5690627
Site 4 – NC D/S Airdrie (Existing - AB05BH0310)	11U709175	5682704
Site 5 – NC U/S WNC (Existing - ABO5BH0330)	11U706614	5668605
Site 6 – WNC @ Bighill Springs Rd. (NEW)	11U690928	5683285

Table J-2.2. Sites currently monitored by The City of Calgary.

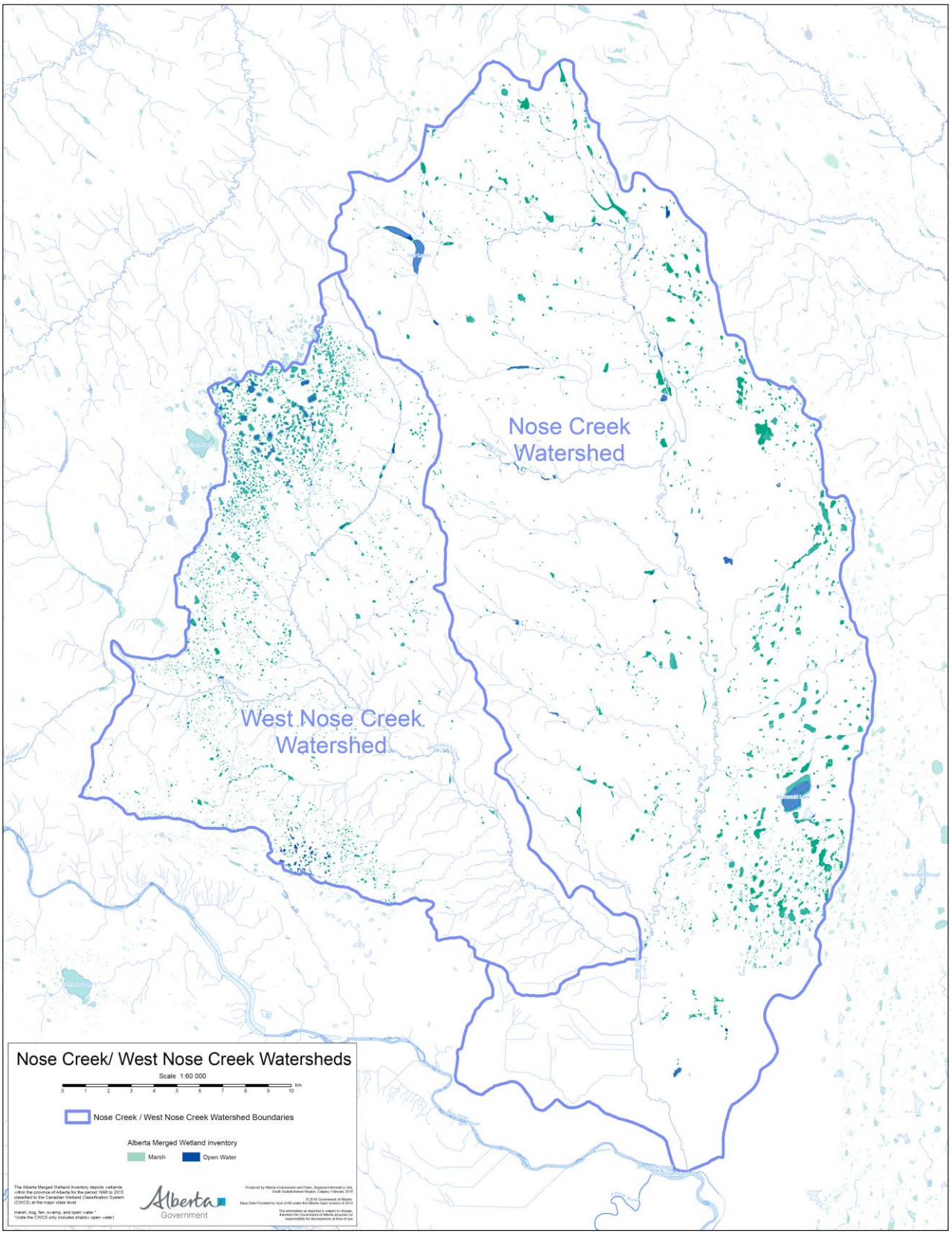
Site Name	UTM Coordinates	
Nose Creek at 15th Street (City Limits)	11U708027	5673032
Nose Creek at the Mouth (AB05BH2600)	11U708859	5659391
West Nose Creek U/S Mountain View Rd NW (AB05BH2590)	11U699702	5674845
West Nose Creek U/S of confluence with Nose Creek (AB05BH0360)	11U706601	5668415

Note: As The City of Calgary and City of Airdrie continue to grow, water monitoring locations should be added to document new city limits. Old city limit sites may be phased out after three years.
Note: The sites NC3 and NC4 were monitored by AENV on five-year cycles for a duration of three years each cycle. In 2009, this program was cancelled due to budget constraints.

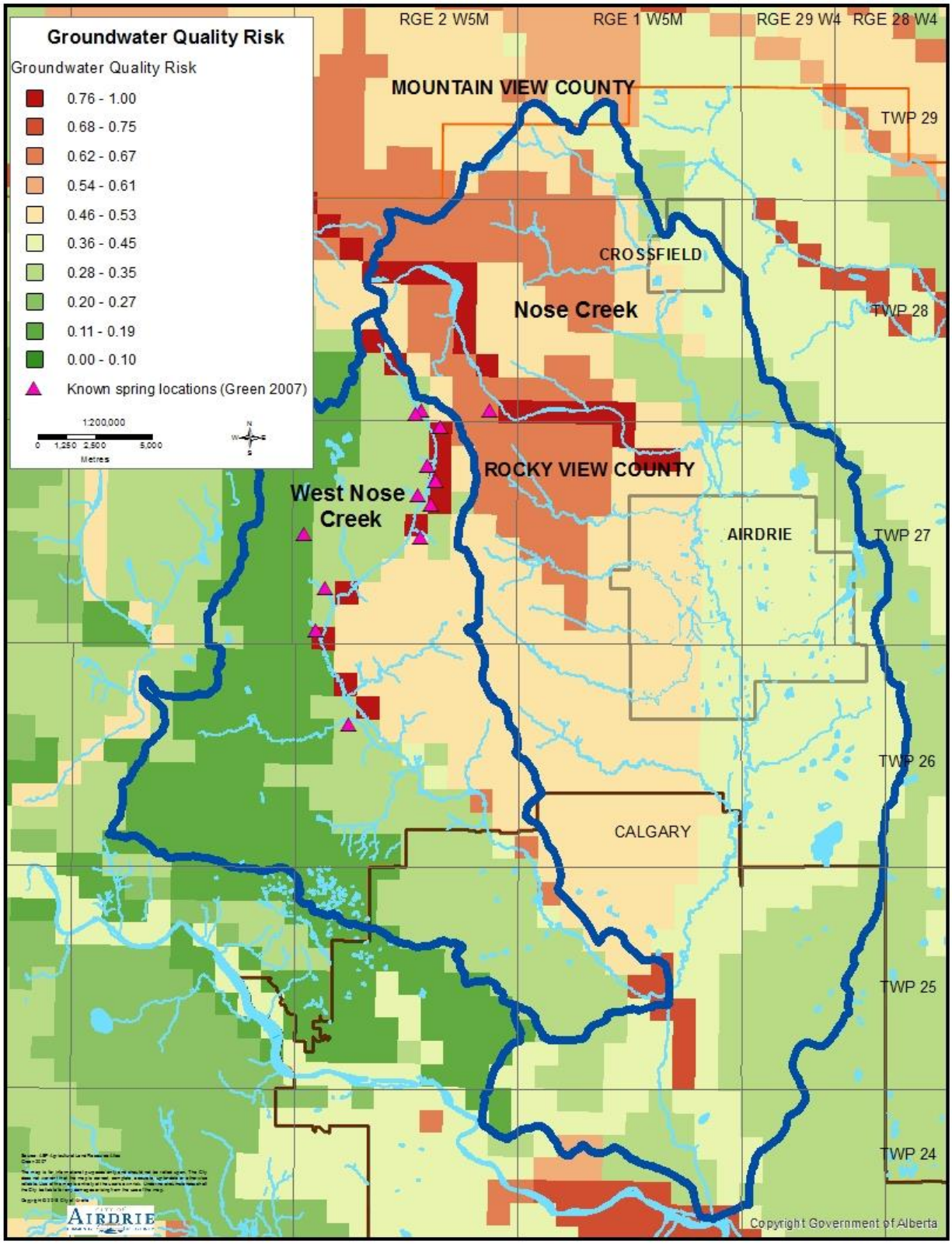
Table J-2.3. Sites currently monitored by City of Airdrie.

Sample Name	Latitude	Longitude	UTM Easting	UTM Northing	Site Location Description
NC1	51.32920045	-114.0258417	11U707195	5690634	TWP RD 274 Bridge
NC2	51.30369955	-114.0283233	11U707167	5687792	Williamstown Environmental Reserve North Pedestrian Bridge
NC3	51.2827152	-114.0137278	11U708249	5685501	Nose Creek Park by Rideau Close SW
NC4	51.2725619	-114.0076459	11U708719	5684389	Summerfield RD SE
NC5	51.26577131	-114.0031085	11U709067	5683647	Sierra Springs Drive SE Bridge
NC6	51.24087791	-114.002125	11U709248	5680882	TWP RD 264

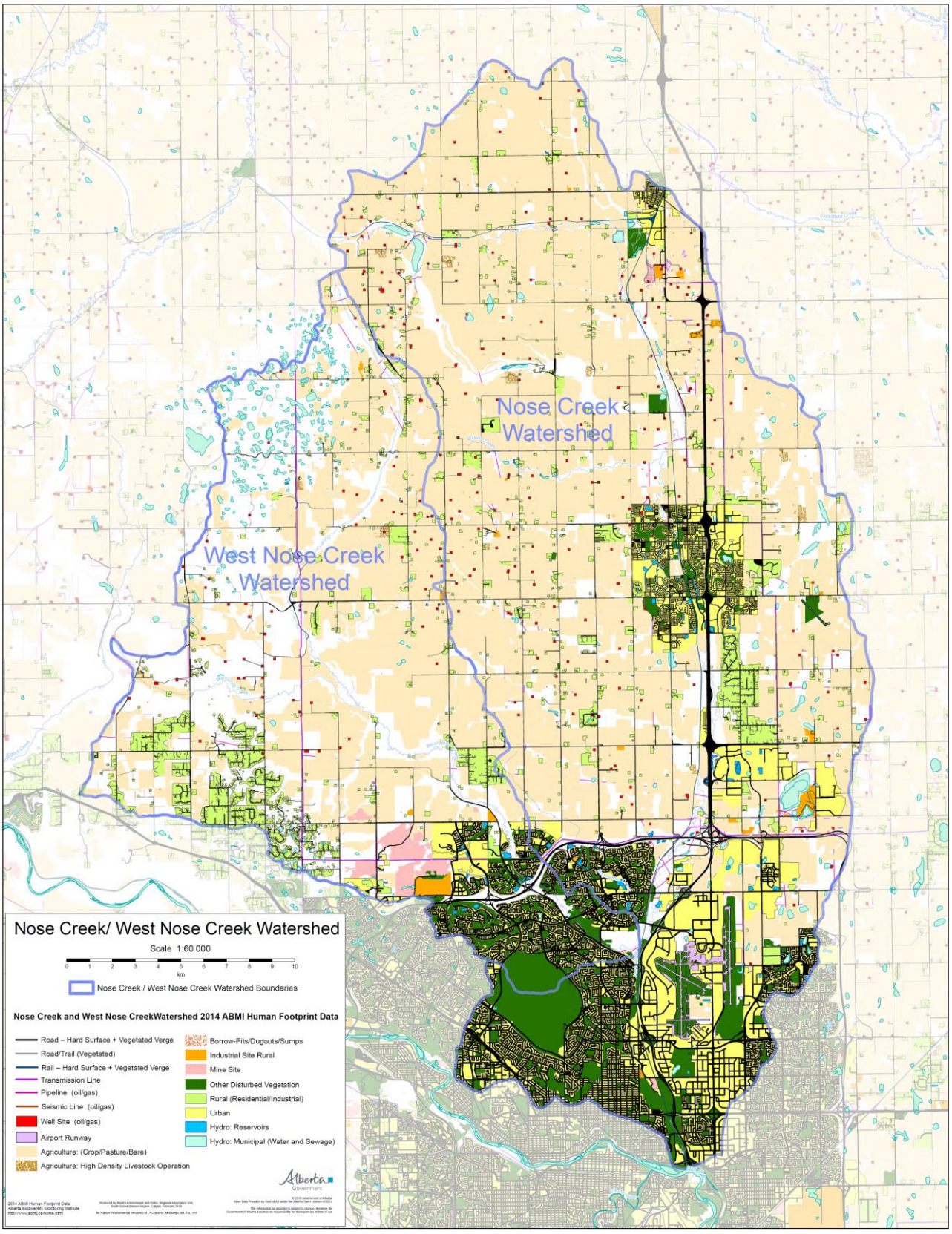
J-3. Alberta Merged Wetland Inventory.



J-4. Groundwater vulnerability.



J-5. Human footprint in the Nose Creek watershed (ABMI 2014) (AEP 2018).



APPENDIX K. NCWP implementation priorities.

Table K-1. Summary of Plan implementation priorities for the NCWP. Note that only the recommendations that were ranked in the top five priorities by at least one jurisdiction are shown.

Priority	Preliminary Implementation Timeline
1, 2 and 3	Short-term
4 and 5	Medium Term
6 +	Long-Term
Not ranked	

Recommendation	Priority Rank				Discussion
	COA	COC	CAA	RVC	
1. Watershed condition reporting					- A core activity, contingent on monitoring data - A priority for communication, evaluate progress
2. Develop a hydrologic/ hydraulic and water quality model					- Considered the tool that is needed to support implementation of many secondary actions (e.g., updates existing hydrologic/hydraulic conditions, evaluation of runoff volume control target, Total Maximum Loadings,) - Unique role for Partnership
3. Develop and implement a standardized water monitoring program					- An urgent need to support the modelling tool - Calgary and Airdrie already monitoring, requires coordination for water quality - Main data gap is streamflow data collection - Discussion should take place with Technical Team and sub-committee to determine monitoring priorities
4. Initiate erosion monitoring					- Important to establish a baseline of channel structure/morphology for future comparison in an erosion monitoring program
5. Develop stormwater quality guidelines					- Viewed as a secondary action
6. Prioritize restoration activities					- Viewed as a secondary action to higher priority recommendations
7. Assess riparian health					- Important for watershed condition reporting, supports main goals - Some Partners are implementing on large scales already
8. Complete a watershed-scale wetland valuation					- Airdrie is working to complete for municipality - An important action but may be limited in capacity - Review recommendation priority annually to determine capacity