The Nursery Golf & Country Club Inc.

Proposed R.V. Park

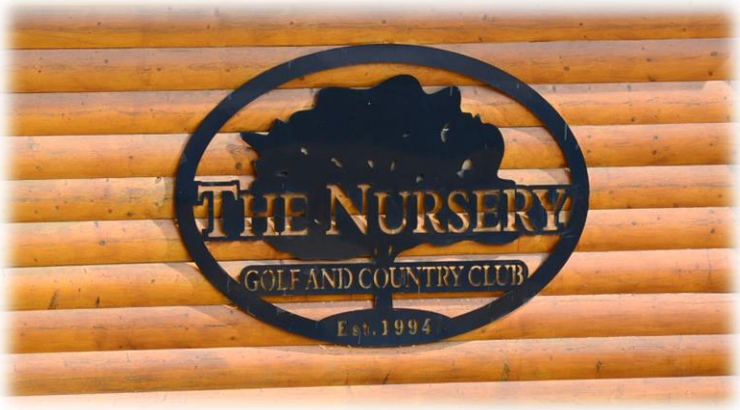
SW ¼ Sec 7-41-26-W4M

Stormwater Management Plan

Revision 2.1

Prepared for:

The Nursery Golf & Country Club Inc.



Prepared by:

WSP Canada Inc.

August 2017

161-15869-00

Executive Summary

On behalf of The Nursery Golf & Country Club Inc., WSP Canada Inc. (WSP) has prepared a Stormwater Management Plan for ***The Nursery Golf & Country Club Inc. Proposed R.V. Park*** site approximately 13 km north of the City of Lacombe, Alberta.

The stormwater management system for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* site will incorporate the following features:

- The proposed stormwater concept for this development is the implementation of the major drainage system concept as well as the stormwater management facility.
- It is recommended that a value of **2.0 L/s/ha** be adopted as the allowable release rate (unit area discharge) to determine runoff storage requirements for the existing *The Nursery Golf & Country Club Inc. Proposed R.V. Park* development as recommended in the MPE report (2014).
- The performed computer modeling indicates that the required storage capacity for the site is **500 m^3**. The outlet pipe will be a 300 mm diameter PVC pipe (approximately 150 m long) complete with a **41 mm diameter orifice**. The preliminary design of the dry pond will include 5H:1V sideslopes, an active storage depth of 1.5 m and a 0.30 m freeboard allowance.
- The outflow from the proposed SWMF will be conveyed east from the proposed pond towards Lake ID 307554. The terrain east of the proposed dry pond generally falls in elevation towards the lake. It is assumed that Lake ID 307554 is hydraulically connected to Lake ID 307526 farther downstream from the Nursery Golf & Country Club. The treatment train composed by the proposed SWMF, Lake ID 307554, and Lake ID 307526 then becomes the adequate outlet for this site.

Table of Contents

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOGRAPHS

1.0 Site Description

1.1 INTRODUCTION

The Nursery Golf & Country Club Inc. (the Nursery) has commissioned WSP Canada Inc. (WSP) to prepare a Stormwater Management Plan for ***The Nursery Golf & Country Club Inc. Proposed R.V. Park*** located approximately 2 km north of the city limits of the City of Lacombe, Alberta.

The Stormwater Drainage Plan defines the development's storm drainage concepts as well as the catchment boundaries of the development.

1.2 STUDY AREA

The parcel of land that defines the study area is situated within Lacombe County. The Nursery Golf & Country Club is located approximately 2 km north of the intersection of Highway 2 and Range Road 270. Access to the Nursery from the intersection of 50th Avenue and Highway 2 (downtown Lacombe) along Highway 2, Township Road 412, and Range Road 270 requires traversing approximately 13 km of highway. Direct access off Highway 2, north along Range Road 270, was not possible at the time of the writing of this report.

The specific development site is located east of the Clubhouse / Pro Shop parking lot and encompasses an area of approximately 2.14 ha (5.29 acres) entirely within the Nursery Golf & Country Club's property (the Driving Range area). The proposed development will replace the existing Driving Range by the proposed R.V. Park. The proposed pond facility will be located at the northeast corner of the existing driving range area.

1.3 BOUNDARIES OF THE STUDY AREA

The Nursery property consists of land located within the SW ¼ Sec 7-41-26-W4M (SW quarter, Section 7, Township 41, Range 26, West of the 4th Meridian) and includes an area of approximately 64.7 ha (160 acres). The *Proposed R.V. Park* development is a subset of the Nursery property. The proposed development site is approximately 2.14 ha in area and is currently being utilized as the driving range of the Golf Course & Country Club. The site is bounded on the south by the existing entrance road, to the west, northwest, north, and east by a

high net enclosure surrounded by trees. There are no significant structures within the plan area (driving range) at present.

Photo 1. Entrance gate to The Nursery Golf & Country Club (view to the north).

Photo 2. Driving Range (view to the southwest).

1.4 BACKGROUND AND SALIENT FEATURES

The present study has referenced the following documents:

- Alberta Environmental Protection *Stormwater Management Guidelines for the Province of Alberta* (January, 1999).
- Alberta Environment and Sustainable Resource Development. *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. Part 5. Stormwater Management Guidelines of a Total of 5 Parts*. (2013).
- Atkinson, N., Utting, D.J., and Pawley, S.M. (2014): Glacial Landforms of Alberta, Canada; Alberta Energy Regulator, AER/AGS Map 604, scale 1:1,000,000.
- Benn, D.I., and Evans, D.J.A. *Glaciers & Glaciation*. 1998 (2006 reprint).
- Environment Canada. *Short Duration Rainfall Intensity-Duration-Frequency Data*. Red Deer Airport. 21 December 2014.
- Fenton, M.M., Waters, E.J., Pawley, S.M., Atkinson, N., Utting, D.J., and McKay, K. (2013): Surficial Geology of Alberta; Alberta Energy Regulator, AER/AGS Map 601, scale 1:1,000,000.
- J.F. Sabourin and Associates Inc. *Stormwater Management Hydrologic Model User's Manual* (May, 2000. Reprinted April 2005).
- J.F. Sabourin and Associates Inc. *Stormwater Management Hydrologic Model Examples Guide* (May, 2000. Reprinted April 2005).
- Lacombe County. *Standards Manual*. https://www.lacombecounty.com/index.php/standards-manual.
- Leet, L.D., Judson, S., and Kauffman, M.E. *Physical Geology*. 1978.
- Natural Resources Conservation Service. United States Department of Agriculture. *National Engineering Handbook. Part 630 Hydrology*. Chapter 9. Hydrologic Soil-Cover Complexes. (2004).

1.4.1 Regional and Local Features

The *Nursery Proposed R.V. Park* property is located in a low relief corridor extending from approximately Morningside to Blackfalds within Lacombe County. This low relief corridor is represented in the *Lacombe County Shaded Elevation Map* (attached hereto as Appendix G) by blue-green shading. This geological feature has been color coded in *Map 601*, *Surficial Geology of Alberta*. The Alberta Geological Survey (AGS) indicates that the "most abundant geological unit that covers the Alberta landscape originated during the Pleistocene, as a result of the advance and retreat of Quaternary ice sheets that deposited moraine and glaciolacustrine deposits." The AGS further notes that:

> "Ice advance was responsible for the widespread deposition of moraine [undivided, stagnant ice, fluted, and ice thrust] extending from plains in the southern, central, and northeastern parts of Alberta, to uplands in the west and north. Stagnant ice moraine is a widespread unit in north-central Alberta. It is also abundant across uplands within the western and eastern Alberta plains, particularly along the flanks of three prominent, low-relief corridors of fluted moraine extending south between Edmonton and Calgary, to the east and west of Red Deer, and southeast from Lac La Biche." AGS, 2013, Map 601 legend.

The AGS has mapped the significant glacial landforms in the region (where the project site is located) in Map 604, *Glacial Landforms of Alberta*. The geological units within the region, where the proposed Nursery R.V. Park is located, include *streamlined bedforms*, *moraine ridges*, and *eskers*. The pertinent sections of Maps 601 and 604 have been attached hereto as Appendix I.

The mentioned geological features in the region give rise to gently undulating terrain with shallow topographical relief containing numerous kettles, sloughs, wetlands, and shallow lakes characterized by poor drainage, geomorphologically referred to as "*ice-stagnation topography."* Benn and Evans, 1998 (2006 reprint), page 481. The Morningside to Blackfalds low-relief corridor resembles "a pitted outwash plain, typical of much of Canada and the United States." Leet, Judson, and Kauffman, 1978, page 314. In the local area surrounding the proposed Nursery R.V. Park development, there are many such depressional geologic features.

The regional and local features are presented below in **Figure 1.1 Regional Context – Low relief corridor** and **Figure 1.2 Local Features for the existing *Nursery Golf Course***. **Figure 1.3 Existing Sub-catchment Flows** indicates the existing overland flows for the proposed RV park area. Within the Nursery Golf & Country Club property, **Figure 1.4 Conceptual RV Park Layout** presents the proposed RV Park, proposed pond location, and outlet pipe alignment.

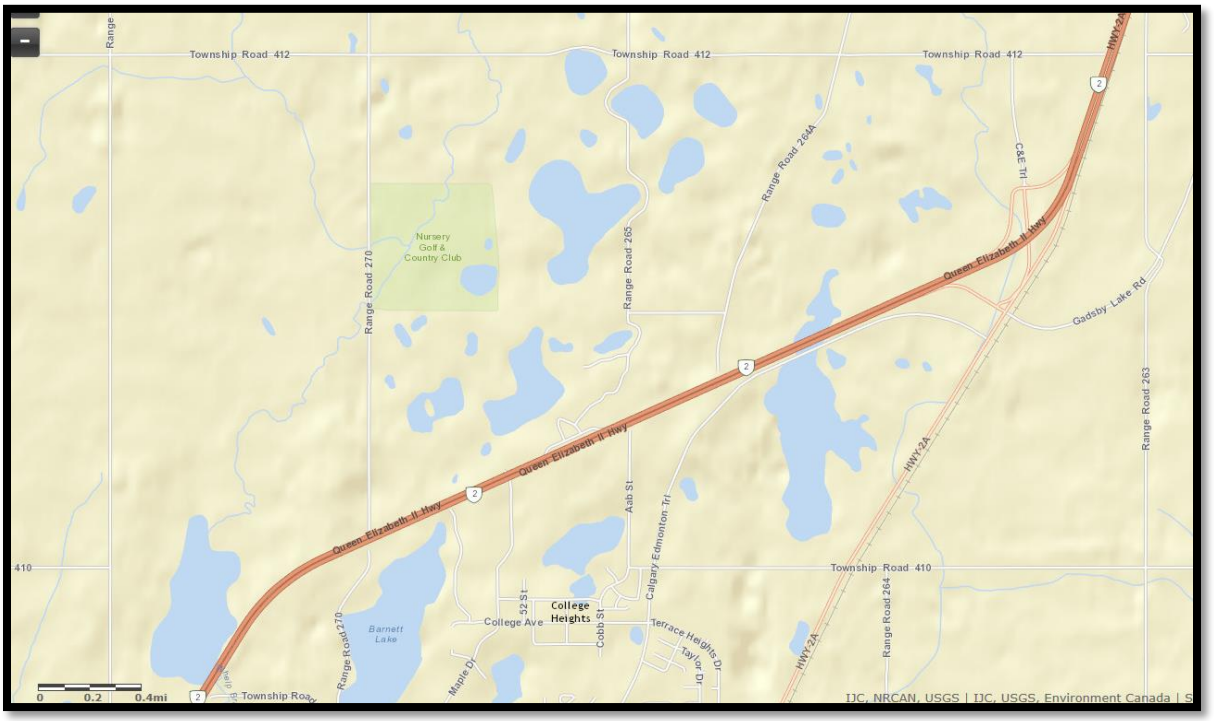
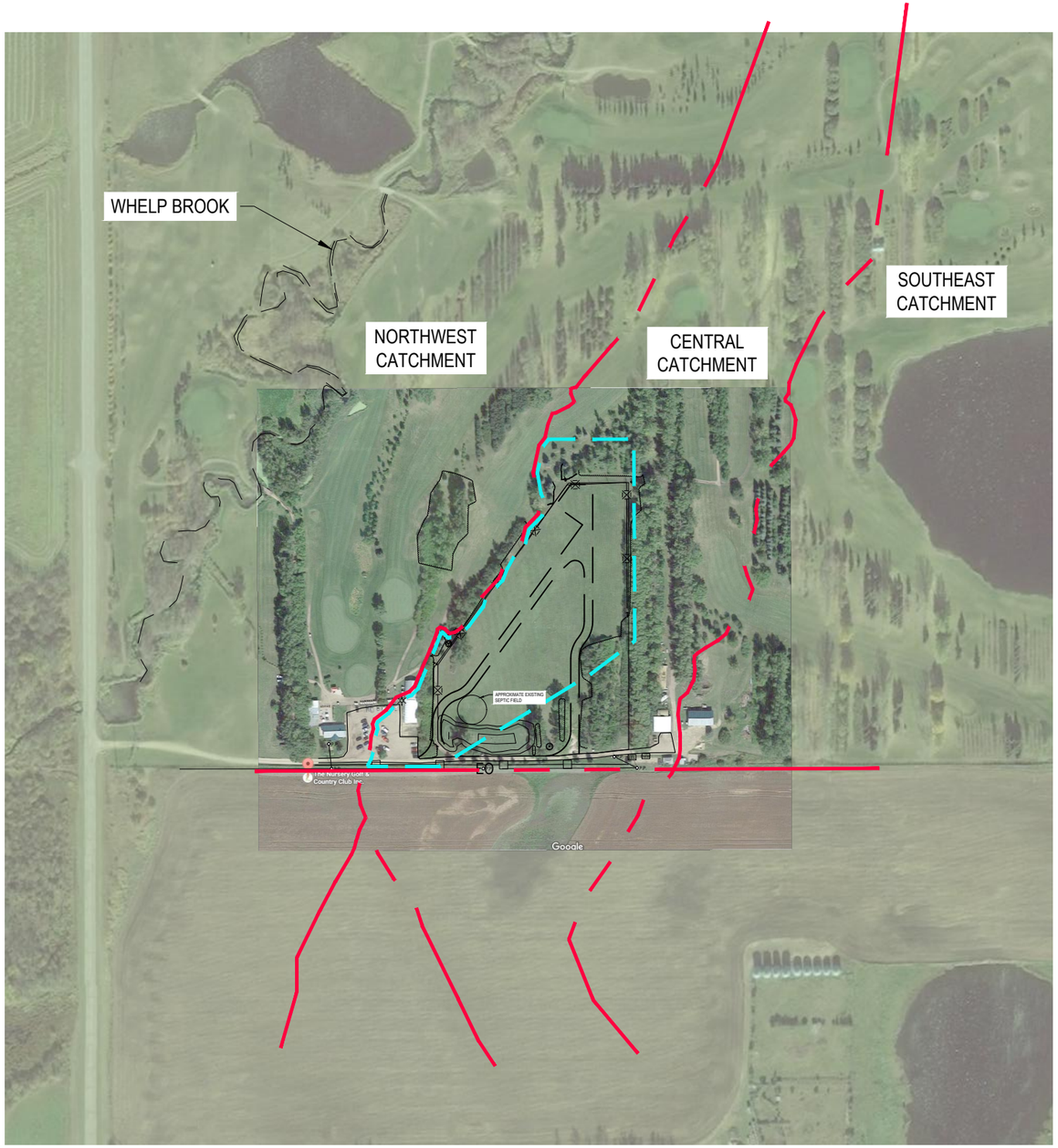


Figure 1.1 Regional Context – Low-relief corridor.
Source: International Joint Commission on shared waters (U.S. – Canada)
(http://www.ijc.org/en_/Oldman-Poplar_River_Drainages, accessed 15 December 2016.)

Figure 1.2 Local Features for the existing *Nursery Golf Course.*
The yellow outline indicates proposed RV park location
Source: Google Earth, accessed 15 December 2016.

FIGURE 1.3 - EXISTING SUB-CATCHMENTS



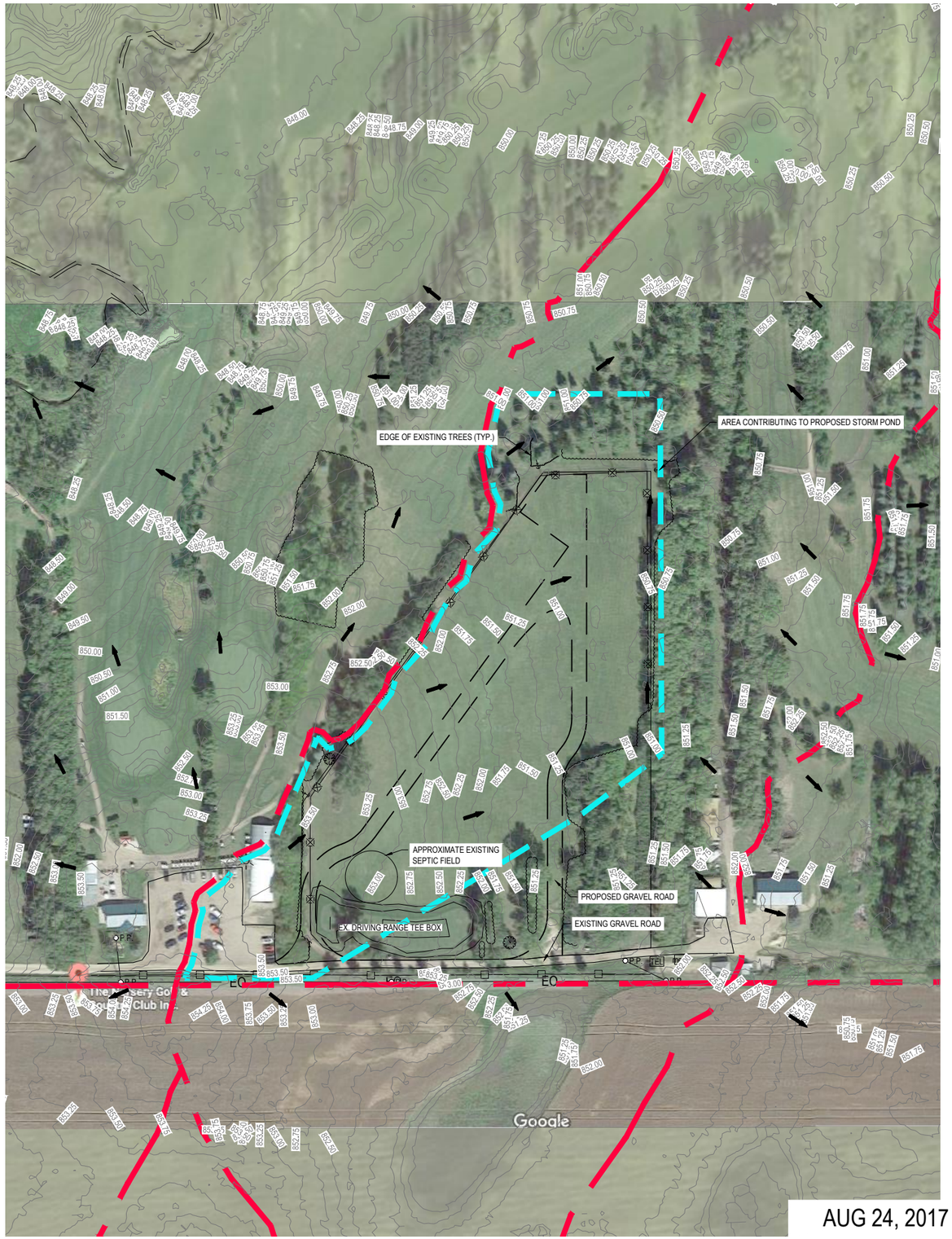


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FIGURE 1.4 - CONCEPTUAL RV PARK LAYOUT

1.4.2 Topography and Drainage

The Regional Hydrology of the area is dominated by the Battle River as it traverses the terrain west, south, and east of the Town of Ponoka. Whelp Brook, with headwaters southwest of the City of Lacombe, traverses the terrain in a southwest to northeast direction towards its confluence with Wolf Creek approximately 5 km northwest of the Hamlet of Morningside, Alberta. Numerous unnamed creeks contribute runoff to both the Whelp and Wolf Creeks along their mainstems. Wolf Creek meanders in a generally north, east, then northwest direction towards the confluence with the Battle River approximately 6 km downstream. The *Master Drainage Plan For the Wolf Creek and Whelp Brook Watersheds* by MPE Engineering Ltd. (2014) characterizes the Wolf Creek watershed as follows:

> "The Wolf Creek watershed has a drainage area of 524 km^2, with its headwaters southeast of the City of Lacombe, and empties into the Battle River about 36 km to the north, near the Town of Ponoka. Located in the western portion of the Wolf Creek watershed, Whelp Brook is the largest subwatershed, having a drainage area of 307 km^2. The Town of Blackfalds is in the headwaters of Whelp Brook which empties into Wolf Creek about 30 km to the north." MPE, 2014, page 3.

The MPE report also indicates the watershed "contains well drained topography as well as shallow topographical relief containing numerous potholes, sloughs and shallow lakes characterized by poor drainage." MPE, 2014, page 3. The Wolf Creek and Whelp Brook drainage basins are presented on Figure 1 of the MPE report, attached hereto as Appendix J.

WSP Personnel visited the site on the 6th and 7th of April 2017 to discuss any salient drainage issues (Spring runoff, flooding, etc.), to examine the site's drainage paths and existing water bodies, to evaluate preferential drainage routes, to examine the existing site's local topography, to obtain photographic records, as well as to discuss the preferred outlet direction from the proposed stormwater management facility. Mr. Karl Dillman, Operations Manager, was on site to facilitate the site visit by WSP personnel.

The Local Hydrology of the area is dominated by Whelp Brook which runs approximately diagonally through the site in a southwest to northeast direction; as well as by approximately 14 water bodies located throughout the site. Mr. Dillman has indicated that these 14 water bodies may be considered to be permanent since they contain water throughout the year. An additional six (6) areas were subject to transient flooding during Spring runoff in any given year. Mr. Dillman also pointed out that extensive flooding approximately paralleling Whelp Brook was observed during 2007 (a year of severe storm events in the area). The predominant direction of the flooding wave during Spring runoff was identified as approximately paralleling Whelp Brook from the

southwest to the northeast. Flooding was reported to affect fairways 10, 11, 12, 14, 15, 17, and 18 to various degrees of severity. In order to minimize the yearly flooding, the Whelp Brook within the Nursery property has been bermed to contain the flow within its banks.

Photo 3. Flooding at the entrance gate to the Nursery (view to the northwest).

Photo 4. Whelp Brook - Berm - Flooded areas east of berm (view to the north).

The Nursery site has been divided into three (3) subcatchments: a northwest subcatchment (east of Whelp Brook), a central subcatchment, and a southeast subcatchment. Figure 1.3 indicates the subcatchments.

Runoff from the NW subcatchment makes its way to Whelp Brook; this subcatchment does not affect the subject site and is not considered further. The central subcatchment's drainage direction is to the north and northwest towards Whelp Brook (further north within the golf course property). The SE subcatchment conveys runoff in a generally east direction to an existing lake at the southeast of the site; this subcatchment does not affect the subject site for overland storm flows.

The *Fisheries and Wildlife Management Information System* (FWMIS) GIS tool identifies this existing lake as "Unnamed ID 307554." Unnamed lake ID 307554 drains, through well-forested terrain, generally to the northeast of the Nursery site area (outside the Nursery property), to a larger lake identified as "Unnamed ID 307526." Unnamed lake ID 307526 is located at the boundary of NE7-41-26-W4M and SE7-41-26-W4M. This larger lake does not appear to have a defined outlet.

1.4.3 Soil Cover Complex

The Natural Resources Conservation Service (U.S.) NEH-630 defines a soil cover complex as the combination of a hydrologic soil group (soil) and a land use and treatment class (cover). This concept is so defined so that Curve Numbers (CN) can be assigned to such complexes. This CN value is indicative of the runoff potential of a soil cover complex during periods when the soil is not frozen (NEH-630, Chapter 9, page 9-1).

As previously stated, the proposed Nursery R.V. Park site is comprised of approximately 2.14 ha of developed land. This area is presently being used as the Driving Range of the Nursery Golf & Country Club. The soil cover complex in the driving range area can be characterized as pasture in good hydrologic condition with a narrow band of trees surrounding the proposed development area in pre-development conditions. The post development drainage concept is expected to include roughly 30 gravelled recreational vehicle (RV) stalls as well as an entrance road (also gravelled). For modeling purposes, an average of hydrologic soil groups (HSG) B and C with relatively flat slopes (less than 2%) has been assumed. A preliminary estimate of the overall site runoff coefficient based on the proposed (post development) soil cover types has yielded the following results:

Table 1.1 Soil Cover and Runoff Coefficient.

Soil Cover Type	Area (ha)	Runoff Coefficient
Gravelled surfaces	0.618 ha	0.815
Proposed Buildings	0.047 ha	0.980
Forested Areas	0.445 ha	0.155
Pasture / green areas	1.030 ha	0.125
Total	2.14 ha	0.350

Consequently, this value (C = 0.350) has been adopted as representative of the proposed post development design concept for computer modeling (SWMHYMO) purposes. For this condition, a curve number of CN = 30 has been used in the modelling.

2.0 Stormwater Management Plan Concepts

2.1 GENERAL CONCEPTS

The *Nursery Golf & Country Club Inc. Proposed R.V. Park* in Alberta is a development which incorporates stormwater management features that have been utilized throughout Alberta. The storm water runoff from the existing development will be managed by providing a dry pond to accommodate runoff originating from precipitation over the existing ground cover complex at the site.

2.1.1 Selection of a Dry Pond as SWMF for site

Stormwater management facilities have a simple purpose: they store rainfall and surface water runoff to help reduce the possibility of flooding and property damage. Through a combination of landscape and structural features, stormwater management facilities slow and filter stormwater runoff after a rain event. The water temporarily stored in stormwater ponds and wetlands is released gradually back into the receiving waters and/or conveyance systems at rates determined by pre-existing stormwater documents or municipality guidelines and ordinances. Such *release rates* are determined to avoid erosion and downstream flooding as a result of receiving water course or conveyance system hydraulic overloading.

Given the extensive amount of information available, it is important to review the fundamental definitions. The City of Calgary *Stormwater Management & Design Manual 2011* (the most current as of the writing of this report) defines:

1. **Detention Storage**. “Detention Storage refers to the temporary storage and gradual release of stormwater from a storage facility. There is little or no infiltration of the stored stormwater. The main purpose of detention storage is to provide quantity control by attenuating runoff. Dry ponds, wet ponds, and wetlands are the most common types of detention storage.”
2. **Retention Storage**. “True Retention Storage refers to the collection and storage of runoff for a considerable length of time, where release is by evaporation, transpiration, or infiltration. Retention facilities are typically designed to provide the dual functions of stormwater quantity and quality control. Infiltration ponds and evaporation ponds are

> examples of retention facilities. Although the terms detention, retention, and extended detention have true definitions, they are often used interchangeably."
>
> The City of Calgary *Stormwater Management & Design Manual 2011,* page 190.

Whether Dry or Wet Ponds are envisioned for any proposed development, it is the principle of *Detention Storage* that is being used. Runoff from each rain event is detained by either displacing the permanent pool (also referred to as the dead storage) of a wet pond or by temporarily filling the active storage allocation of a dry pond. Pollutant removal occurs in the permanent pool, or temporary pool, through gravitational settling as well as biological uptake and filtering by the pond's vegetation. For this purpose, municipality guidelines usually specify a minimum detention time of 24 hours or more.

The recommended active storage for the Nursery's stormwater management facility has been calculated at 500 m^3, with a permissible outflow (release rate) of 2.0 L/s/ha. The tributary area to the pond was determined to be 2.14 ha. Consequently, the permissible outflow from the pond becomes 0.00428 m^3/s (4.28 L/s). At this outflow rate, the 500 m^3 pond will take approximately 32 hours to empty. This detention time is considered adequate for pollutant removal purposes. In order to reduce the velocity of incoming flows and capture coarser sediment and debris, a sedimentation forebay is recommended for the Nursery stormwater management facility.

While it is recognized that wet ponds are generally superior to dry ponds in their capacity to treat runoff in order to achieve adequate water quality, their design requires a sufficiently large drainage area and/or base flow (groundwater flow contribution) to maintain the volume and environmental quality of the permanent pool. These criteria may be summarized as follows:

- Minimum tributary drainage area of 10-50 acres (approximately 4-20 ha)
- Minimum average permanent pool depth of approximately 1m (about 3 ft)

It is standard industry practice to consult established guidelines when specific local guidelines are not available or do not contain sufficient specific details. In the Province of Alberta, the Design and Construction Guidelines issued by the City of Calgary as well as the City of Edmonton are usually consulted.

The City of Edmonton's *Design and Construction Standards*, *Volume 3*, *Drainage*, under section 16.13 *Design Details for Constructed Wetlands*, subsection 16.13.4 *Wetland drainage area*, specifies:

i) A minimum drainage area of 5 ha is required to generate constant or periodic flow to the constructed wetland.

ii) The smallest practical drainage area is considered to be 20 ha.

The Standards also provide for a minimum wetland surface area under section 16.13.9 as follows:

i) The surface area of the constructed wetland shall be a minimum of one hectare at the NWL.

ii) The wetland surface area is typically about 3% to 5% of the drainage area.

The City of Edmonton Standards summarize the Design Parameters for Constructed Wetlands in Table 1 – Design Summary Guide for Constructed Wetland (page 88 of 129).

The City of Calgary's *Stormwater Management & Design Manual 2011*, under section 6.3, subsection 6.3.2.4 (page 226) indicates "The minimum area of a wet pond must be 2 ha at the (L) NWL."

Considering the local driving range drainage area (2.14 ha) and its hydrological characteristics, it is unlikely that a wet pond will be an adequate and cost-effective BMP. It is therefore recommended that a dry pond with a sedimentation forebay be utilized for this proposed development.

2.2 MAJOR-MINOR DRAINAGE SYSTEM

An urban drainage system may be conceptualized as having two components. The first is referred to as the minor system, which consists of storm sewers, manholes, and catch basins. The minor system is designed to accommodate the runoff resulting from a 1:5 year return period storm event. For stormwater management purposes for *The Nursery Proposed R.V. Park,* the minor system concept generally does not apply.

The second component is referred to as the major system, which accommodates the runoff in excess of the capacity of the minor system. The major system is generally composed of the development's streets, roads, surface pathways, ditches / swales and other overland flow paths. It is important to recognize that a major drainage system always exists. The natural processes of precipitation and runoff will form a drainage system anywhere precipitation occurs; however, its function may be unsuitable for the purposes of the development's drainage.

The common Stormwater Best Management Practice in the Province of Alberta is to provide a major system that can safely convey runoff resulting from a storm event up to a 1:100 year return

period, usually of 24 hour duration, without exposing buildings and property to damage by flooding.

For *The Nursery Golf & Country Club Inc. Proposed R.V. Park* site, the major system concept as well as the stormwater management facility will be used as the design basis.

2.3 PRE-DEVELOPMENT ANALYSIS

For this study area, the pre-development conditions were examined using available topographic maps, air photos, and two (2) site visits in April of 2017.

Concerns of local flooding and potential erosion within the Wolf Creek and Whelp Brook drainage basins resulted in the commissioning of a study aimed at the production of a Master Drainage Plan for the Wolf Creek and Whelp Brook watersheds. MPE Engineering Ltd. completed such a study in August of 2014.

The MPE report, under section 4.1 *Pre-Development Flow Rates*, presents a regional flood frequency analysis using data from six (6) Water Survey of Canada hydrometric stations. The MPE report states that "The resulting estimated 1:100 year pre-development unit runoff rate varied from 2 L/s/ha for the smaller watersheds to 1 L/s/ha for Wolf Creek at Battle River." MPE, 2014, page 12. Under section 5.1 *Allowable Unit Release Rate*, the report indicates "**For the Wolf Creek watershed, the allowable unit release rate is estimated to be 2 L/s/ha.**" MPE, 2014, page 16. This statement may seem to indicate that this release rate applies only to the Wolf Creek watershed; however, under section 2.0 *Watershed Description*, the MPE report states:

> "The Wolf Creek watershed has a drainage area of 524 km^2, with its headwaters southeast of the City of Lacombe, and empties into the Battle River about 36 km to the north, near the Town of Ponoka. *Located in the western portion of the Wolf Creek watershed, Whelp Brook is the largest subwatershed [emphasis by WSP]*, having a drainage area of 307 km^2." MPE, 2014, page 3.

The presented paragraph clarifies that the unit area discharge (release rate) applies to both the Wolf Creek and Whelp Brook's drainage basins.

For comparison purposes, WSP performed a Single Station Flood Frequency Analysis (FFA) which is discussed in the sections that follow.

WSP performed a single-station FFA on data from hydrometric station 05FA001 *Battle River near Ponoka*. A direct application of the single-station FFA, using the Log-Pearson Type III distribution and the Weibull plotting position, yielded a unit area discharge of 1.26 L/s/ha for the Battle River drainage basin. Considering that the Battle River has a larger drainage basin (1,821.5 km^2) than the drainage basins of the creeks presented in the MPE report (an average of approximately 420 km^2), the results correlate well.

The FFA concept is presented in the following sections.

2.3.1 Flood Frequency Analysis

Alberta Environment requires that the runoff flow rate in post development conditions should be equal to or less than the runoff flow rate in pre-development conditions for all new developments. For comparison purposes, a *Single Station Flood Frequency Analysis* (FFA) was performed to establish predevelopment flow rates for the development area.

2.3.2 Flood Data Source

A flood is defined as the highest instantaneous stream discharge in a year.

The flood series for the hydrometric station used in this study were obtained from the *Water Survey of Canada, Archived Hydrometric Data.* The data sets are available on CD (HYDAT) as well as on-line. The website for extracting these record sets can be accessed at: https://ec.gc.ca/rhc-wsc/default.asp?lang=En&n=9018B5EC-1 (accessed 19 April 2016).

The raw data set is attached hereto as Appendix C.

2.3.3 Estimation of Missing Data

A linear regression between the annual maximum instantaneous discharge data (I-MAX) and the annual maximum daily discharge data (MAX) was performed for the *Battle River near Ponoka* Hydrometric Station number 05FA001 in order to fill the missing data values for the record period between 1913 and 2010.

The *Single Station Flood Frequency Analysis* has been attached hereto as Appendix B.

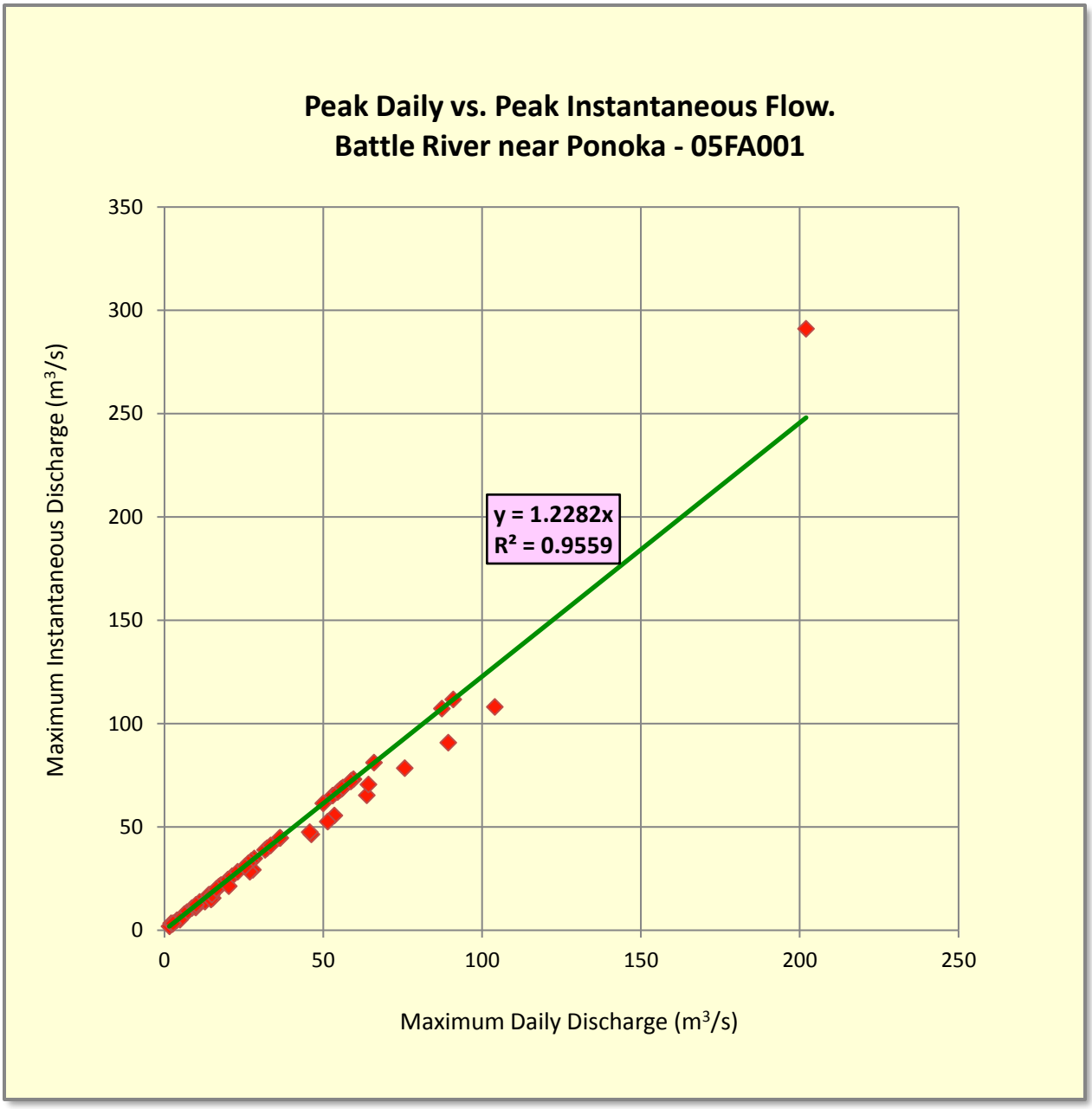


Figure 2.1 Linear regression of I-MAX and MAX flow values.

2.3.4 Single Station Flood Frequency Analysis Results

The results of the Single Station Analysis using the LP3 procedure for hydrometric station 05FA001 are presented in Table 2.1 as follows:

Table 2.1 Results of the Single Station Analysis for hydrometric station 05FA001.

Log-Pearson Type III	Notation	Return Period, T (years)	Probability of Exceedance, p (%)	K_T	$LogQ_T$	**Q_T (m^3/s)**	Unit Release Rate ($m^3/s/km^2$)	**Unit Release Rate (L/s/ha)**
BATTLE RIVER NEAR PONOKA (05FA001)	**Q_2**	2	50	0.095	1.4906	**30.9**	0.020	**0.20**
	Q_5	5	20	0.856	1.8282	**67.3**	0.043	**0.43**
	Q_{10}	10	10	1.203	1.9825	**96.1**	0.062	**0.62**
	Q_{20}	20	5	1.466	2.0991	**125.6**	0.081	**0.81**
	Q_{50}	50	2	1.736	2.2190	**165.6**	0.107	**1.07**
	Q_{100}	100	1	1.901	2.2926	**196.1**	0.126	**1.26**

2.3.5 Allowable Unit Area Discharge (Release Rates)

The performed single-station FFA has indicated an allowable unit area discharge (release rate) for areas within the drainage basin of the Battle River of approximately 1.26 L/s/ha (WSP results).

The more refined results of the Regional FFA by MPE (2014) indicate a unit area discharge (release rate), for a 1:100 year return period, of 2.0 L/s/ha. **It is recommended that this value (2.0 L/s/ha) be adopted as the allowable release rate (unit area discharge) to determine runoff storage requirements for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* Site**. The MPE value correlates well to a Preliminary Stormwater Runoff Rate Chart prepared by Environment and Sustainable Resource Development. The chart, under the title "*ESRD Preliminary 1:100 Year, Pre-Development Stormwater Runoff Rate Iso-Chart Units in l/s/ha*" has been attached hereto as Appendix H.

The details of the performed Single Station Flood Frequency Analysis (FFA) are attached as Appendix B.

3.0 Analysis Methodology

3.1 SINGLE EVENT ANALYSIS

The analysis considered rainfall events up to a 1:100 year, 24-hour duration storm event. To achieve this purpose, the analysis made use of computer modeling based on a single storm event.

The most common method of analysis used for stormwater management is based on a single storm event, either a real historic storm or a theoretical design storm. Single event analysis and design is the accepted procedure in Alberta. For this analysis, this method will form the basic procedure.

Current municipal and provincial guidelines require that storm water management works, including detention storage facilities and overland conveyance systems, shall be designed to accommodate the runoff resulting from a 1:100 year return period storm event. Accordingly, a 1:100 year design storm event of the *Chicago* distribution was used for this study.

A design storm event of 24 hour duration with 15 minute rainfall increments (time step) was used in the simulation.

As the intensity–duration–frequency (IDF) curves for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* are not available, the intensity–duration–frequency (IDF) curves for the City of Red Deer, for a 1:100 year, 24 hour duration design storm event, were used in the development of the modeling.

Rainfall intensities for the Chicago distribution are determined from an *intensity-duration-frequency* (IDF) relationship that is described as

$$i = \frac{A}{(t + B)^C}$$

where i is the rainfall intensity (mm/hr); A, B and C are IDF parameters, and t is the rainfall event time duration (minutes).

The time to storm hydrograph peak is determined by:

$$\frac{t_p}{t_d} = r \quad \text{or} \quad t_p = r(t_d)$$

where t_p is the time to hydrograph peak and r is the ratio of time to peak (t_p) versus storm duration (t_d), sometimes referred to as the *storm advancement coefficient*.

The **1:100 Year Chicago Design Storm** derived for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* is shown in **Figure 3.0.**

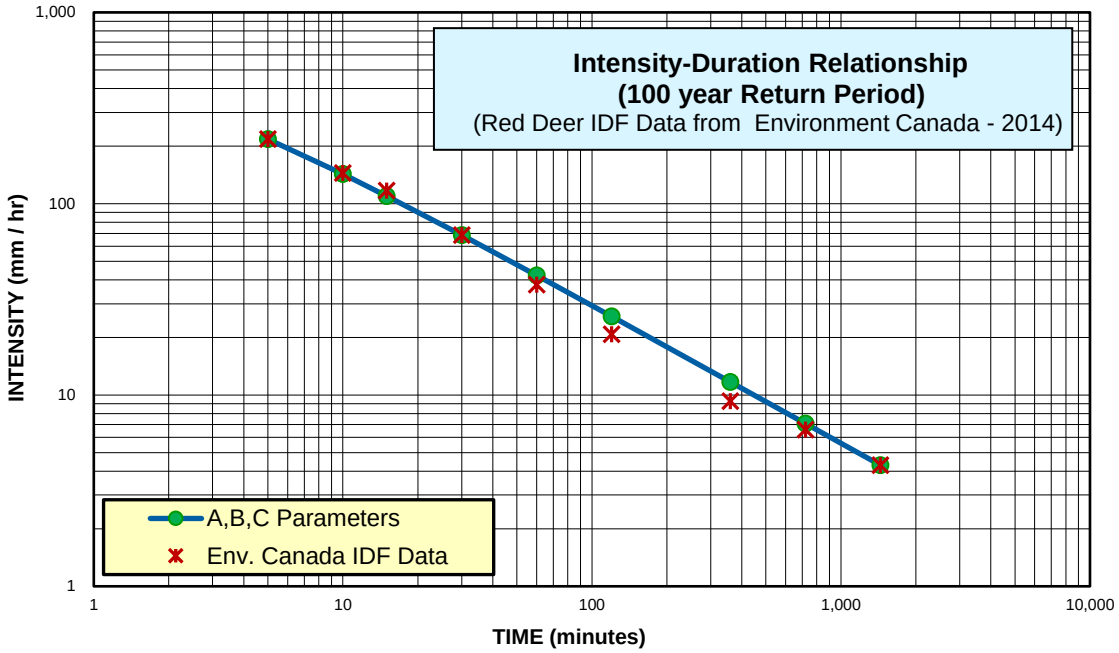
The 2014 Environment Canada IDF Data for the City of Red Deer Airport shows a Return Period Rainfall Amount (P_T) of 102.7 mm for the 1:100 year, 24 hr duration storm event. In order to approximate this precipitation value, WSP has developed A,B,C parameters based on Environment Canada IDF Data (2014); these values are:

1:100 year storm, 24-hour duration (2014 edition data):

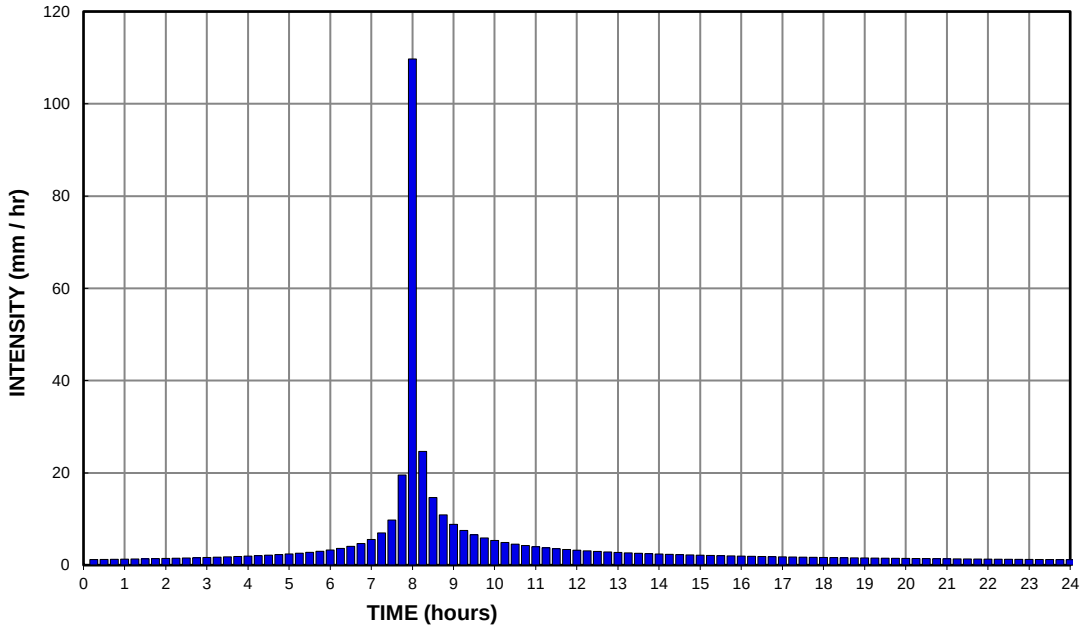
A = 830.226

B = 1.367

C = 0.724



(a) Intensity-Duration Relationship



(b) Distribution of Intensity Versus Time (Hyetograph)

Figure 3.0 Chicago Design Storm (1:100 year, 24 hr duration).

3.2 COMPUTER MODELS

The Stormwater Management Hydrologic Model, commonly referred to as SWMHYMO-99 (Version 4.05. September 2011), was used in this study for the single event analysis. This is a *lumped* model that was developed to provide watershed modeling for stormwater management, flood control and infiltration studies.

For pre and post development scenarios, the Stormwater Management Hydrologic Model (SWMHYMO-99) was used. This software uses a modular command structure, where command blocks are combined in accordance to the desired modeling logic.

The CHICAGO STORM command is used to derive a Chicago type Design Storm. Chicago Design Storms are derived based on local Intensity-Duration-Frequency (IDF) curves.

The CALIB STANDHYD command is used to simulate the runoff from urban watersheds with impervious ratios larger than 0.20. The rainfall losses can be simulated with the Horton Infiltration equations, the SCS procedure, or a proportional loss coefficient. This command allows the user to input most of the watershed parameters; hence, provides the highest degree of control over the simulation parameters.

The CALIB NASHYD command is a hydrograph command used to simulate the runoff from a rural area. This command is based on Nash's synthetic instantaneous unit hydrograph which views the watershed as a series of "N" linear storage reservoirs. Rainfall losses can be simulated with a modified SCS procedure or a proportional loss coefficient.

The ROUTE RESERVOIR command is used to simulate the effects of reservoir (pond) routing. The routing is conducted with the storage-indication method where the solution is based on the principle of Conservation of Mass (Sabourin, 2002. User's Manual).

The SWMHYMO User's Manual (J.F. Sabourin, 2002, reprinted 2005) provides a detailed description of the model structure, program commands, input data requirements, output, and suggested *Useful Tables* for design parameters. Examples and explanations of the use of the software can be found in the *Examples Guide*.

The computer model detailed input and output files for the Post-development conditions from the SWMHYMO modeling are provided in Appendix A.

4.0 Post Development Analysis

4.1 MODELLING PARAMETERS AND HYDROGRAPHS

The modeling parameters were developed for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* based on available air photos, topographic maps, site photographs, and two (2) site visits.

4.1.1 Land Use and Modeling Parameters

The post development analysis of this rural parcel of land has been performed in accordance to the US Soil Conservation Service guidelines, or the SCS method. In October 20, 1994, the agency was renamed the *Natural Resources Conservation Service* (NRCS) as part of the Federal Crop Insurance Reform and Department of Agriculture Reorganization Act of 1994 (U.S.). However, the method is still widely known as the SCS Curve Number Method.

In this method, soil group, ground cover, and antecedent moisture conditions are assessed, and a Curve Number (CN) assigned.

Per cent imperviousness and Curve Numbers were assigned to each subcatchment on the basis of each individual soil cover complex (soil and cover type).

To model the rainfall-runoff response from each of the subcatchments, the losses over pervious surfaces were calculated using the Curve Number Method in order to characterize the soils in the area.

4.1.2 Initial Abstractions, Manning's n, and Infiltration Parameters

The Initial Abstractions (IA) in pervious areas (depression storage) was assigned a value of 3.2 mm; while the IA for impervious areas (depression storage) was assigned 1.6 mm as per industry practice. To simulate the flow retarding characteristics of pervious areas, a Manning's "n" of 0.25 was used; while the impervious areas (roof and gravelled surfaces) were assigned a Manning's "n" of 0.029. The pervious and impervious longest flow paths were calculated after an examination of the development configuration. In all cases no base or dry weather flow (groundwater component) was assumed (DWF = 0 m^3/s) for modeling purposes.

4.2 Detention Pond and Discharge Rates

The proposed stormwater concept for this development is the implementation of the major drainage system concept as well as the stormwater management facility.

For the existing *The Nursery Golf & Country Club Inc. Proposed R.V. Park* area, during rainfall events, the runoff flows will be conveyed via the major system (i.e. overland as surface flow) to the SWMF. The runoff will then undergo hydrograph attenuation and translation, as well as sedimentation within the SWMF.

The proposed stormwater detention pond has been adequately sized to accommodate the runoff from *The Nursery Proposed R.V. Park* site. The proposed storm detention facility is designed so that **a unit area discharge (release rate) of 2.0 L/s/ha will not be exceeded**.

The proposed dry pond will have a **control structure** composed of a berm (where necessary) and an outlet pipe sloped towards the unnamed lake identified as ID 307554 at the southeast of the site. The outlet pipe will be a **300 mm diameter PVC pipe (approximately 150 m long) complete with a 41 mm diameter orifice** at the upstream end of the outlet pipe. Preliminary calculations indicate a pipe slope of the order of 0.25% (0.0025 m/m). The orifice diameter, as well as the pipe slope, may change at the detailed design stage when final elevations are confirmed. It is recommended that a trash rack be installed to protect the orifice plate from debris. The orifice plate or inlet control device should be removable for dewatering and maintenance purposes.

The preliminary design of the dry pond will include 5H:1V sideslopes, an active storage depth of 1.5 m and a 0.30 m freeboard allowance.

The ROUTE RESERVOIR command has been used to simulate Pond Routing. This calculation block is used to determine the required volume (capacity) for the Ponds. The performed computer modeling indicates that the **required active storage capacity for the proposed pond at *The Nursery Golf & Country Club Inc. Proposed R.V. Park* is 500 m^3**.

Photo 5. Approximate location of proposed dry pond (view to the north).

4.3 Flow Path and Adequate Outlet

The existing drainage within the proposed RV Park area presently proceeds in an east or northeast direction towards the northeast corner of the site. The grading within the proposed RV Park is expected to make use of the existing topography in step with one of the fundamental tenets of environmental design: *design with the topography, not against it*. As such, the proposed SWMF has been proposed at approximately the lowest area of the site, at the northeast of the proposed development's plan area.

Within this design framework, the proposed Concept Plan will convey stormwater runoff from the proposed RV stalls, along the proposed gravel roads, towards the proposed SWMF at the northeast of the site. The outlet from the proposed SWMF will be a 300 mm PVC pipe running east from the proposed pond towards Lake ID 307554. As indicated on Figure 1.4, the use of

swales will assist with directing drainage to the new pond. The final layout for swales will be determined during detailed design for the site.

The terrain east of the proposed dry pond generally falls in elevation towards the lake. However, there are local highs at points approximately 30 m, 60 m, and 120 m east of the proposed pond's location. In order to traverse these points without causing ponded water on fairways 2 and 4, as well as to avoid interfering with the normal use of the fairways, open cut trench excavation, pipe installation, and backfilling is the preferred option. Mr. Karl Dillman (Operations Manager at the Nursery) has indicated that equipment on site would be able to proceed with this type of construction method. It should be noted that, although the outflow from the proposed dry pond could be conveyed over a shorter distance northwest towards Whelp Brook, the additional runoff would interfere with the normal functioning of fairways 1, 9, and 18, and would worsen the known flooding problems in the area during Spring runoff. It is therefore recommended that the outlet pipe follow an alignment east from the SWMF towards Lake ID 307554, as stated. Lake ID 307554 then becomes the receiving water body.

A standard pipe outlet protection apron should be provided at the outlet point to address any potential energy dissipation or erosion issues downstream. Any inlet and outlet points should be provided with safety grates / trash racks.

Since the outflow from the proposed SWMF will be controlled to the 2.0 L/s/ha pre-development level at the outlet point of the proposed dry pond, it is not expected that the seasonal water surface elevations of either Lake ID 307554 (receiving water body) or Lake ID 307526 (larger lake) will be significantly affected. Attenuation and hydrograph translation will be achieved within the proposed SWMF. Water quality treatment will be achieved within the proposed SWMF, and, to a significantly lesser extent, within Lake ID 307554 and within Lake ID 307526, if any. The treatment train composed by the proposed SWMF, Lake ID 307554, and Lake ID 307526 then becomes the adequate outlet for this site. It is noted that, due to the small drainage area at the site, it is expected that little or no runoff will reach the mentioned lakes. Although a survey of the area has not been

completed (as it would be outside the scope of this report), Lake ID 307554 and Lake ID 307526 are assumed to be / appear to be hydraulically connected.

It should be noted that the inclusion of natural prairie grasses into the stormwater management design will assist in the removal of suspended particles present in the storm runoff. These Best Management Practices (BMPs), included in the design of the pond, address the water quality issues as well as the water quantity issues for *The Nursery Proposed R.V. Park* development, as per Alberta Environment's stormwater quality requirements.

Photo 6. Approximate location of outlet point (between 2 trees) upstream of Lake ID 307554 (view to the east).

Photo 7. Approximate location of outlet point – detail (view to the east).

4.4 Hydrographs

The modeling included the creation of inflow and outflow hydrographs for the drainage areas as well as the pond routing. The outflow hydrographs for the tributary areas to the pond were used as the inflow hydrograph for the pond routing. This procedure is used to determine the required volume (i.e. required capacity) of the stormwater pond. The inflow and outflow hydrographs for *The Nursery Proposed R.V. Park* site are presented in Appendix F.

A summary of the modelling parameters is presented in **Table 4.1 Summary of Parameters** at the end of this section.

4.5 Modelling Results

The modeling results are attached in the various Appendices at the end of this document. The results are also presented in the various Figures of the report. The information attached in the Appendices may be characterized as follows:

The SWMHYMO (Computer) Modeling Results for the Chicago Design Storm are presented in Appendix A1, A2, and A3 for the 1:100 year, 24 hour duration storm event.

The modelling results are presented as follows:

Appendix B – Single Station Flood Frequency Analysis.

Appendix C – Data Sheet for WSC Hydrometric Station 05FA001.

Appendix D – Calculation of IDF parameters.

Appendix E – Red Deer Airport IDF Data (2014).

Appendix F – The Nursery Proposed R.V. Park Hydrographs.

Appendix G – Lacombe County “County Elevation Map.”

Appendix H – ESRD Preliminary Unit Area Discharge for Central Alberta.

Appendix I – Alberta Geological Survey Maps.

Appendix J – Wolf Creek and Whelp Brook Drainage Basins (MPE, 2014).

4.6 Adjacent Lands and Future Development

The proposed RV Park development will replace the existing driving range at the Nursery Golf & Country Club. The RV Park project boundaries are then “flexible” in that they can be extended to any point within the boundaries of the Nursery without encroaching on any other property. The proposed RV Park then becomes a type of infill development within the Nursery Golf & Country Club. Conceptual discussions regarding a potential Phase II of the RV Park development have been advanced; however, it is not anticipated that the lands surrounding *The Nursery Proposed R.V. Park* property will be developed in the foreseeable future. Should development occur in these adjacent lands, stormwater management facilities and/or concepts will have to be implemented in order to accommodate the drainage from these lands in post development conditions, if any. The proposed stormwater management concepts, to be implemented at *The Nursery Proposed R.V. Park* property, have been recommended to control storm water discharge to pre-development rates for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* (2.14 ha) site only.

Table 4.1 - Summary of Parameters

Description / Parameter	Value
Storm Hyetograph	Chicago Distribution
Storm Duration	24 hours
Environment Canada IDF Data	Red Deer Airport (2014)
1:100 year, 24 hour total rainfall amount (Environment Canada IDF Data - 2014)	102.7 mm
Parameter	**Post Development**
Hydrologic Soil Group Classification	Hydrologic Soils B and C
Land Use	R.V. Park (Pasture, Gravel, Woods)
Pervious Losses – Curve Number Method (CN)	30
Per cent (%) impervious (overall for site)	25 %
Drainage Area contributing runoff to Pond	2.14 ha
Allowable Unit Area Discharge	2.0 L/s/ha
Allowable Pond Outflow	0.00428 m^3/s
Runoff Coefficient (C)	0.351
Required pond storage for site (at HWL)	**500.0 m^3**

5.0 Conclusion

The *Nursery Golf & Country Club Inc. Proposed R.V. Park* project land (SW 1/4 Sec 7-41-26-W4M) and immediately adjacent lands have been examined and BMPs prepared.

The proposed stormwater concept for this development is the implementation of the major drainage system concept as well as the stormwater management facility.

It is recommended that a value of **2.0 L/s/ha** be adopted as the allowable release rate (unit area discharge) to determine runoff storage requirements for *The Nursery Proposed R.V. Park.* The performed computer modeling indicates that the required storage capacity for the site is **500.0 m^3**. The outlet pipe will be a **300 mm diameter PVC pipe (approximately 150 m long) complete with a 41 mm diameter orifice.** The preliminary design of the dry pond will include 5H:1V sideslopes, an active storage depth of 1.5 m and a 0.30 m freeboard allowance.

The outflow from the proposed SWMF will be conveyed east from the proposed pond towards Lake ID 307554. The terrain east of the proposed dry pond generally falls in elevation towards the lake. It is assumed that Lake ID 307554 is hydraulically connected to Lake ID 307526 farther downstream from the Nursery Golf & Country Club. The treatment train composed by the proposed SWMF, Lake ID 307554, and Lake ID 307526 then becomes the adequate outlet for this site.

The stormwater management BMPs have been proposed to provide stormwater detention, and sedimentation, for *The Nursery Golf & Country Club Inc. Proposed R.V. Park* parcel of land. Should development occur in adjacent lands, stormwater management facilities and/or concepts will have to be implemented to accommodate the runoff from these lands. Stormwater Best Management Practices have been recommended in order to satisfy Alberta Environment's stormwater quantity and quality standards.

6.0 References

1. Alberta Environmental Protection *Stormwater Management Guidelines for the Province of Alberta* (January, 1999).

2. Alberta Environment and Sustainable Resource Development. *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. Part 5. Stormwater Management Guidelines of a Total of 5 Parts*. (2013).

3. Atkinson, N., Utting, D.J., and Pawley, S.M. (2014): Glacial Landforms of Alberta, Canada; Alberta Energy Regulator, AER/AGS Map 604, scale 1:1,000,000.

4. Benn, D.I., and Evans, D.J.A. *Glaciers & Glaciation*. 1998 (2006 reprint).

5. Environment Canada. *Short Duration Rainfall Intensity-Duration-Frequency Data*. Red Deer Airport. 21 December 2014.

6. Fenton, M.M., Waters, E.J., Pawley, S.M., Atkinson, N., Utting, D.J., and McKay, K. (2013): Surficial Geology of Alberta; Alberta Energy Regulator, AER/AGS Map 601, scale 1:1,000,000.

7. J.F. Sabourin and Associates Inc. *Stormwater Management Hydrologic Model User's Manual* (May, 2000. Reprinted April 2005).

8. J.F. Sabourin and Associates Inc. *Stormwater Management Hydrologic Model Examples Guide* (May, 2000. Reprinted April 2005).

9. Lacombe County. *Standards Manual*. https://www.lacombecounty.com/index.php/standards-manual.

10. Leet, L.D., Judson, S., and Kauffman, M.E. *Physical Geology*. 1978.

11. Natural Resources Conservation Service. United States Department of Agriculture. *National Engineering Handbook. Part 630 Hydrology*. Chapter 9. Hydrologic Soil-Cover Complexes. (2004).

7.0 Corporate Authorization

This document entitled "The Nursery Golf & Country Club Inc. Proposed R.V. Park Stormwater Management Plan" was prepared by WSP for the account of The Nursery Golf & Country Club Inc. The material in it reflects WSP's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or reliance on or decisions made based on it, are the responsibilities of such third parties. WSP accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Prepared by: Andries Castro, B.Sc. Civil Engineering, Co-operative Program.

August 25, 2017

Authenticated by: Darren Otto, P. Eng.

APEGA Permit P07641

Appendix A

SWMHYMO Results

A.1 SWMHYMO - Input File

```
2     Metric units
*#*************************************************************************
*#  Project Name: NURSERY RV PARK Stormwater Management
*#  Project No. : WSP 161-15869-00
*#  Date        : December 2016
*#  Modeller    : AOC
*#  Company     : WSP Canada Inc.
*#  License #   : 2268234
*#*************************************************************************
*%-----------------|-------------------------------------------------------|
START               TZERO=[0.0],  METOUT=[2],  NSTORM=[0],  NRUN=[0]
*%                   [  ] <--storm filename, one per line for NSTORM time
*%-----------------|-------------------------------------------------------|
*************************************************************************
*
*  1:100, 24 hour duration CHICAGO DESIGN STORM
*
*  In order to approximate a total precipitation value of Pt = 102.7 mm (Red
*  Deer Airport IDF data from Environment Canada, 2014) for the 1:100 year,
*  24 hour duration storm event, A,B,C values have been developed.
*
*  These values are:
*
*       A = 830.226
*       B = 1.367
*       C = 0.724
*
*************************************************************************
*
*
CHICAGO STORM       IUNITS=[2], TD=[24.0](hrs), TPRAT=[0.33], CSDT=[15.0](min),
                    ICASEcs=[1],
                     A=[830.226],  B=[1.367], and C=[0.724],
*-----------------|-------------------------------------------------------|
*
*
*  The "Master Drainage Plan For the Wolf Creek and Whelp Brook Watersheds"
*  by MPE Engineering Ltd., August 2014, indicates an allowable Unit Area
*  Discharge (UAD) for the Wolf Creek (and therefore the Whelp Brook) of:
*
*                     2.0 L/s/ha.
*
*  Since the Nursery Golf & Country Club site is located within the Whelp
*  Brook drainage basin, this UAD has been used for modelling.
*
*-----------------|-------------------------------------------------------|
*
```

```
*  It is not anticipated that any substantial portion of the Nursery RV Park
*  will be paved, hence:
*
*    Component                    Area (ha)     Runoff C
*    ------------------------------------------------
*     Gravel                      0.618 ha       0.815
*     Building                    0.047 ha       0.980
*     Woodlands                   0.445 ha       0.155
*     Lawns(sandy soil, flat)     1.030 ha       0.125
*    ------------------------------------------------
*     TOTAL                       2.140 ha       0.350
*
*
*  Per cent (%) impervious as follows:
*  -----------------------------------
*  Of entire Nursery site (2.140 ha), impervious would be the building area +
*  the gravelled areas (considered impervious as a conservative estimate).
*        As % of site area:
*         ((0.047 ha + 0.618 ha) / 2.140) * 100% = 31.07% of site.
*        Of this, get runoff C = 0.815, calculate:
*          31.07% impervious * 0.815 = 25.33% impervious.
*  For modelling, say, use 25% impervious as overall value for site.
*
*  For these conditios, equivalent curve number is:
*        CN = 30.
*
*
CALIB STANDHYD      ID=[1], NHYD=["NurRV"], DT=[1.0](min), AREA=[2.14](ha),
                    XIMP=[0.25], TIMP=[0.25], DWF=[0](cms), LOSS=[2],
                    SCS curve number CN=[30],
                    Pervious   surfaces: IAper=[3.2](mm), SLPP=[1.0](%),
                                         LGP=[25](m), MNP=[0.25], SCP=[0](min),
                    Impervious surfaces: IAimp=[1.6](mm), SLPI=[1.0](%),
                                         LGI=[230](m), MNI=[0.029], SCI=[0](min),
                    RAINFALL=[ ,  ,  ,  , ](mm/hr) ,  END=-1
*
*-----------------|-------------------------------------------------------------|
*
SAVE HYD            ID=[1],   # OF PCYCLES=[2],  ICASEsh=[1]
                    HYD_COMMENT=["NurRV"]
*
*-----------------|-------------------------------------------------------------|
*
*  UAD = 2.0 L/s/ha
*
*  The pond outflow is then:
*      2.0 x 2.14 ha = 4.28 L/s or about 0.00428 cms.
*
```

```
*  A Storage-Outflow Table was developed for input into the SWMHYMO Model.
*  In developing the Storage-Outflow table, the pond was assumed to:
*                     1. have 5H:1V sideslopes
*                     2. max. 1.5 m active storage depth.
*                     3. be orifice controlled.
*                     5. calculated orifice diameter = 41 mm
*
ROUTE RESERVOIR     IDout=[2],   NHYD=["POND"],  IDin=[1],
                    RDT=[1.0](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms) - (ha-m)
                                    [0.00000 , 0.0000]
                                    [0.00099 , 0.0011]
                                    [0.00149 , 0.0025]
                                    [0.00186 , 0.0042]
                                    [0.00216 , 0.0062]
                                    [0.00243 , 0.0085]
                                    [0.00267 , 0.0112]
                                    [0.00289 , 0.0142]
                                    [0.00310 , 0.0177]
                                    [0.00329 , 0.0215]
                                    [0.00347 , 0.0258]
                                    [0.00365 , 0.0305]
                                    [0.00381 , 0.0357]
                                    [0.00397 , 0.0414]
                                    [0.00412 , 0.0476]
                                    [0.00427 , 0.0544]
                                    [-1  ,  -1]  (max twenty pts)
                          IDovf=[   ], NHYDovf=[   ]

*
*-----------------|-------------------------------------------------------------|
*
SAVE HYD            ID=[2],   # OF PCYCLES=[5],  ICASEsh=[1]
                    HYD_COMMENT=["POND"]
*
*-----------------|-------------------------------------------------------------|
*
COMPUTE DUALHYD     IDin=[1], CINLET=[0.00428](cms), NINLET=[1],
                    MAJID=[3], MajNHYD=["major"],
                    MINID=[4], MinNHYD=["minor"],
                    TMJSTO=[99999](cu-m)
*-----------------|-------------------------------------------------------------|
*
SAVE HYD            ID=[4],   # OF PCYCLES=[5],  ICASEsh=[1]
                    HYD_COMMENT=["Hydrograph"]
*
*-----------------|-------------------------------------------------------------|
*
```

```
*-----------------|-------------------------------------------------------------|
*
COMPUTE VOLUME      ID=[1], STRATE=[-100](cms), RELRATE=[0.00428](cms)
*
*-----------------|-------------------------------------------------------------|
*
FINISH
```

A2. SWMHYMO - Detailed Output File

```
================================================================================

  SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999    999    =========
  S      W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
  SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9   Ver  4.05
      S   W W   M   M  H   H    Y    M   M  O   O       9999   9999   Sept 2011
  SSSSS   W W   M   M  H   H    Y    M   M   OOO           9      9   =========
                                                       9   9  9   9   # 2268234
       StormWater Management HYdrologic Model           999    999    =========

********************************************************************************
***************************** SWMHYMO Ver/4.05  ********************************
*********  A single event and continuous hydrologic simulation model  *********
*********     based on the principles of HYMO and its successors      *********
*********                 OTTHYMO-83 and OTTHYMO-89.                  *********
********************************************************************************
********* Distributed by:  J.F. Sabourin and Associates Inc.          *********
*********                  Ottawa,  Ontario: (613) 836-3884           *********
*********                  Gatineau, Quebec: (819) 243-6858           *********
*********                  E-Mail: swmhymo@jfsa.Com                   *********
********************************************************************************

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++++ Licensed user: WSP Canada Inc                                +++++++++
+++++++++                Red Deer              SERIAL#:2268234         +++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

********************************************************************************
*********           ++++++ PROGRAM ARRAY DIMENSIONS ++++++             *********
*********           Maximum value for ID numbers  :     10             *********
*********           Max. number of rainfall points: 105408             *********
*********           Max. number of flow points    : 105408             *********
********************************************************************************


**********************   D E T A I L E D   O U T P U T   **********************
********************************************************************************
*         DATE: 2017-04-11     TIME: 08:12:33     RUN COUNTER: 002357          *
********************************************************************************
* Input   filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\NUR9.dat                 *
* Output  filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\NUR9.out                 *
* Summary filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\NUR9.sum                 *
* User comments:                                                               *
* 1:_____________________________________________________________________________*
* 2:_____________________________________________________________________________*
* 3:_____________________________________________________________________________*
********************************************************************************
```

```
--------------------------------------------------------------------------------
001:0001----------------------------------------------------------------------------
*#**************************************************************************
*#  Project Name: NURSERY RV PARK Stormwater Management
*#  Project No. : WSP 161-15869-00
*#  Date        : December 2016
*#  Modeller    : AOC
*#  Company     : WSP Canada Inc.
*#  License #   : 2268234
*#**************************************************************************
--------------------
| START            |  Project  dir.: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\
--------------------  Rainfall dir.: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 001
    NSTORM=   0
--------------------------------------------------------------------------------
001:0002----------------------------------------------------------------------------
******************************************************************************
*
*  1:100, 24 hour duration CHICAGO DESIGN STORM
*
*  In order to approximate a total precipitation value of Pt = 102.7 mm (Red
*  Deer Airport IDF data from Environment Canada, 2014) for the 1:100 year,
*  24 hour duration storm event, A,B,C values have been developed.
*
*  These values are:
*
*       A = 830.226
*       B = 1.367
*       C = 0.724
*
******************************************************************************
*
*
--------------------
| CHICAGO STORM    |    IDF curve parameters: A= 830.226
| Ptotal=102.91 mm |                          B=   1.367
--------------------                          C=    .724
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  = 24.00 hrs
                         Storm time step    = 15.00 min
                         Time to peak ratio =   .33

              TIME    RAIN |   TIME    RAIN |   TIME    RAIN |   TIME    RAIN
               hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr
               .25   1.210 |   6.25   3.631 |  12.25   3.102 |  18.25   1.640
               .50   1.239 |   6.50   4.079 |  12.50   2.977 |  18.50   1.612
               .75   1.271 |   6.75   4.687 |  12.75   2.862 |  18.75   1.585
```

1.00	1.303	7.00	5.568	13.00	2.758	19.00	1.559
1.25	1.339	7.25	6.989	13.25	2.662	19.25	1.534
1.50	1.376	7.50	9.782	13.50	2.574	19.50	1.509
1.75	1.416	7.75	19.545	13.75	2.493	19.75	1.486
2.00	1.459	8.00	109.719	14.00	2.417	20.00	1.464
2.25	1.505	8.25	24.655	14.25	2.347	20.25	1.442
2.50	1.555	8.50	14.655	14.50	2.281	20.50	1.421
2.75	1.609	8.75	10.900	14.75	2.220	20.75	1.401
3.00	1.667	9.00	8.845	15.00	2.162	21.00	1.381
3.25	1.731	9.25	7.524	15.25	2.108	21.25	1.362
3.50	1.802	9.50	6.593	15.50	2.057	21.50	1.344
3.75	1.879	9.75	5.897	15.75	2.008	21.75	1.326
4.00	1.964	10.00	5.353	16.00	1.963	22.00	1.309
4.25	2.060	10.25	4.916	16.25	1.920	22.25	1.292
4.50	2.168	10.50	4.555	16.50	1.879	22.50	1.276
4.75	2.289	10.75	4.251	16.75	1.840	22.75	1.261
5.00	2.429	11.00	3.992	17.00	1.802	23.00	1.245
5.25	2.591	11.25	3.767	17.25	1.767	23.25	1.230
5.50	2.781	11.50	3.570	17.50	1.733	23.50	1.216
5.75	3.008	11.75	3.397	17.75	1.701	23.75	1.202
6.00	3.284	12.00	3.242	18.00	1.670	24.00	1.188

```
--------------------------------------------------------------------------------
001:0003----------------------------------------------------------------------
*-----------------|------------------------------------------------------------|
*
*
*  The "Master Drainage Plan For the Wolf Creek and Whelp Brook Watersheds"
*  by MPE Engineering Ltd., August 2014, indicates an allowable Unit Area
*  Discharge (UAD) for the Wolf Creek (and therefore the Whelp Brook) of:
*
*                     2.0 L/s/ha.
*
*  Since the Nursery Golf & Country Club site is located within the Whelp
*  Brook drainage basin, this UAD has been used for modelling.
*
*
*-----------------|------------------------------------------------------------|
*
*  It is not anticipated that any substantial portion of the Nursery RV Park
*  will be paved, hence:
*
*    Component                    Area (ha)     Runoff C
*    ------------------------------------------------
*     Gravel                      0.618 ha       0.815
*     Building                    0.047 ha       0.980
*     Woodlands                   0.445 ha       0.155
*     Lawns(sandy soil, flat)     1.030 ha       0.125
*    ------------------------------------------------
*     TOTAL                       2.140 ha       0.350
*
```

```
*
*  Per cent (%) impervious as follows:
*  -----------------------------------
*  Of entire Nursery site (2.140 ha), impervious would be the building area +
*  the gravelled areas (considered impervious as a conservative estimate).
*        As % of site area:
*         ((0.047 ha + 0.618 ha) / 2.140) * 100% = 31.07% of site.
*        Of this, get runoff C = 0.815, calculate:
*          31.07% impervious * 0.815 = 25.33% impervious.
*  For modelling, say, use 25% impervious as overall value for site.
*
*  For these conditios, equivalent curve number is:
*        CN = 30.
*
*
----------------------
| CALIB STANDHYD     |   Area    (ha)=    2.14
| 01:NurRV  DT= 1.00 |   Total Imp(%)=   25.00   Dir. Conn.(%)=   25.00
----------------------
                            IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .54         1.61
     Dep. Storage     (mm)=       1.60         3.20
     Average Slope     (%)=       1.00         1.00
     Length            (m)=     230.00        25.00
     Mannings n           =       .029         .250

     Max.eff.Inten.(mm/hr)=     109.72         8.87
               over (min)         7.00        24.00
     Storage Coeff.  (min)=       6.57 (ii)   23.84 (ii)
     Unit Hyd. Tpeak (min)=       7.00        24.00
     Unit Hyd. peak  (cms)=        .17          .05
                                                      *TOTALS*
     PEAK FLOW       (cms)=        .14          .02          .151 (iii)
     TIME TO PEAK    (hrs)=       8.02         8.33         8.033
     RUNOFF VOLUME    (mm)=     101.29        14.35        36.096
     TOTAL RAINFALL   (mm)=     102.91       102.91       102.908
     RUNOFF COEFFICIENT   =        .98          .14          .351

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  30.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
001:0004----------------------------------------------------------------------
*
*-----------------|------------------------------------------------------------|
*
--------------------
| SAVE HYD         |   AREA       (ha)=    2.140
```

```
| ID=01 (NurRV )    |   QPEAK     (cms)=     .151 (i)
| DT= 1.00 PCYC= 2 |   TPEAK     (hrs)=    8.033
--------------------   VOLUME     (mm)=   36.096
  Filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\H-NurRV.001
  Comments: NurRV

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	5.27	.004	10.53	.012	15.80	.005	21.07	.004
.03	.000	5.30	.004	10.57	.012	15.83	.005	21.10	.004
.07	.000	5.33	.004	10.60	.011	15.87	.005	21.13	.004
.10	.000	5.37	.004	10.63	.011	15.90	.005	21.17	.004
.13	.000	5.40	.004	10.67	.011	15.93	.005	21.20	.004
.17	.000	5.43	.004	10.70	.011	15.97	.005	21.23	.004
.20	.000	5.47	.004	10.73	.011	16.00	.005	21.27	.004
.23	.000	5.50	.004	10.77	.011	16.03	.005	21.30	.004
.27	.000	5.53	.004	10.80	.011	16.07	.005	21.33	.004
.30	.000	5.57	.004	10.83	.011	16.10	.005	21.37	.004
.33	.000	5.60	.004	10.87	.011	16.13	.005	21.40	.004
.37	.000	5.63	.004	10.90	.010	16.17	.005	21.43	.004
.40	.000	5.67	.005	10.93	.010	16.20	.005	21.47	.004
.43	.000	5.70	.005	10.97	.010	16.23	.005	21.50	.004
.47	.000	5.73	.005	11.00	.010	16.27	.005	21.53	.004
.50	.000	5.77	.005	11.03	.010	16.30	.005	21.57	.004
.53	.000	5.80	.005	11.07	.010	16.33	.005	21.60	.004
.57	.000	5.83	.005	11.10	.010	16.37	.005	21.63	.004
.60	.000	5.87	.005	11.13	.010	16.40	.005	21.67	.004
.63	.000	5.90	.005	11.17	.010	16.43	.005	21.70	.004
.67	.000	5.93	.005	11.20	.010	16.47	.005	21.73	.004
.70	.000	5.97	.005	11.23	.010	16.50	.005	21.77	.004
.73	.000	6.00	.005	11.27	.010	16.53	.005	21.80	.004
.77	.000	6.03	.005	11.30	.010	16.57	.005	21.83	.004
.80	.000	6.07	.005	11.33	.009	16.60	.005	21.87	.004
.83	.000	6.10	.005	11.37	.009	16.63	.005	21.90	.004
.87	.000	6.13	.005	11.40	.009	16.67	.005	21.93	.004
.90	.000	6.17	.005	11.43	.009	16.70	.005	21.97	.004
.93	.000	6.20	.006	11.47	.009	16.73	.005	22.00	.004
.97	.000	6.23	.006	11.50	.009	16.77	.005	22.03	.004
1.00	.000	6.27	.006	11.53	.009	16.80	.005	22.07	.003
1.03	.000	6.30	.006	11.57	.009	16.83	.005	22.10	.003
1.07	.000	6.33	.006	11.60	.009	16.87	.005	22.13	.003
1.10	.000	6.37	.006	11.63	.009	16.90	.005	22.17	.003
1.13	.000	6.40	.006	11.67	.009	16.93	.005	22.20	.003
1.17	.000	6.43	.006	11.70	.009	16.97	.005	22.23	.003
1.20	.000	6.47	.006	11.73	.009	17.00	.005	22.27	.003
1.23	.000	6.50	.006	11.77	.009	17.03	.005	22.30	.003
1.27	.000	6.53	.006	11.80	.009	17.07	.005	22.33	.003
1.30	.000	6.57	.007	11.83	.009	17.10	.005	22.37	.003
1.33	.000	6.60	.007	11.87	.008	17.13	.005	22.40	.003
1.37	.001	6.63	.007	11.90	.008	17.17	.005	22.43	.003

1.40	.001	6.67	.007	11.93	.008	17.20	.005	22.47	.003
1.43	.001	6.70	.007	11.97	.008	17.23	.005	22.50	.003
1.47	.002	6.73	.007	12.00	.008	17.27	.005	22.53	.003
1.50	.002	6.77	.007	12.03	.008	17.30	.005	22.57	.003
1.53	.002	6.80	.007	12.07	.008	17.33	.005	22.60	.003
1.57	.002	6.83	.008	12.10	.008	17.37	.005	22.63	.003
1.60	.002	6.87	.008	12.13	.008	17.40	.005	22.67	.003
1.63	.002	6.90	.008	12.17	.008	17.43	.005	22.70	.003
1.67	.002	6.93	.008	12.20	.008	17.47	.005	22.73	.003
1.70	.002	6.97	.009	12.23	.008	17.50	.005	22.77	.003
1.73	.002	7.00	.009	12.27	.008	17.53	.005	22.80	.003
1.77	.002	7.03	.009	12.30	.008	17.57	.005	22.83	.003
1.80	.002	7.07	.009	12.33	.008	17.60	.005	22.87	.003
1.83	.002	7.10	.009	12.37	.008	17.63	.005	22.90	.003
1.87	.002	7.13	.010	12.40	.008	17.67	.004	22.93	.003
1.90	.002	7.17	.010	12.43	.008	17.70	.004	22.97	.003
1.93	.002	7.20	.011	12.47	.008	17.73	.004	23.00	.003
1.97	.002	7.23	.011	12.50	.008	17.77	.004	23.03	.003
2.00	.002	7.27	.011	12.53	.008	17.80	.004	23.07	.003
2.03	.002	7.30	.011	12.57	.008	17.83	.004	23.10	.003
2.07	.002	7.33	.012	12.60	.008	17.87	.004	23.13	.003
2.10	.002	7.37	.013	12.63	.007	17.90	.004	23.17	.003
2.13	.002	7.40	.014	12.67	.007	17.93	.004	23.20	.003
2.17	.002	7.43	.014	12.70	.007	17.97	.004	23.23	.003
2.20	.002	7.47	.015	12.73	.007	18.00	.004	23.27	.003
2.23	.002	7.50	.015	12.77	.007	18.03	.004	23.30	.003
2.27	.002	7.53	.016	12.80	.007	18.07	.004	23.33	.003
2.30	.002	7.57	.017	12.83	.007	18.10	.004	23.37	.003
2.33	.002	7.60	.020	12.87	.007	18.13	.004	23.40	.003
2.37	.002	7.63	.023	12.90	.007	18.17	.004	23.43	.003
2.40	.002	7.67	.025	12.93	.007	18.20	.004	23.47	.003
2.43	.002	7.70	.027	12.97	.007	18.23	.004	23.50	.003
2.47	.002	7.73	.028	13.00	.007	18.27	.004	23.53	.003
2.50	.002	7.77	.031	13.03	.007	18.30	.004	23.57	.003
2.53	.002	7.80	.041	13.07	.007	18.33	.004	23.60	.003
2.57	.002	7.83	.059	13.10	.007	18.37	.004	23.63	.003
2.60	.002	7.87	.085	13.13	.007	18.40	.004	23.67	.003
2.63	.002	7.90	.108	13.17	.007	18.43	.004	23.70	.003
2.67	.002	7.93	.125	13.20	.007	18.47	.004	23.73	.003
2.70	.002	7.97	.138	13.23	.007	18.50	.004	23.77	.003
2.73	.002	8.00	.148	13.27	.007	18.53	.004	23.80	.003
2.77	.002	8.03	.151	13.30	.007	18.57	.004	23.83	.003
2.80	.002	8.07	.145	13.33	.007	18.60	.004	23.87	.003
2.83	.002	8.10	.131	13.37	.007	18.63	.004	23.90	.003
2.87	.002	8.13	.112	13.40	.007	18.67	.004	23.93	.003
2.90	.002	8.17	.099	13.43	.007	18.70	.004	23.97	.003
2.93	.002	8.20	.089	13.47	.007	18.73	.004	24.00	.003
2.97	.002	8.23	.082	13.50	.007	18.77	.004	24.03	.003
3.00	.002	8.27	.077	13.53	.007	18.80	.004	24.07	.003
3.03	.002	8.30	.072	13.57	.007	18.83	.004	24.10	.003
3.07	.002	8.33	.067	13.60	.007	18.87	.004	24.13	.002

3.10	.003	8.37	.062	13.63	.007	18.90	.004	24.17	.002
3.13	.003	8.40	.057	13.67	.006	18.93	.004	24.20	.002
3.17	.003	8.43	.053	13.70	.006	18.97	.004	24.23	.002
3.20	.003	8.47	.050	13.73	.006	19.00	.004	24.27	.001
3.23	.003	8.50	.048	13.77	.006	19.03	.004	24.30	.001
3.27	.003	8.53	.046	13.80	.006	19.07	.004	24.33	.001
3.30	.003	8.57	.044	13.83	.006	19.10	.004	24.37	.001
3.33	.003	8.60	.042	13.87	.006	19.13	.004	24.40	.001
3.37	.003	8.63	.039	13.90	.006	19.17	.004	24.43	.001
3.40	.003	8.67	.037	13.93	.006	19.20	.004	24.47	.001
3.43	.003	8.70	.036	13.97	.006	19.23	.004	24.50	.001
3.47	.003	8.73	.035	14.00	.006	19.27	.004	24.53	.001
3.50	.003	8.77	.034	14.03	.006	19.30	.004	24.57	.001
3.53	.003	8.80	.033	14.07	.006	19.33	.004	24.60	.001
3.57	.003	8.83	.031	14.10	.006	19.37	.004	24.63	.001
3.60	.003	8.87	.030	14.13	.006	19.40	.004	24.67	.000
3.63	.003	8.90	.029	14.17	.006	19.43	.004	24.70	.000
3.67	.003	8.93	.028	14.20	.006	19.47	.004	24.73	.000
3.70	.003	8.97	.027	14.23	.006	19.50	.004	24.77	.000
3.73	.003	9.00	.027	14.27	.006	19.53	.004	24.80	.000
3.77	.003	9.03	.026	14.30	.006	19.57	.004	24.83	.000
3.80	.003	9.07	.025	14.33	.006	19.60	.004	24.87	.000
3.83	.003	9.10	.024	14.37	.006	19.63	.004	24.90	.000
3.87	.003	9.13	.024	14.40	.006	19.67	.004	24.93	.000
3.90	.003	9.17	.023	14.43	.006	19.70	.004	24.97	.000
3.93	.003	9.20	.022	14.47	.006	19.73	.004	25.00	.000
3.97	.003	9.23	.022	14.50	.006	19.77	.004	25.03	.000
4.00	.003	9.27	.021	14.53	.006	19.80	.004	25.07	.000
4.03	.003	9.30	.021	14.57	.006	19.83	.004	25.10	.000
4.07	.003	9.33	.020	14.60	.006	19.87	.004	25.13	.000
4.10	.003	9.37	.020	14.63	.006	19.90	.004	25.17	.000
4.13	.003	9.40	.019	14.67	.006	19.93	.004	25.20	.000
4.17	.003	9.43	.019	14.70	.006	19.97	.004	25.23	.000
4.20	.003	9.47	.019	14.73	.006	20.00	.004	25.27	.000
4.23	.003	9.50	.018	14.77	.006	20.03	.004	25.30	.000
4.27	.003	9.53	.018	14.80	.006	20.07	.004	25.33	.000
4.30	.003	9.57	.018	14.83	.006	20.10	.004	25.37	.000
4.33	.003	9.60	.017	14.87	.006	20.13	.004	25.40	.000
4.37	.003	9.63	.017	14.90	.006	20.17	.004	25.43	.000
4.40	.003	9.67	.017	14.93	.006	20.20	.004	25.47	.000
4.43	.003	9.70	.016	14.97	.006	20.23	.004	25.50	.000
4.47	.003	9.73	.016	15.00	.006	20.27	.004	25.53	.000
4.50	.003	9.77	.016	15.03	.006	20.30	.004	25.57	.000
4.53	.003	9.80	.016	15.07	.006	20.33	.004	25.60	.000
4.57	.003	9.83	.015	15.10	.006	20.37	.004	25.63	.000
4.60	.003	9.87	.015	15.13	.006	20.40	.004	25.67	.000
4.63	.003	9.90	.015	15.17	.006	20.43	.004	25.70	.000
4.67	.003	9.93	.015	15.20	.005	20.47	.004	25.73	.000
4.70	.003	9.97	.014	15.23	.005	20.50	.004	25.77	.000
4.73	.003	10.00	.014	15.27	.005	20.53	.004	25.80	.000
4.77	.003	10.03	.014	15.30	.005	20.57	.004	25.83	.000

```
   4.80    .004|  10.07    .014|  15.33    .005|  20.60    .004|  25.87    .000
   4.83    .004|  10.10    .014|  15.37    .005|  20.63    .004|  25.90    .000
   4.87    .004|  10.13    .013|  15.40    .005|  20.67    .004|  25.93    .000
   4.90    .004|  10.17    .013|  15.43    .005|  20.70    .004|  25.97    .000
   4.93    .004|  10.20    .013|  15.47    .005|  20.73    .004|  26.00    .000
   4.97    .004|  10.23    .013|  15.50    .005|  20.77    .004|  26.03    .000
   5.00    .004|  10.27    .013|  15.53    .005|  20.80    .004|  26.07    .000
   5.03    .004|  10.30    .013|  15.57    .005|  20.83    .004|  26.10    .000
   5.07    .004|  10.33    .013|  15.60    .005|  20.87    .004|  26.13    .000
   5.10    .004|  10.37    .012|  15.63    .005|  20.90    .004|  26.17    .000
   5.13    .004|  10.40    .012|  15.67    .005|  20.93    .004|  26.20    .000
   5.17    .004|  10.43    .012|  15.70    .005|  20.97    .004|
   5.20    .004|  10.47    .012|  15.73    .005|  21.00    .004|
   5.23    .004|  10.50    .012|  15.77    .005|  21.03    .004|
-------------------------------------------------------------------------------
001:0005---------------------------------------------------------------------
*
*-----------------|-------------------------------------------------------|
*
*  UAD = 2.0 L/s/ha
*
*  The pond outflow is then:
*      2.0 x 2.14 ha = 4.28 L/s or about 0.00428 cms.
*
*  A Storage-Outflow Table was developed for input into the SWMHYMO Model.
*  In developing the Storage-Outflow table, the pond was assumed to:
*                      1. have 5H:1V sideslopes
*                      2. max. 1.5 m active storage depth.
*                      3. be orifice controlled.
*                      5. calculated orifice diameter = 41 mm
*
----------------------
| ROUTE RESERVOIR    |    Requested routing time step =  1.0 min.
|  IN>01:(NurRV )    |
| OUT<02:(POND  )    |    =========  OUTLFOW STORAGE TABLE  =========
---------------------    OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
                           (cms)    (ha.m.)    |    (cms)    (ha.m.)
                            .000  .0000E+00    |     .003  .1770E-01
                            .001  .1100E-02    |     .003  .2150E-01
                            .001  .2500E-02    |     .003  .2580E-01
                            .002  .4200E-02    |     .004  .3050E-01
                            .002  .6200E-02    |     .004  .3570E-01
                            .002  .8500E-02    |     .004  .4140E-01
                            .003  .1120E-01    |     .004  .4760E-01
                            .003  .1420E-01    |     .004  .5440E-01

     ROUTING RESULTS            AREA     QPEAK     TPEAK       R.V.
     --------------------       (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (NurRV )       2.14      .151     8.033     36.096
     OUTFLOW<02: (POND  )       2.14      .004    18.717     36.096
```

```
                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=    2.778
                    TIME SHIFT OF PEAK FLOW         (min)=   641.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=.5101E-01

--------------------------------------------------------------------------------
001:0006----------------------------------------------------------------------
*
*-----------------|-----------------------------------------------------------|
*
--------------------
| SAVE HYD         |   AREA       (ha)=    2.140
| ID=02 (POND  )   |   QPEAK     (cms)=     .004 (i)
| DT= 1.00 PCYC= 5 |   TPEAK     (hrs)=   18.717
--------------------   VOLUME     (mm)=   36.096
  Filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\H-POND.001
  Comments: POND

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
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TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	16.75	.004	33.50	.004	50.25	.003	67.00	.001
.08	.000	16.83	.004	33.58	.004	50.33	.003	67.08	.001
.17	.000	16.92	.004	33.67	.004	50.42	.003	67.17	.001
.25	.000	17.00	.004	33.75	.004	50.50	.003	67.25	.001
.33	.000	17.08	.004	33.83	.004	50.58	.003	67.33	.001
.42	.000	17.17	.004	33.92	.004	50.67	.003	67.42	.001
.50	.000	17.25	.004	34.00	.004	50.75	.003	67.50	.001
.58	.000	17.33	.004	34.08	.004	50.83	.003	67.58	.001
.67	.000	17.42	.004	34.17	.004	50.92	.003	67.67	.001
.75	.000	17.50	.004	34.25	.004	51.00	.003	67.75	.001
.83	.000	17.58	.004	34.33	.004	51.08	.003	67.83	.001
.92	.000	17.67	.004	34.42	.004	51.17	.003	67.92	.001
1.00	.000	17.75	.004	34.50	.004	51.25	.003	68.00	.001
1.08	.000	17.83	.004	34.58	.004	51.33	.003	68.08	.001
1.17	.000	17.92	.004	34.67	.004	51.42	.003	68.17	.001
1.25	.000	18.00	.004	34.75	.004	51.50	.003	68.25	.001
1.33	.000	18.08	.004	34.83	.004	51.58	.003	68.33	.001
1.42	.000	18.17	.004	34.92	.004	51.67	.003	68.42	.001
1.50	.000	18.25	.004	35.00	.004	51.75	.003	68.50	.001
1.58	.000	18.33	.004	35.08	.004	51.83	.003	68.58	.001
1.67	.000	18.42	.004	35.17	.004	51.92	.003	68.67	.001
1.75	.000	18.50	.004	35.25	.004	52.00	.003	68.75	.001
1.83	.000	18.58	.004	35.33	.004	52.08	.003	68.83	.001
1.92	.000	18.67	.004	35.42	.004	52.17	.003	68.92	.001
2.00	.000	18.75	.004	35.50	.004	52.25	.003	69.00	.001
2.08	.000	18.83	.004	35.58	.004	52.33	.003	69.08	.001
2.17	.000	18.92	.004	35.67	.004	52.42	.003	69.17	.001
2.25	.000	19.00	.004	35.75	.004	52.50	.003	69.25	.001
2.33	.001	19.08	.004	35.83	.004	52.58	.003	69.33	.001
2.42	.001	19.17	.004	35.92	.004	52.67	.003	69.42	.001
2.50	.001	19.25	.004	36.00	.004	52.75	.003	69.50	.001

2.58	.001|	19.33	.004|	36.08	.004|	52.83	.003|	69.58	.001
2.67	.001|	19.42	.004|	36.17	.004|	52.92	.003|	69.67	.001
2.75	.001|	19.50	.004|	36.25	.004|	53.00	.003|	69.75	.001
2.83	.001|	19.58	.004|	36.33	.004|	53.08	.003|	69.83	.001
2.92	.001|	19.67	.004|	36.42	.004|	53.17	.003|	69.92	.001
3.00	.001|	19.75	.004|	36.50	.004|	53.25	.003|	70.00	.001
3.08	.001|	19.83	.004|	36.58	.004|	53.33	.003|	70.08	.001
3.17	.001|	19.92	.004|	36.67	.004|	53.42	.003|	70.17	.001
3.25	.001|	20.00	.004|	36.75	.004|	53.50	.003|	70.25	.001
3.33	.001|	20.08	.004|	36.83	.004|	53.58	.003|	70.33	.001
3.42	.001|	20.17	.004|	36.92	.004|	53.67	.003|	70.42	.001
3.50	.001|	20.25	.004|	37.00	.004|	53.75	.003|	70.50	.001
3.58	.001|	20.33	.004|	37.08	.004|	53.83	.003|	70.58	.001
3.67	.001|	20.42	.004|	37.17	.004|	53.92	.003|	70.67	.001
3.75	.001|	20.50	.004|	37.25	.004|	54.00	.003|	70.75	.001
3.83	.001|	20.58	.004|	37.33	.004|	54.08	.003|	70.83	.001
3.92	.001|	20.67	.004|	37.42	.004|	54.17	.003|	70.92	.001
4.00	.001|	20.75	.004|	37.50	.004|	54.25	.003|	71.00	.001
4.08	.001|	20.83	.004|	37.58	.004|	54.33	.003|	71.08	.001
4.17	.001|	20.92	.004|	37.67	.004|	54.42	.003|	71.17	.001
4.25	.001|	21.00	.004|	37.75	.004|	54.50	.003|	71.25	.001
4.33	.001|	21.08	.004|	37.83	.004|	54.58	.003|	71.33	.001
4.42	.001|	21.17	.004|	37.92	.004|	54.67	.003|	71.42	.001
4.50	.001|	21.25	.004|	38.00	.004|	54.75	.003|	71.50	.000
4.58	.001|	21.33	.004|	38.08	.004|	54.83	.003|	71.58	.000
4.67	.001|	21.42	.004|	38.17	.004|	54.92	.003|	71.67	.000
4.75	.001|	21.50	.004|	38.25	.004|	55.00	.003|	71.75	.000
4.83	.001|	21.58	.004|	38.33	.004|	55.08	.003|	71.83	.000
4.92	.001|	21.67	.004|	38.42	.004|	55.17	.003|	71.92	.000
5.00	.001|	21.75	.004|	38.50	.004|	55.25	.003|	72.00	.000
5.08	.001|	21.83	.004|	38.58	.004|	55.33	.003|	72.08	.000
5.17	.001|	21.92	.004|	38.67	.004|	55.42	.003|	72.17	.000
5.25	.001|	22.00	.004|	38.75	.004|	55.50	.003|	72.25	.000
5.33	.002|	22.08	.004|	38.83	.004|	55.58	.003|	72.33	.000
5.42	.002|	22.17	.004|	38.92	.004|	55.67	.003|	72.42	.000
5.50	.002|	22.25	.004|	39.00	.004|	55.75	.003|	72.50	.000
5.58	.002|	22.33	.004|	39.08	.004|	55.83	.003|	72.58	.000
5.67	.002|	22.42	.004|	39.17	.004|	55.92	.003|	72.67	.000
5.75	.002|	22.50	.004|	39.25	.004|	56.00	.003|	72.75	.000
5.83	.002|	22.58	.004|	39.33	.004|	56.08	.003|	72.83	.000
5.92	.002|	22.67	.004|	39.42	.004|	56.17	.003|	72.92	.000
6.00	.002|	22.75	.004|	39.50	.004|	56.25	.003|	73.00	.000
6.08	.002|	22.83	.004|	39.58	.004|	56.33	.003|	73.08	.000
6.17	.002|	22.92	.004|	39.67	.004|	56.42	.003|	73.17	.000
6.25	.002|	23.00	.004|	39.75	.004|	56.50	.003|	73.25	.000
6.33	.002|	23.08	.004|	39.83	.004|	56.58	.003|	73.33	.000
6.42	.002|	23.17	.004|	39.92	.004|	56.67	.003|	73.42	.000
6.50	.002|	23.25	.004|	40.00	.004|	56.75	.003|	73.50	.000
6.58	.002|	23.33	.004|	40.08	.004|	56.83	.003|	73.58	.000
6.67	.002|	23.42	.004|	40.17	.004|	56.92	.002|	73.67	.000
6.75	.002|	23.50	.004|	40.25	.004|	57.00	.002|	73.75	.000

6.83	.002	23.58	.004	40.33	.004	57.08	.002	73.83	.000
6.92	.002	23.67	.004	40.42	.004	57.17	.002	73.92	.000
7.00	.002	23.75	.004	40.50	.004	57.25	.002	74.00	.000
7.08	.002	23.83	.004	40.58	.004	57.33	.002	74.08	.000
7.17	.002	23.92	.004	40.67	.004	57.42	.002	74.17	.000
7.25	.002	24.00	.004	40.75	.004	57.50	.002	74.25	.000
7.33	.002	24.08	.004	40.83	.004	57.58	.002	74.33	.000
7.42	.002	24.17	.004	40.92	.004	57.67	.002	74.42	.000
7.50	.002	24.25	.004	41.00	.004	57.75	.002	74.50	.000
7.58	.002	24.33	.004	41.08	.004	57.83	.002	74.58	.000
7.67	.002	24.42	.004	41.17	.003	57.92	.002	74.67	.000
7.75	.002	24.50	.004	41.25	.003	58.00	.002	74.75	.000
7.83	.003	24.58	.004	41.33	.003	58.08	.002	74.83	.000
7.92	.003	24.67	.004	41.42	.003	58.17	.002	74.92	.000
8.00	.003	24.75	.004	41.50	.003	58.25	.002	75.00	.000
8.08	.003	24.83	.004	41.58	.003	58.33	.002	75.08	.000
8.17	.003	24.92	.004	41.67	.003	58.42	.002	75.17	.000
8.25	.003	25.00	.004	41.75	.003	58.50	.002	75.25	.000
8.33	.004	25.08	.004	41.83	.003	58.58	.002	75.33	.000
8.42	.004	25.17	.004	41.92	.003	58.67	.002	75.42	.000
8.50	.004	25.25	.004	42.00	.003	58.75	.002	75.50	.000
8.58	.004	25.33	.004	42.08	.003	58.83	.002	75.58	.000
8.67	.004	25.42	.004	42.17	.003	58.92	.002	75.67	.000
8.75	.004	25.50	.004	42.25	.003	59.00	.002	75.75	.000
8.83	.004	25.58	.004	42.33	.003	59.08	.002	75.84	.000
8.92	.004	25.67	.004	42.42	.003	59.17	.002	75.92	.000
9.00	.004	25.75	.004	42.50	.003	59.25	.002	76.00	.000
9.08	.004	25.83	.004	42.58	.003	59.33	.002	76.09	.000
9.17	.004	25.92	.004	42.67	.003	59.42	.002	76.17	.000
9.25	.004	26.00	.004	42.75	.003	59.50	.002	76.25	.000
9.33	.004	26.08	.004	42.83	.003	59.58	.002	76.34	.000
9.42	.004	26.17	.004	42.92	.003	59.67	.002	76.42	.000
9.50	.004	26.25	.004	43.00	.003	59.75	.002	76.50	.000
9.58	.004	26.33	.004	43.08	.003	59.83	.002	76.59	.000
9.67	.004	26.42	.004	43.17	.003	59.92	.002	76.67	.000
9.75	.004	26.50	.004	43.25	.003	60.00	.002	76.75	.000
9.83	.004	26.58	.004	43.33	.003	60.08	.002	76.84	.000
9.92	.004	26.67	.004	43.42	.003	60.17	.002	76.92	.000
10.00	.004	26.75	.004	43.50	.003	60.25	.002	77.00	.000
10.08	.004	26.83	.004	43.58	.003	60.33	.002	77.09	.000
10.17	.004	26.92	.004	43.67	.003	60.42	.002	77.17	.000
10.25	.004	27.00	.004	43.75	.003	60.50	.002	77.25	.000
10.33	.004	27.08	.004	43.83	.003	60.58	.002	77.34	.000
10.42	.004	27.17	.004	43.92	.003	60.67	.002	77.42	.000
10.50	.004	27.25	.004	44.00	.003	60.75	.002	77.50	.000
10.58	.004	27.33	.004	44.08	.003	60.83	.002	77.59	.000
10.67	.004	27.42	.004	44.17	.003	60.92	.002	77.67	.000
10.75	.004	27.50	.004	44.25	.003	61.00	.002	77.75	.000
10.83	.004	27.58	.004	44.33	.003	61.08	.002	77.84	.000
10.92	.004	27.67	.004	44.42	.003	61.17	.002	77.92	.000
11.00	.004	27.75	.004	44.50	.003	61.25	.002	78.00	.000

11.08	.004	27.83	.004	44.58	.003	61.33	.002	78.09	.000
11.17	.004	27.92	.004	44.67	.003	61.42	.002	78.17	.000
11.25	.004	28.00	.004	44.75	.003	61.50	.002	78.25	.000
11.33	.004	28.08	.004	44.83	.003	61.58	.002	78.34	.000
11.42	.004	28.17	.004	44.92	.003	61.67	.002	78.42	.000
11.50	.004	28.25	.004	45.00	.003	61.75	.002	78.50	.000
11.58	.004	28.33	.004	45.08	.003	61.83	.002	78.59	.000
11.67	.004	28.42	.004	45.17	.003	61.92	.002	78.67	.000
11.75	.004	28.50	.004	45.25	.003	62.00	.002	78.75	.000
11.83	.004	28.58	.004	45.33	.003	62.08	.002	78.84	.000
11.92	.004	28.67	.004	45.42	.003	62.17	.002	78.92	.000
12.00	.004	28.75	.004	45.50	.003	62.25	.002	79.00	.000
12.08	.004	28.83	.004	45.58	.003	62.33	.002	79.09	.000
12.17	.004	28.92	.004	45.67	.003	62.42	.002	79.17	.000
12.25	.004	29.00	.004	45.75	.003	62.50	.002	79.25	.000
12.33	.004	29.08	.004	45.83	.003	62.58	.002	79.34	.000
12.42	.004	29.17	.004	45.92	.003	62.67	.002	79.42	.000
12.50	.004	29.25	.004	46.00	.003	62.75	.002	79.50	.000
12.58	.004	29.33	.004	46.08	.003	62.83	.002	79.59	.000
12.67	.004	29.42	.004	46.17	.003	62.92	.002	79.67	.000
12.75	.004	29.50	.004	46.25	.003	63.00	.002	79.75	.000
12.83	.004	29.58	.004	46.33	.003	63.08	.002	79.84	.000
12.92	.004	29.67	.004	46.42	.003	63.17	.002	79.92	.000
13.00	.004	29.75	.004	46.50	.003	63.25	.002	80.00	.000
13.08	.004	29.83	.004	46.58	.003	63.33	.002	80.09	.000
13.17	.004	29.92	.004	46.67	.003	63.42	.002	80.17	.000
13.25	.004	30.00	.004	46.75	.003	63.50	.002	80.25	.000
13.33	.004	30.08	.004	46.83	.003	63.58	.002	80.34	.000
13.42	.004	30.17	.004	46.92	.003	63.67	.002	80.42	.000
13.50	.004	30.25	.004	47.00	.003	63.75	.002	80.50	.000
13.58	.004	30.33	.004	47.08	.003	63.83	.002	80.59	.000
13.67	.004	30.42	.004	47.17	.003	63.92	.002	80.67	.000
13.75	.004	30.50	.004	47.25	.003	64.00	.002	80.75	.000
13.83	.004	30.58	.004	47.33	.003	64.08	.002	80.84	.000
13.92	.004	30.67	.004	47.42	.003	64.17	.002	80.92	.000
14.00	.004	30.75	.004	47.50	.003	64.25	.002	81.00	.000
14.08	.004	30.83	.004	47.58	.003	64.33	.002	81.09	.000
14.17	.004	30.92	.004	47.67	.003	64.42	.002	81.17	.000
14.25	.004	31.00	.004	47.75	.003	64.50	.002	81.25	.000
14.33	.004	31.08	.004	47.83	.003	64.58	.002	81.34	.000
14.42	.004	31.17	.004	47.92	.003	64.67	.002	81.42	.000
14.50	.004	31.25	.004	48.00	.003	64.75	.002	81.50	.000
14.58	.004	31.33	.004	48.08	.003	64.83	.002	81.59	.000
14.67	.004	31.42	.004	48.17	.003	64.92	.002	81.67	.000
14.75	.004	31.50	.004	48.25	.003	65.00	.002	81.75	.000
14.83	.004	31.58	.004	48.33	.003	65.08	.002	81.84	.000
14.92	.004	31.67	.004	48.42	.003	65.17	.002	81.92	.000
15.00	.004	31.75	.004	48.50	.003	65.25	.002	82.00	.000
15.08	.004	31.83	.004	48.58	.003	65.33	.002	82.09	.000
15.17	.004	31.92	.004	48.67	.003	65.42	.002	82.17	.000
15.25	.004	32.00	.004	48.75	.003	65.50	.002	82.25	.000

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  15.33    .004|  32.08    .004|  48.83    .003|  65.58    .002|  82.34    .000
  15.42    .004|  32.17    .004|  48.92    .003|  65.67    .002|  82.42    .000
  15.50    .004|  32.25    .004|  49.00    .003|  65.75    .002|  82.50    .000
  15.58    .004|  32.33    .004|  49.08    .003|  65.83    .002|  82.59    .000
  15.67    .004|  32.42    .004|  49.17    .003|  65.92    .002|  82.67    .000
  15.75    .004|  32.50    .004|  49.25    .003|  66.00    .002|  82.75    .000
  15.83    .004|  32.58    .004|  49.33    .003|  66.08    .001|  82.84    .000
  15.92    .004|  32.67    .004|  49.42    .003|  66.17    .001|  82.92    .000
  16.00    .004|  32.75    .004|  49.50    .003|  66.25    .001|  83.00    .000
  16.08    .004|  32.83    .004|  49.58    .003|  66.33    .001|  83.09    .000
  16.17    .004|  32.92    .004|  49.67    .003|  66.42    .001|  83.17    .000
  16.25    .004|  33.00    .004|  49.75    .003|  66.50    .001|  83.25    .000
  16.33    .004|  33.08    .004|  49.83    .003|  66.58    .001|  83.34    .000
  16.42    .004|  33.17    .004|  49.92    .003|  66.67    .001|  83.42    .000
  16.50    .004|  33.25    .004|  50.00    .003|  66.75    .001|  83.50    .000
  16.58    .004|  33.33    .004|  50.08    .003|  66.83    .001|
  16.67    .004|  33.42    .004|  50.17    .003|  66.92    .001|
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001:0007----------------------------------------------------------------------
*
*-----------------|-------------------------------------------------------|
*
----------------------
| COMPUTE DUALHYD    |   Average inlet capacities   [CINLET] =    .004  (cms)
| TotalHyd 01:NurRV  |   Number of inlets in system [NINLET] =      1
----------------------   Total minor system capacity         =    .004  (cms)
                         Total major system storage [TMJSTO] =   99999.(cu.m.)

                  ID: NHYD        AREA     QPEAK     TPEAK     R.V.      DWF
                                  (ha)     (cms)     (hrs)     (mm)     (cms)
     TOTAL HYD.   01:NurRV        2.14      .151     8.033   36.096     .000
     ========================================================================
     MAJOR SYST   03:major         .00      .000      .000     .000     .000
     MINOR SYST   04:minor        2.14      .004     5.533   36.102     .000

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

     Maximum MAJOR SYSTEM storage used =     454.(cu.m.)

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001:0008----------------------------------------------------------------------
*-----------------|-------------------------------------------------------|
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| SAVE HYD         |   AREA       (ha)=    2.140
| ID=04 (minor )   |   QPEAK     (cms)=     .004 (i)
| DT= 1.00 PCYC= 5 |   TPEAK     (hrs)=    5.533
--------------------   VOLUME     (mm)=   36.102
  Filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\H-minor.001
  Comments: Hydrograph
```

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	10.67	.004	21.33	.004	32.00	.004	42.67	.004
.08	.000	10.75	.004	21.42	.004	32.08	.004	42.75	.004
.17	.000	10.83	.004	21.50	.004	32.17	.004	42.83	.004
.25	.000	10.92	.004	21.58	.004	32.25	.004	42.92	.004
.33	.000	11.00	.004	21.67	.004	32.33	.004	43.00	.004
.42	.000	11.08	.004	21.75	.004	32.42	.004	43.08	.004
.50	.000	11.17	.004	21.83	.004	32.50	.004	43.17	.004
.58	.000	11.25	.004	21.92	.004	32.58	.004	43.25	.004
.67	.000	11.33	.004	22.00	.004	32.67	.004	43.33	.004
.75	.000	11.42	.004	22.08	.004	32.75	.004	43.42	.004
.83	.000	11.50	.004	22.17	.004	32.83	.004	43.50	.004
.92	.000	11.58	.004	22.25	.004	32.92	.004	43.58	.004
1.00	.000	11.67	.004	22.33	.004	33.00	.004	43.67	.004
1.08	.000	11.75	.004	22.42	.004	33.08	.004	43.75	.004
1.17	.000	11.83	.004	22.50	.004	33.17	.004	43.83	.004
1.25	.000	11.92	.004	22.58	.004	33.25	.004	43.92	.004
1.33	.000	12.00	.004	22.67	.004	33.33	.004	44.00	.004
1.42	.001	12.08	.004	22.75	.004	33.42	.004	44.08	.004
1.50	.002	12.17	.004	22.83	.004	33.50	.004	44.17	.004
1.58	.002	12.25	.004	22.92	.004	33.58	.004	44.25	.004
1.67	.002	12.33	.004	23.00	.004	33.67	.004	44.33	.004
1.75	.002	12.42	.004	23.08	.004	33.75	.004	44.42	.004
1.83	.002	12.50	.004	23.17	.004	33.83	.004	44.50	.004
1.92	.002	12.58	.004	23.25	.004	33.92	.004	44.58	.004
2.00	.002	12.67	.004	23.33	.004	34.00	.004	44.67	.004
2.08	.002	12.75	.004	23.42	.004	34.08	.004	44.75	.004
2.17	.002	12.83	.004	23.50	.004	34.17	.004	44.83	.004
2.25	.002	12.92	.004	23.58	.004	34.25	.004	44.92	.004
2.33	.002	13.00	.004	23.67	.004	34.33	.004	45.00	.004
2.42	.002	13.08	.004	23.75	.004	34.42	.004	45.08	.004
2.50	.002	13.17	.004	23.83	.004	34.50	.004	45.17	.004
2.58	.002	13.25	.004	23.92	.004	34.58	.004	45.25	.004
2.67	.002	13.33	.004	24.00	.004	34.67	.004	45.33	.004
2.75	.002	13.42	.004	24.08	.004	34.75	.004	45.42	.004
2.83	.002	13.50	.004	24.17	.004	34.83	.004	45.50	.004
2.92	.002	13.58	.004	24.25	.004	34.92	.004	45.58	.004
3.00	.002	13.67	.004	24.33	.004	35.00	.004	45.67	.004
3.08	.002	13.75	.004	24.42	.004	35.08	.004	45.75	.004
3.17	.003	13.83	.004	24.50	.004	35.17	.004	45.83	.004
3.25	.003	13.92	.004	24.58	.004	35.25	.004	45.92	.004
3.33	.003	14.00	.004	24.67	.004	35.33	.004	46.00	.004
3.42	.003	14.08	.004	24.75	.004	35.42	.004	46.08	.004
3.50	.003	14.17	.004	24.83	.004	35.50	.004	46.17	.004
3.58	.003	14.25	.004	24.92	.004	35.58	.004	46.25	.004
3.67	.003	14.33	.004	25.00	.004	35.67	.004	46.33	.004
3.75	.003	14.42	.004	25.08	.004	35.75	.004	46.42	.004
3.83	.003	14.50	.004	25.17	.004	35.83	.004	46.50	.004
3.92	.003	14.58	.004	25.25	.004	35.92	.004	46.58	.004

4.00	.003	14.67	.004	25.33	.004	36.00	.004	46.67	.004
4.08	.003	14.75	.004	25.42	.004	36.08	.004	46.75	.004
4.17	.003	14.83	.004	25.50	.004	36.17	.004	46.83	.004
4.25	.003	14.92	.004	25.58	.004	36.25	.004	46.92	.004
4.33	.003	15.00	.004	25.67	.004	36.33	.004	47.00	.004
4.42	.003	15.08	.004	25.75	.004	36.42	.004	47.08	.004
4.50	.003	15.17	.004	25.83	.004	36.50	.004	47.17	.004
4.58	.003	15.25	.004	25.92	.004	36.58	.004	47.25	.004
4.67	.003	15.33	.004	26.00	.004	36.67	.004	47.33	.004
4.75	.003	15.42	.004	26.08	.004	36.75	.004	47.42	.004
4.83	.004	15.50	.004	26.17	.004	36.83	.004	47.50	.004
4.92	.004	15.58	.004	26.25	.004	36.92	.004	47.58	.004
5.00	.004	15.67	.004	26.33	.004	37.00	.004	47.67	.004
5.08	.004	15.75	.004	26.42	.004	37.08	.004	47.75	.004
5.17	.004	15.83	.004	26.50	.004	37.17	.004	47.83	.004
5.25	.004	15.92	.004	26.58	.004	37.25	.004	47.92	.004
5.33	.004	16.00	.004	26.67	.004	37.33	.004	48.00	.004
5.42	.004	16.08	.004	26.75	.004	37.42	.004	48.08	.004
5.50	.004	16.17	.004	26.83	.004	37.50	.004	48.17	.004
5.58	.004	16.25	.004	26.92	.004	37.58	.004	48.25	.004
5.67	.004	16.33	.004	27.00	.004	37.67	.004	48.33	.004
5.75	.004	16.42	.004	27.08	.004	37.75	.004	48.42	.004
5.83	.004	16.50	.004	27.17	.004	37.83	.004	48.50	.004
5.92	.004	16.58	.004	27.25	.004	37.92	.004	48.58	.004
6.00	.004	16.67	.004	27.33	.004	38.00	.004	48.67	.004
6.08	.004	16.75	.004	27.42	.004	38.08	.004	48.75	.004
6.17	.004	16.83	.004	27.50	.004	38.17	.004	48.83	.004
6.25	.004	16.92	.004	27.58	.004	38.25	.004	48.92	.004
6.33	.004	17.00	.004	27.67	.004	38.33	.004	49.00	.004
6.42	.004	17.08	.004	27.75	.004	38.42	.004	49.08	.004
6.50	.004	17.17	.004	27.83	.004	38.50	.004	49.17	.004
6.58	.004	17.25	.004	27.92	.004	38.58	.004	49.25	.004
6.67	.004	17.33	.004	28.00	.004	38.67	.004	49.33	.004
6.75	.004	17.42	.004	28.08	.004	38.75	.004	49.42	.004
6.83	.004	17.50	.004	28.17	.004	38.83	.004	49.50	.004
6.92	.004	17.58	.004	28.25	.004	38.92	.004	49.58	.004
7.00	.004	17.67	.004	28.33	.004	39.00	.004	49.67	.004
7.08	.004	17.75	.004	28.42	.004	39.08	.004	49.75	.004
7.17	.004	17.83	.004	28.50	.004	39.17	.004	49.83	.004
7.25	.004	17.92	.004	28.58	.004	39.25	.004	49.92	.004
7.33	.004	18.00	.004	28.67	.004	39.33	.004	50.00	.004
7.42	.004	18.08	.004	28.75	.004	39.42	.004	50.08	.004
7.50	.004	18.17	.004	28.83	.004	39.50	.004	50.17	.004
7.58	.004	18.25	.004	28.92	.004	39.58	.004	50.25	.004
7.67	.004	18.33	.004	29.00	.004	39.67	.004	50.33	.004
7.75	.004	18.42	.004	29.08	.004	39.75	.004	50.42	.004
7.83	.004	18.50	.004	29.17	.004	39.83	.004	50.50	.004
7.92	.004	18.58	.004	29.25	.004	39.92	.004	50.58	.004
8.00	.004	18.67	.004	29.33	.004	40.00	.004	50.67	.004
8.08	.004	18.75	.004	29.42	.004	40.08	.004	50.75	.004
8.17	.004	18.83	.004	29.50	.004	40.17	.004	50.83	.004

```
   8.25    .004|  18.92    .004|  29.58    .004|  40.25    .004|  50.92    .004
   8.33    .004|  19.00    .004|  29.67    .004|  40.33    .004|  51.00    .004
   8.42    .004|  19.08    .004|  29.75    .004|  40.42    .004|  51.08    .004
   8.50    .004|  19.17    .004|  29.83    .004|  40.50    .004|  51.17    .004
   8.58    .004|  19.25    .004|  29.92    .004|  40.58    .004|  51.25    .004
   8.67    .004|  19.33    .004|  30.00    .004|  40.67    .004|  51.33    .004
   8.75    .004|  19.42    .004|  30.08    .004|  40.75    .004|  51.42    .004
   8.83    .004|  19.50    .004|  30.17    .004|  40.83    .004|  51.50    .004
   8.92    .004|  19.58    .004|  30.25    .004|  40.92    .004|  51.58    .004
   9.00    .004|  19.67    .004|  30.33    .004|  41.00    .004|  51.67    .004
   9.08    .004|  19.75    .004|  30.42    .004|  41.08    .004|  51.75    .004
   9.17    .004|  19.83    .004|  30.50    .004|  41.17    .004|  51.83    .004
   9.25    .004|  19.92    .004|  30.58    .004|  41.25    .004|  51.92    .004
   9.33    .004|  20.00    .004|  30.67    .004|  41.33    .004|  52.00    .004
   9.42    .004|  20.08    .004|  30.75    .004|  41.42    .004|  52.08    .004
   9.50    .004|  20.17    .004|  30.83    .004|  41.50    .004|  52.17    .004
   9.58    .004|  20.25    .004|  30.92    .004|  41.58    .004|  52.25    .004
   9.67    .004|  20.33    .004|  31.00    .004|  41.67    .004|  52.33    .004
   9.75    .004|  20.42    .004|  31.08    .004|  41.75    .004|  52.42    .004
   9.83    .004|  20.50    .004|  31.17    .004|  41.83    .004|  52.50    .004
   9.92    .004|  20.58    .004|  31.25    .004|  41.92    .004|  52.58    .004
  10.00    .004|  20.67    .004|  31.33    .004|  42.00    .004|  52.67    .004
  10.08    .004|  20.75    .004|  31.42    .004|  42.08    .004|  52.75    .004
  10.17    .004|  20.83    .004|  31.50    .004|  42.17    .004|  52.83    .004
  10.25    .004|  20.92    .004|  31.58    .004|  42.25    .004|  52.92    .004
  10.33    .004|  21.00    .004|  31.67    .004|  42.33    .004|
  10.42    .004|  21.08    .004|  31.75    .004|  42.42    .004|
  10.50    .004|  21.17    .004|  31.83    .004|  42.50    .004|
  10.58    .004|  21.25    .004|  31.92    .004|  42.58    .004|
--------------------------------------------------------------------------------
001:0009----------------------------------------------------------------------
*
*-----------------|-------------------------------------------------------------|
*
*-----------------|-------------------------------------------------------------|
*
--------------------
| COMPUTE VOLUME   |
| ID:01  (NurRV )  |             DISCHARGE      TIME
--------------------                (cms)       (hrs)
           START CONTROLLING AT     .000       1.250
           INFLOW HYD. PEAKS AT     .151       8.033
           STOP  CONTROLLING AT     .004      18.403

           REQUIRED STORAGE VOLUME (ha.m.)=    .0562
           TOTAL HYDROGRAPH VOLUME (ha.m.)=    .0772
           % OF HYDROGRAPH TO STORE       =  72.7457

           NOTE:  Storage was computed to reduce the Inflow
                  peak to     .004  (cms).
```

```
--------------------------------------------------------------------------------
001:0010--------------------------------------------------------------------------
*
*-----------------|-----------------------------------------------------------|
*
      FINISH
--------------------------------------------------------------------------------
********************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
   Simulation ended on 2017-04-11     at 08:12:34
================================================================================
```

A3. SWMHYMO - Summary Output File

```
================================================================================

  SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999    999    =========
  S      W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
  SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9   Ver  4.05
      S   W W   M   M  H   H    Y    M   M  O   O       9999   9999   Sept 2011
  SSSSS   W W   M   M  H   H    Y    M   M   OOO           9      9   =========
                                                       9   9  9   9   # 2268234
       StormWater Management HYdrologic Model           999    999    =========

********************************************************************************
***************************** SWMHYMO Ver/4.05  ********************************
*********  A single event and continuous hydrologic simulation model  *********
*********     based on the principles of HYMO and its successors      *********
*********                  OTTHYMO-83 and OTTHYMO-89.                  *********
********************************************************************************
********* Distributed by:  J.F. Sabourin and Associates Inc.           *********
*********                   Ottawa,  Ontario: (613) 836-3884           *********
*********                   Gatineau, Quebec: (819) 243-6858           *********
*********                   E-Mail: swmhymo@jfsa.Com                   *********
********************************************************************************

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++++ Licensed user: WSP Canada Inc                                +++++++++
+++++++++                Red Deer              SERIAL#:2268234         +++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

********************************************************************************
*********           ++++++ PROGRAM ARRAY DIMENSIONS ++++++             *********
*********           Maximum value for ID numbers  :     10            *********
*********           Max. number of rainfall points: 105408            *********
*********           Max. number of flow points    : 105408            *********
********************************************************************************

***** DESCRIPTION SUMMARY TABLE HEADERS (units depend on METOUT in START) *****
*****-------------------------------------------------------------------*****
*****    ID:  Hydrograph IDentification numbers, (1-10).                 *****
*****  NHYD:  Hydrograph reference numbers, (6 digits or characters).    *****
*****  AREA:  Drainage area associated with hydrograph, (ac.) or (ha.).  *****
***** QPEAK:  Peak flow of simulated hydrograph, (ft^3/s) or (m^3/s).    *****
***** TpeakDate_hh:mm is the date and time of the peak flow.             *****
*****  R.V.:  Runoff Volume of simulated hydrograph, (in) or (mm).       *****
*****  R.C.:  Runoff Coefficient of simulated hydrograph, (ratio).       *****
*****     *:  see WARNING or NOTE message printed at end of run.         *****
*****    **:  see  ERROR  message printed at end of run.                 *****
********************************************************************************
********************************************************************************
```

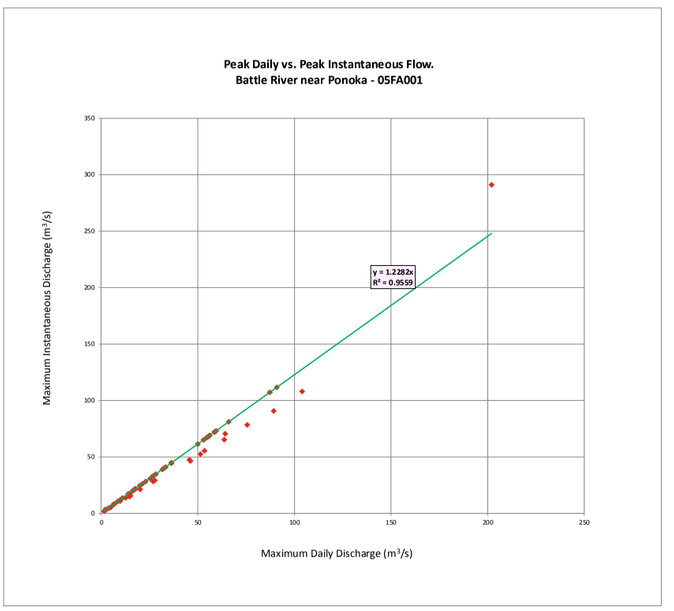
```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

 ******************************************************************************

 **********************   S U M M A R Y   O U T P U T   **********************
 ******************************************************************************
 *         DATE: 2017-04-11     TIME: 08:12:33     RUN COUNTER: 002357         *
 ******************************************************************************
 * Input   filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\NUR9.dat                *
 * Output  filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\NUR9.out                *
 * Summary filename: C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\NUR9.sum                *
 * User comments:                                                               *
 * 1:_____________________________________________________________________________*
 * 2:_____________________________________________________________________________*
 * 3:_____________________________________________________________________________*
 ******************************************************************************


#*******************************************************************************
#  Project Name: NURSERY RV PARK Stormwater Management
#  Project No. : WSP 161-15869-00
#  Date        : December 2016
#  Modeller    : AOC
#  Company     : WSP Canada Inc.
#  License #   : 2268234
#*******************************************************************************
 RUN:COMMAND#
 001:0001-------------------------------------------------------------------------------
     START
      [TZERO =    .00 hrs on        0]
      [METOUT=   2    (1=imperial, 2=metric output)]
      [NSTORM=   0 ]
      [NRUN  =   1 ]
 001:0002-------------------------------------------------------------------------------
     CHICAGO STORM
      [SDT=15.00:SDUR=  24.00:PTOT= 102.91]
      [A/B/C= 830.226/   1.367/    .724]
 001:0003---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     CALIB STANDHYD     01:NurRV          2.14     .151 No_date    8:02   36.10 .351
      [XIMP=.25:TIMP=.25]
      [LOSS= 2 :CN= 30.0]
      [Pervious     area: IAper= 3.20:SLPP=1.00:LGP=  25.:MNP=.250:SCP=   .0]
      [Impervious   area: IAimp= 1.60:SLPI=1.00:LGI= 230.:MNI=.029:SCI=   .0]
 001:0004---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     SAVE HYD           01:NurRV          2.14     .151 No_date    8:02   36.10  n/a
      fname :C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\H-NurRV.001
      remark:NurRV
 001:0005---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     ROUTE RESERVOIR -> 01:NurRV          2.14     .151 No_date    8:02   36.10  n/a
      [RDT= 1.00] out<- 02:POND           2.14     .004 No_date   18:43   36.10  n/a
     {MxStoUsed=.5101E-01}
```

```
 001:0006---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     SAVE HYD           02:POND           2.14     .004 No_date   18:43   36.10  n/a
      fname :C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\H-POND.001
      remark:POND
 001:0007---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     COMPUTE DUALHYD    01:NurRV          2.14     .151 No_date    8:02   36.10  n/a
        Major System /  03:major           .00     .000 No_date    0:00     .00  n/a
        Minor System \  04:minor          2.14     .004 No_date    5:32   36.10  n/a
      {MjSysSto=.4539E+03, TotOvfVol=.0000E+00, N-Ovf=    0, TotDurOvf=    0.hrs}
 001:0008---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     SAVE HYD           04:minor          2.14     .004 No_date    5:32   36.10  n/a
      fname :C:\PROGRA~2\SWMHYMO\PROJECTS\NURSE\H-minor.001
      remark:Hydrograph
 001:0009---------------ID:NHYD-----------AREA----QPEAK-TpeakDate_hh:mm----R.V.-R.C.-
     COMPUTE VOLUME     01:NurRV          2.14     .151 No_date    8:02   36.10  n/a
      {ST=    .056 ha.m   to control at       .004  (cms)}
 001:0010---------------------------------------------------------------------------
      FINISH
-------------------------------------------------------------------------------
*******************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
   Simulation ended on 2017-04-11     at 08:12:34
===============================================================================
```

Appendix B

Single Station Flood Frequency Analysis.

BATTLE RIVER NEAR PONOKA (05FA001)								
Gross Drainage Area		1821.5	km²	Effective Drainage Area			1551.4	km²
Hydrometric Station Number	Year	I-MAX (Maximum Instantaneous Daily Discharge) (m³/s)	MAX (Maximum Daily Discharge) (m³/s)	I-MAX (Ranked) (m³/s)	Weibull Plotting Position (Rank)	Probability of Exceedance p (%)	Return Period T (years)	LOG(I-MAX)
05FA001	1913	20.8794	17	291	1	1.56	64.000	2.463892989
05FA001	1914	68.1651	55.5	111.64338	2	3.13	32.000	2.047812976
05FA001	1915	68.53356	55.8	108	3	4.69	21.333	2.033423755
05FA001	1916	72.34098	58.9	107.22186	4	6.25	16.000	2.03028337
05FA001	1917	73.0779	59.5	90.7	5	7.81	12.800	1.957607287
05FA001	1918	8.695656	7.08	81.0612	6	9.38	10.667	1.908813029
05FA001	1919	34.75806	28.3	78.4	7	10.94	9.143	1.894316063
05FA001	1920	111.64338	90.9	73.0779	8	12.50	8.000	1.863786059
05FA001	1921	39.67086	32.3	72.34098	9	14.06	7.111	1.859384388
05FA001	1922	2.959962	2.41	71.97252	10	15.63	6.400	1.857166709
05FA001	1923	7.749942	6.31	70.5	11	17.19	5.818	1.848189117
05FA001	1924	4.863672	3.96	69.02484	12	18.75	5.333	1.839005409
05FA001	1925	67.79664	55.2	68.53356	13	20.31	4.923	1.835903292
05FA001	1926	46.4	46.2	68.1651	14	21.88	4.571	1.833562076
05FA001	1927	78.4	75.6	67.79664	15	23.44	4.267	1.831208171
05FA001	1928	65.0946	53	66.9369	16	25.00	4.000	1.825665595
05FA001	1929	10.648494	8.67	65.3	17	26.56	3.765	1.814913181
05FA001	1930	1.879146	1.53	65.0946	18	28.13	3.556	1.813544963
05FA001	1931	44.6678219	36.36852459	61.41	19	29.69	3.368	1.788219097
05FA001	1967	21.37068	17.4	55.5	20	31.25	3.200	1.744292983
05FA001	1968	44.6678219	36.36852459	52.5	21	32.81	3.048	1.72015903
05FA001	1969	81.0612	66	47.5	22	34.38	2.909	1.676693610
05FA001	1970	38.93394	31.7	46.4	23	35.94	2.783	1.666517981
05FA001	1971	55.5	53.5	44.6678219	24	37.50	2.667	1.649994776
05FA001	1972	21.86196	17.8	44.6678219	25	39.06	2.560	1.649994776
05FA001	1973	29.2	27.8	44.58366	26	40.63	2.462	1.649175718
05FA001	1974	108	104	41.02188	27	42.19	2.370	1.613015560
05FA001	1975	24.564	20	39.67086	28	43.75	2.286	1.598471615
05FA001	1976	13.63302	11.1	38.93394	29	45.31	2.207	1.590328355
05FA001	1977	11	9.88	34.75806	30	46.88	2.133	1.541055529
05FA001	1978	13.8	12.7	33.52986	31	48.44	2.065	1.525431740
05FA001	1979	15.6	15.2	32.42448	32	50.00	2.000	1.510873020
05FA001	1980	17.3	14.4	30.8	33	51.56	1.939	1.488550717
05FA001	1981	65.3	63.7	29.2	34	53.13	1.882	1.465382851
05FA001	1982	90.7	89.3	28.3	35	54.69	1.829	1.451784636
05FA001	1983	26.16066	21.3	28.2486	36	56.25	1.778	1.450996929
05FA001	1984	11.1	9.76	26.16066	37	57.81	1.730	1.417648696
05FA001	1985	66.9369	54.5	24.564	38	59.38	1.684	1.390299089
05FA001	1986	47.5	45.7	21.86196	39	60.94	1.641	1.339689095
05FA001	1987	33.52986	27.3	21.37068	40	62.50	1.600	1.329813341
05FA001	1988	61.41	50	21.3	41	64.06	1.561	1.328379603
05FA001	1989	41.02188	33.4	20.8794	42	65.63	1.524	1.319718014
05FA001	1990	291	202	20.01966	43	67.19	1.488	1.301456697
05FA001	1991	44.58366	36.3	17.3	44	68.75	1.455	1.238046103
05FA001	1992	17.1948	14	17.2	45	70.31	1.422	1.235523447
05FA001	1993	28.2486	23	17.1948	46	71.88	1.391	1.235397129
05FA001	1994	12.269718	9.99	15.6	47	73.44	1.362	1.193124598
05FA001	1995	7.811352	6.36	14.9	48	75.00	1.333	1.173186268
05FA001	1996	69.02484	56.2	13.8	49	76.56	1.306	1.139879086
05FA001	1997	32.42448	26.4	13.63302	50	78.13	1.280	1.134592072
05FA001	1998	14.9	14.7	12.269718	51	79.69	1.255	1.088834581
05FA001	1999	52.5	51.4	11.1	52	81.25	1.231	1.045322979
05FA001	2000	28.3	26.9	11	53	82.81	1.208	1.041392685
05FA001	2001	17.2	14.9	10.648494	54	84.38	1.185	1.027288191
05FA001	2002	30.8	25.4	8.695656	55	85.94	1.164	0.939302351
05FA001	2003	107.22186	87.3	7.811352	56	87.50	1.143	0.892726209
05FA001	2004	3.38	2.13	7.749942	57	89.06	1.123	0.889298452
05FA001	2005	71.97252	58.6	5.12	58	90.63	1.103	0.709269961
05FA001	2006	20.01966	16.3	4.863672	59	92.19	1.085	0.686964279
05FA001	2007	70.5	64.2	3.38	60	93.75	1.067	0.528916700
05FA001	2008	5.12	4.85	3.37755	61	95.31	1.049	0.528601787
05FA001	2009	3.37755	2.75	2.959962	62	96.88	1.032	0.471286136
05FA001	2010	21.3	20.2	1.879146	63	98.44	1.016	0.273960524



Average (I-MAX)	43.14
Maximum (I-MAX)	291.00

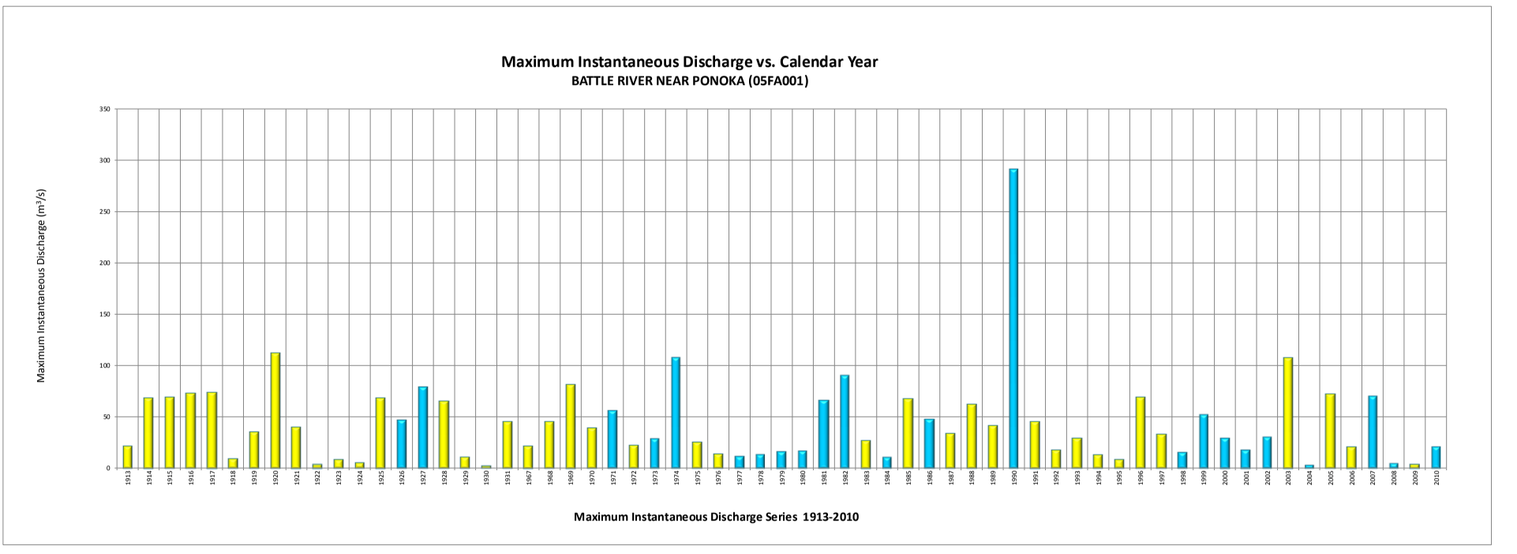
LOG (I-MAX) Statistics	
05FA001	
Mean, μ	1.44824425
Standard Deviation, Sx	0.444046034
Coefficient of Skewness, Cs	-0.578101096

05FA001	
Mean, μ	1.44824425
Standard Deviation, Sx	0.444046034
Coefficient of Skewness, Cs	-0.578101096

	Probability of Exceedance p(%)	Probability of Exceedance p	Return Period T = 1/p (years)	w value	Frequency Factors K_T or z	Z Value	Coefficient of Skew C_s	k value	LP3 Frequency Factors K_T	Return Period Discharges Q_T	$LOGQ_T$	Q_T (m^3/s)	Calculated Return Period Discharge (online LP3 calculator) Q_T
BATTLE RIVER NEAR PONOKA (05FA001)	99.00	0.990	1.010	0.14	-2.04	-2.04	-0.57810110	-0.0963502	-2.32600791	$Q_{1.010}$	0.4154	**2.602**	****
	95.00	0.950	1.053	0.32	-1.56	-1.56	-0.57810110	-0.0963502	-1.674447791	$Q_{1.053}$	0.7047	**5.067**	**4.0**
	90.00	0.900	1.111	0.46	-1.24	-1.24	-0.57810110	-0.0963502	-1.275563379	$Q_{1.111}$	0.8818	**7.618**	**7.0**
	85.00	0.850	1.176	0.57	-1.01	-1.01	-0.57810110	-0.0963502	-1.001577794	$Q_{1.176}$	1.0035	**10.081**	****
	80.00	0.800	1.250	0.67	-0.83	-0.83	-0.57810110	-0.0963502	-0.785286035	$Q_{1.250}$	1.0995	**12.576**	**12.0**
	50.00	0.500	2.00	1.18	0.00	0.00	-0.57810110	-0.0963502	0.095452862	Q_2	1.4906	**30.948**	**31.0**
	20.00	0.200	5.00	1.79	0.84	0.84	-0.57810110	-0.0963502	0.855615389	Q_5	1.8282	**67.325**	**67.0**
	10.00	0.100	10.00	2.15	1.28	1.28	-0.57810110	-0.0963502	1.20319315	Q_{10}	1.9825	**96.054**	**96.0**
	5.00	0.050	20.00	2.45	1.65	1.65	-0.57810110	-0.0963502	1.465668601	Q_{20}	2.0991	**125.623**	****
	4.00	0.04	25.00	2.54	1.75	1.75	-0.57810110	-0.0963502	1.538090673	Q_{25}	2.1312	**135.28**	**135.0**
	2.00	0.020	50.00	2.80	2.05	2.05	-0.57810110	-0.0963502	1.735708228	Q_{50}	2.2190	**165.569**	**165.0**
	1.00	0.010	100.00	3.03	2.33	2.33	-0.57810110	-0.0963502	1.901428404	Q_{100}	2.2926	**196.140**	**195.0**
	0.50	0.005	200.00	3.26	2.58	2.58	-0.57810110	-0.0963502	2.043450248	Q_{200}	2.3556	**226.793**	**225.0**
	0.20	0.002	500.00	3.53	2.88	2.88	-0.57810110	-0.0963502	2.203640818	Q_{500}	2.4268	**267.154**	****
	0.10	0.001	1000.00	3.72	3.09	3.09	-0.57810110	-0.0963502	2.308475616	Q_{1000}	2.4733	**297.381**	****

Log-Pearson Type III	Notation	Return Period, T (years)	Probability of Exceedance, p (%)	K_T	$LogQ_T$	Q_T (m^3/s)
BATTLE RIVER NEAR PONOKA (05FA001)	Q_2	2	50	0.095	1.4906	**30.9**
	Q_5	5	20	0.856	1.8282	**67.3**
	Q_{10}	10	10	1.203	1.9825	**96.1**
Effective Drainage Area 1551.4 km2	Q_{20}	20	5	1.466	2.0991	**125.6**
	Q_{50}	50	2	1.736	2.2190	**165.6**
	Q_{100}	100	1	1.901	2.2926	**196.1**

Unit Release Rate ($m^3/s/km^3$)	**Unit Release Rate (L/s/ha)**
0.020	**0.20**
0.043	**0.43**
0.062	**0.62**
0.081	**0.81**
0.107	**1.07**
0.126	**1.26**



Environment Canada Data Explorer - HYDAT Version: 1.0 (Nov. 15,2012)

File Export View Help

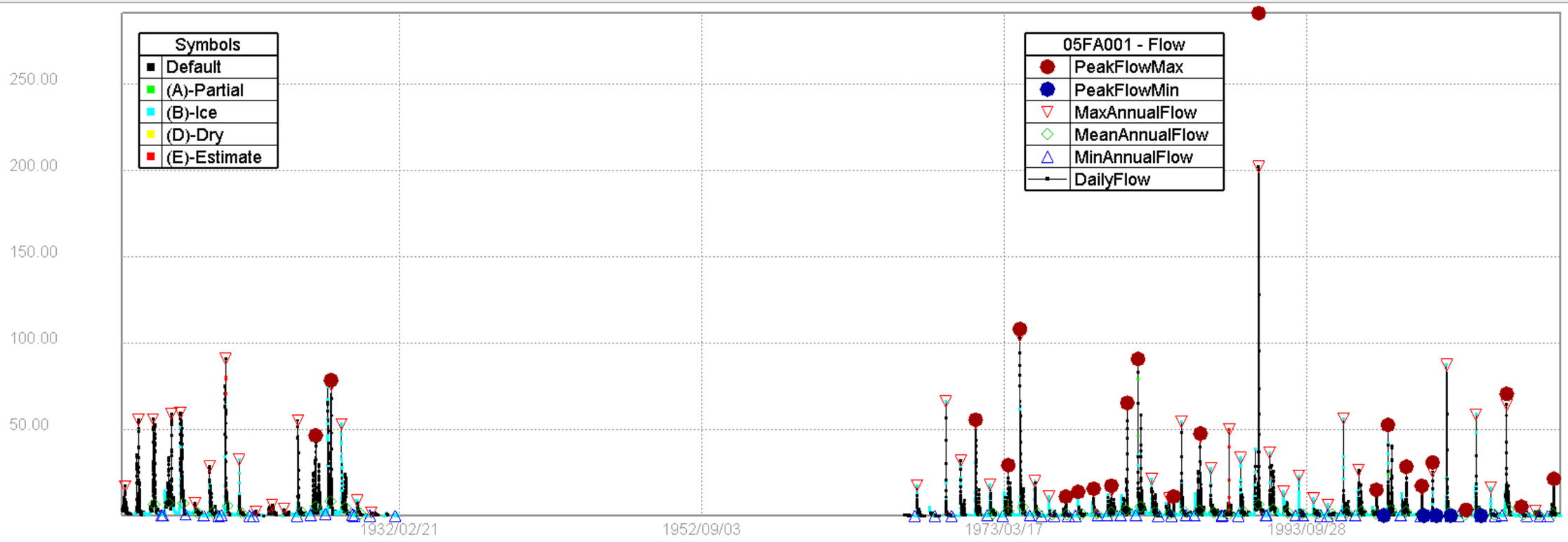
Stations 05FA001

BATTLE RIVER NEAR PONOKA		Prov/Terr/State	AB	Regional Office	CALGARY		
Latitude	52°39'47.7" N	Longitude	113°34'53.1" W	Drainage Area (km²), Gross	1821.5	Effective	1551.4
Hyd Status	Active	Sed Status		RHBN		RealTime	Yes

MetaData	Details
Contributor	WATER SURVEY OF CANADA (DOE) (CANADA)
Operator	WATER SURVEY OF CANADA (DOE) (CANADA)
Datum	ASSUMED DATUM
DataCollection	Flow, (1912 - 1912), Manual, Miscellaneous
DataCollection	Flow, (1913 - 1922), Manual, Continuous
DataCollection	Flow, (1923 - 1923), Manual, Seasonal

Flow

Show: Daily Monthly Annual Peak



Appendix C

Data Sheet for WSC Hydrometric Station 05FA001.

ID	PARAM	Year	PeakFlowV	SYM	HH:MM	CODE	MM--DD	MaxAnnua	SYM	MM--DD	MinAnnual	SYM	MM--DD
05FA001	1	1913						17		07--16			
05FA001	1	1914						55.5		06--10			
05FA001	1	1915						55.8		06--06	0.34	B	12--31
05FA001	1	1916						58.9		09--08	0.173	B	02--09
05FA001	1	1917						59.5		04--14	0.68		08--18
05FA001	1	1918						7.08		04--14	0.085	B	11--14
05FA001	1	1919						28.3		04--14	0.028	B	11--14
05FA001	1	1920						90.9		05--09	0.249	B	01--25
05FA001	1	1921						32.3	B	04--16	0.006	B	12--25
05FA001	1	1922						2.41		06--06	0	B	03--26
05FA001	1	1923						6.31		07--11			
05FA001	1	1924						3.96	B	04--28			
05FA001	1	1925						55.2		04--10	0.02	B	03--16
05FA001	1	1926	46.4		7:35	MST	06--23	46.2		06--23	0.609	B	02--17
05FA001	1	1927	78.4		0:00		07--10	75.6		07--11	0.991	B	02--17
05FA001	1	1928						53	B	03--26	0.479	B	12--20
05FA001	1	1929						8.67	B	04--18	0.04	B	02--07
05FA001	1	1930						1.53	B	04--02	0.037	B	02--24
05FA001	1	1931									0	B	11--19
05FA001	1	1967						17.4	B	04--26	0	B	03--01
05FA001	1	1968									0	A	07--05
05FA001	1	1969						66	B	04--10	0		08--30
05FA001	1	1970						31.7		04--12			
05FA001	1	1971	55.5		18:00	MST	04--16	53.5		04--16			
05FA001	1	1972						17.8	B	04--09	0.076	B	02--01
05FA001	1	1973	29.2		23:59	MST	07--04	27.8		07--05	0.059	B	02--09
05FA001	1	1974	108		11:00	MST	04--19	104		04--19	0.113	B	12--18
05FA001	1	1975						20	B	04--22	0.024		09--29
05FA001	1	1976						11.1	B	04--10	0.017		08--14
05FA001	1	1977	11		13:00	MST	05--31	9.88		05--31	0.009		07--27
05FA001	1	1978	13.8	B	4:30	MST	04--01	12.7	B	04--01	0.023	B	01--21
05FA001	1	1979	15.6		13:00	MST	04--22	15.2		04--22	0.073	A	07--25
05FA001	1	1980	17.3		7:00	MST	07--04	14.4		07--04	0.065	B	03--18
05FA001	1	1981	65.3		5:15	MST	08--02	63.7		08--02	0.36	B	02--18
05FA001	1	1982	90.7		2:21	MST	04--24	89.3		04--24	0.28	B	03--03
05FA001	1	1983						21.3	B	04--04	0.033		09--10
05FA001	1	1984	11.1		15:27	MST	09--25	9.76		06--11	0.001		08--02
05FA001	1	1985						54.5	B	04--04	0.093		07--30
05FA001	1	1986	47.5		13:55	MST	07--21	45.7		07--21	0.12	B	02--21
05FA001	1	1987						27.3	B	04--06	0.062	B	12--31
05FA001	1	1988						50	E	07--09	0.029	B	01--13
05FA001	1	1989						33.4	B	04--15	0.052	B	02--18
05FA001	1	1990	291		18:20	MST	07--04	202		07--04	0.135	B	12--31
05FA001	1	1991						36.3	B	04--05	0.102	B	01--09
05FA001	1	1992						14	B	03--16	0.14	B	12--28
05FA001	1	1993						23	B	03--26	0.098		07--10
05FA001	1	1994						9.99	B	04--01	0.037		09--19
05FA001	1	1995						6.36	B	03--19	0.056	B	03--10
05FA001	1	1996						56.2	B	04--11	0.141	B	02--07
05FA001	1	1997						26.4		04--18	0.18	B	01--26
05FA001	1	1998	14.9		9:25	MST	07--03	14.7		07--03			
05FA001	1	1999	52.5		7:50	MST	04--14	51.4		04--14	0.08	B	01--02
05FA001	1	2000	28.3		18:30	MST	07--13	26.9		07--13	0.196	B	02--27
05FA001	1	2001	17.2		12:10	MST	08--01	14.9		08--01	0.034		07--11
05FA001	1	2002	30.8		6:55	MST	04--24	25.4		04--23	0.002		07--24
05FA001	1	2003						87.3	B	04--11	0.014		07--18
05FA001	1	2004	3.38		15:30	MST	08--04	2.13		08--04	0.016	B	01--29
05FA001	1	2005						58.6	B	04--05	0.032		08--07
05FA001	1	2006						16.3	B	04--06	0.008		07--27
05FA001	1	2007	70.5		16:55	MST	05--07	64.2		05--07	0.081	B	01--13
05FA001	1	2008	5.12		18:30	MST	05--06	4.85		05--06	0.01		09--15
05FA001	1	2009						2.75	B	04--17	0.001		08--08
05FA001	1	2010	21.3		21:25	MST	07--20	20.2		07--20	0.043	B	02--27

Appendix D

Calculation of IDF Parameters.

CALCULATION OF IDF PARAMETERS

Project: **Red Deer**

File:

Date:

Source: **Red Deer Airport IDF Data - 2014**

Return Period: **1:100 event**

RAINFALL DATA:

Time Interval	Time (min.)	Intensity Interval	Intensity (mm/hr)
T_1	5	i_1	**217.5**
T_2	30	i_2	**68.6**
T_3	1440	i_3	**4.3**

a) The parameter B is selected by trial & error using the relationship

$$\frac{\ln(i_1)-\ln(i_2)}{\ln(i_1)-\ln(i_3)}=\frac{\ln(B+T_2)-\ln(B+T_1)}{\ln(B+T_3)-\ln(B+T_1)}$$

Select B until the left side equals the right side …..

B = 1.367 ⟶ Left Side = 0.29409 Right Side = 0.29409

b) The parameter C is calculated by

$$C=\frac{\ln(i_2)-\ln(i_3)}{\ln(B+T_3)-\ln(B+T_1)}$$

C = 0.7236

c) The parameter A is calculated by

$$A=i_1(T_1+B)^C$$

A = 830.226

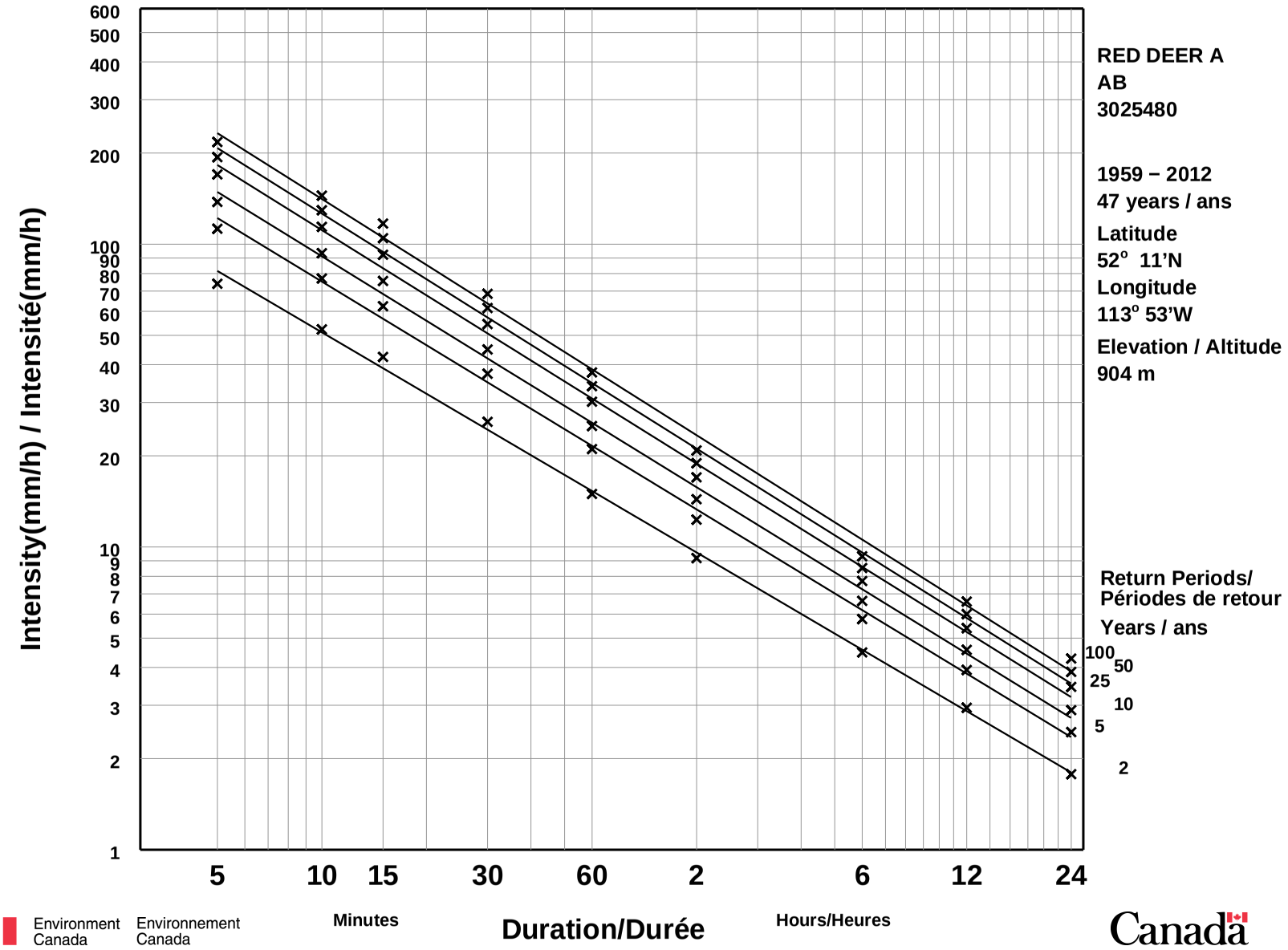
Appendix E

Red Deer Airport IDF Data (2014).

Short Duration Rainfall Intensity−Duration−Frequency Data

2014/12/21

Données sur l’intensité, la durée et la fréquence des chutes de pluie de courte durée



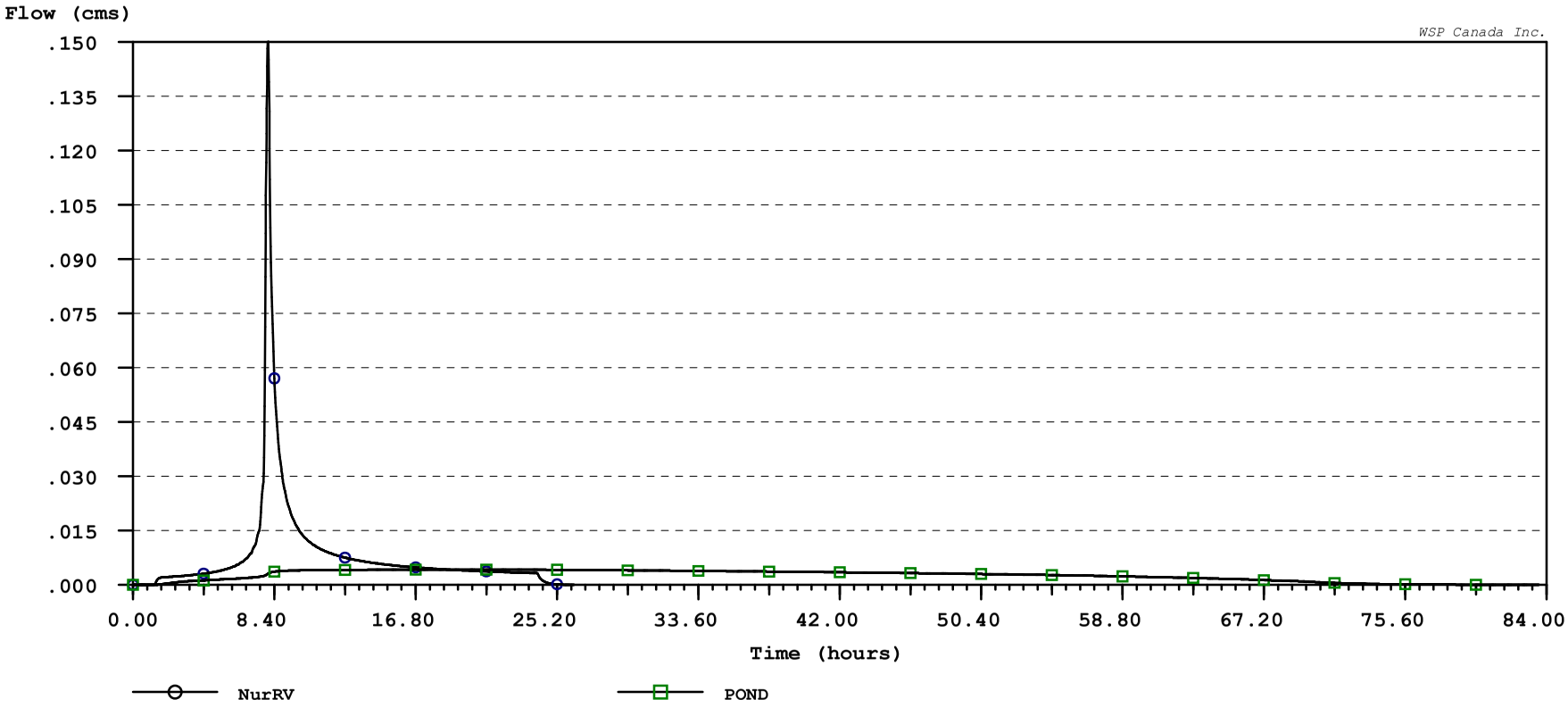
Environment Canada Environnement Canada

Canada

Appendix F

The Nursery Proposed R.V. Park Hydrographs.

The Nursery Golf & Country Club (north of Lacombe, Alberta) - HYDROGRAPHS - WSP project number 161-15869-00



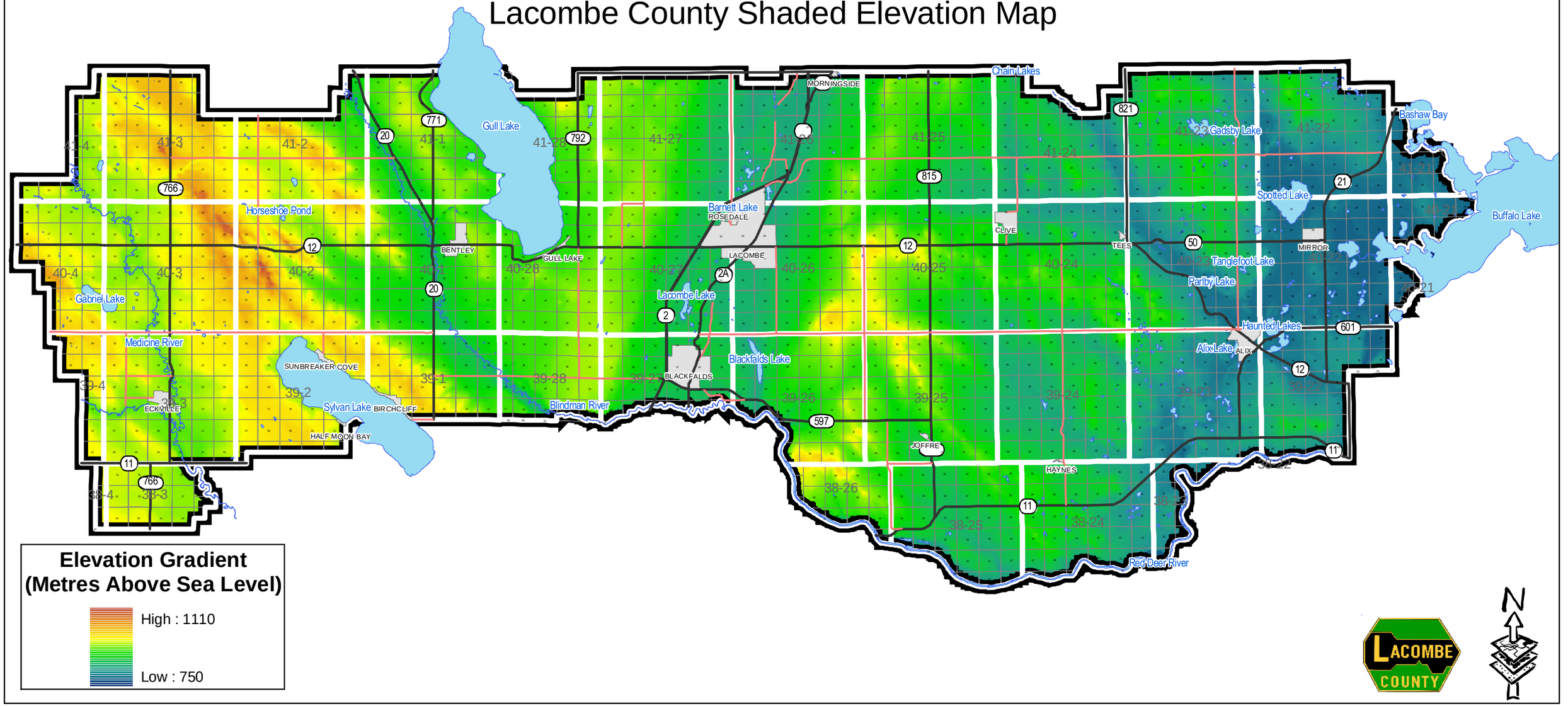
Hydrograph Statistics:

Legend	Filename & Comment	Time Step (min)	Drainage Area (ha)	Peak Flow (cms)	Time to Peak (hrs)	Runoff Volume (mm)	Runoff Volume (cu.m)	Duration of flow (hrs)	Average flow (cms)
—○—	H-NurRV.001 : NurRV	1.00	2.14	0.151	8.033	36.10	7.725E+02	26.217	0.008
—□—	H-POND.001 : POND	1.00	2.14	0.004	17.950	36.09	7.723E+02	83.533	0.003

Appendix G

Lacombe County "County Elevation Map."

Lacombe County Shaded Elevation Map



Elevation Gradient
(Metres Above Sea Level)

High : 1110

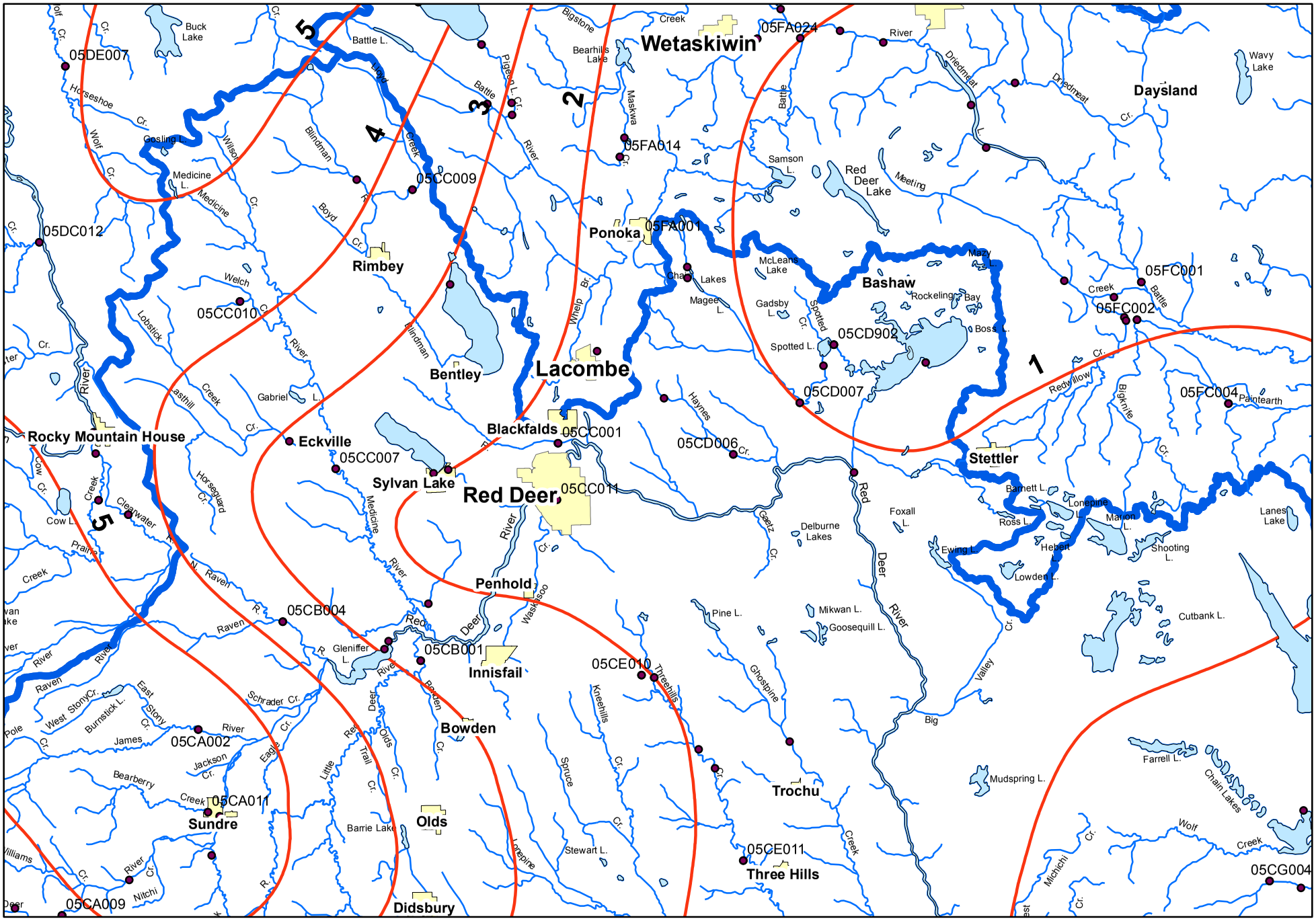
Low : 750

LACOMBE COUNTY

Appendix H

ESRD Preliminary Unit Area Discharge for Central Alberta.

ESRD Preliminary 1:100 Year, Pre-Development Stormwater Runoff Rate Iso-Chart
Units in l/s/ha



Appendix I

Alberta Geological Survey Maps.

Pigeon Lake

Camrose

Wetaskiwin

Gull Lake

Rocky Mountain House

Red Deer

Glacial Landforms

- Streamlined bedforms
- Moraine ridges
- Overridden moraines
- Ice-thrust ridges
- Crevasse-fill ridges
- Major meltwater channels
- Minor meltwater channels
- Eskers

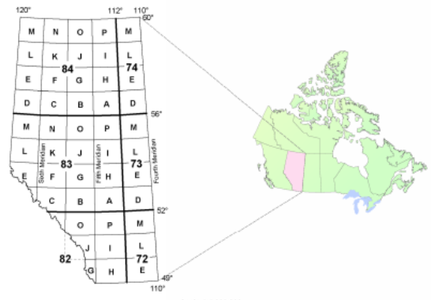
Alberta Energy Regulator

AGS Alberta Geological Survey

Alberta Geological Survey Map 604

Glacial Landforms of Alberta

N. Atkinson, D.J. Utting and S.M. Pawley



Projection: 10 Degree Transverse Mercator
Datum: North American Datum, 1983

Legend on accompanying page

Pigeon Lake

2

Camrose

Wetaskiwin

Gull Lake

Rocky Mountain House

Red Deer River

Red Deer

Pleistocene

Glaciolacustrine Deposits: Sediments deposited in or along the margins of glacial lakes; includes a) offshore sediment; rhythmically laminated to massive fine sand, silt, and clay, locally containing debris released by the melting of floating ice; and b) littoral (nearshore) sediments; massive to stratified, well-sorted silty sand, pebbly sand, and minor gravel; occurs in beaches, bars, and deltas.

Glaciofluvial Deposits: Sediments deposited by glacial meltwater in subaerial, subaqueous, and subglacial environments; sediment ranges from massive to stratified, poor to well sorted, coarse to fine grained; in places, this unit includes till; may show evidence of ice melting (slumped structures).

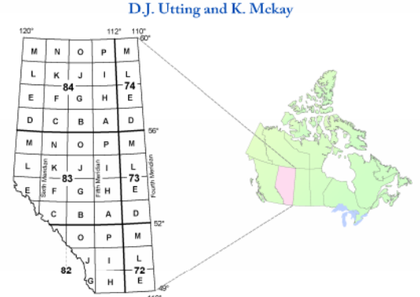
Alberta Energy Regulator

AGS ALBERTA GEOLOGICAL SURVEY

Alberta Geological Survey Map 601

Surficial Geology of Alberta

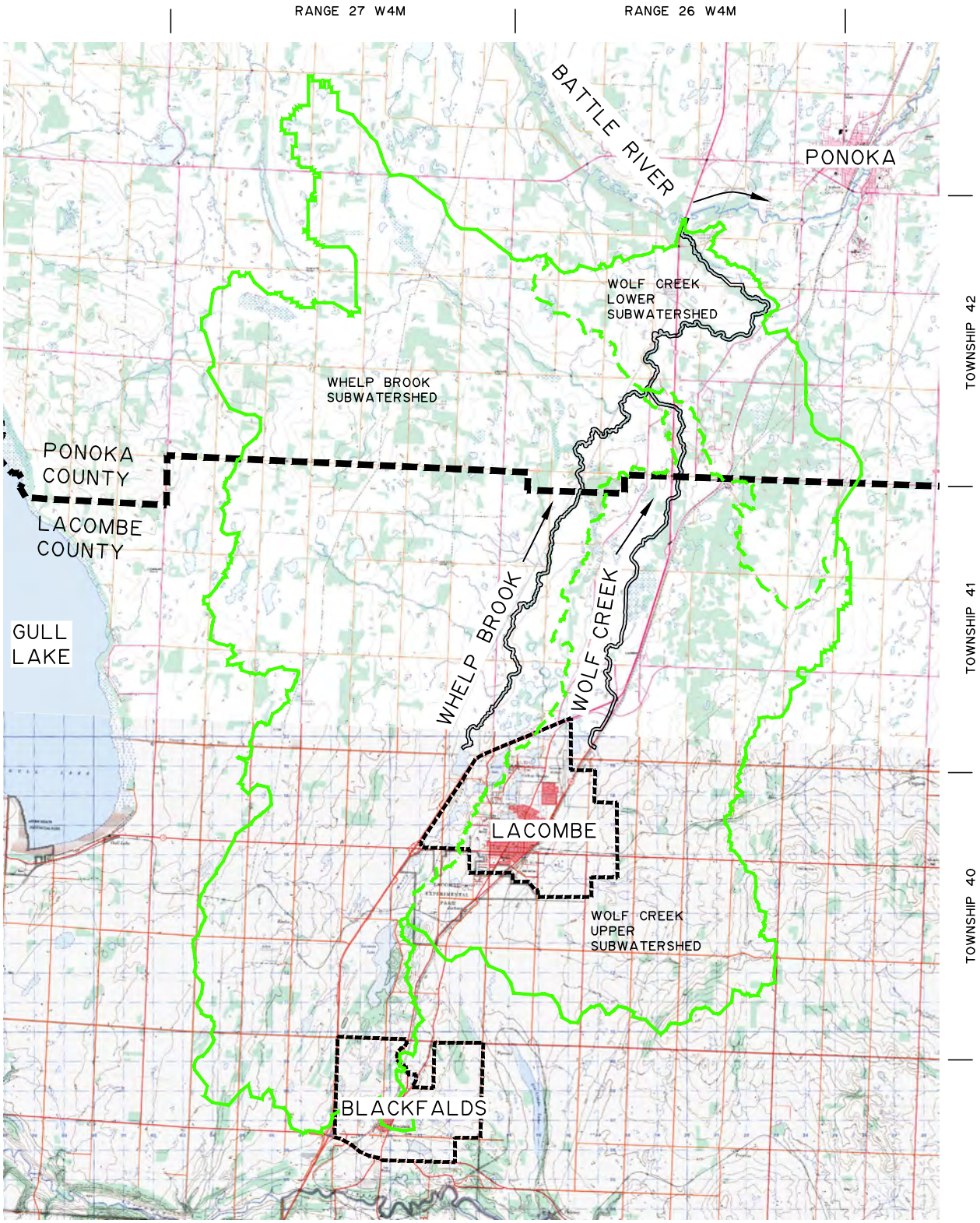
M.M. Fenton, E.J. Waters, S.M. Pawley, N. Atkinson, D.J. Utting and K. Mckay



Legend on accompanying page

Appendix J

Wolf Creek and Whelp Brook Drainage Basins (MPE, 2014).



MPE Engineering Ltd.

LACOMBE COUNTY

WOLF CREEK AND WHELP BROOK
LOCATION PLAN

SCALE: 1:200 000	DATE: JANUARY 2014	JOB: 4210-014-00	FIGURE: 1