Final Report

Master Drainage Plan

for

Queens Business Park – Hazlett Lake

Prepared for:

THE CITY OF Red Deer

Prepared by:

Westhoff Engineering Resources, Inc.
Land & Water Resources Management Consultants

Suite 601
1040 – 7th Avenue S.W.
Calgary, Alberta T2P 3G9
Phone: (403) 264-9366
Fax: (403) 264-8796
Email: werinc@westhoff.ab.ca

W:\Projects\2005\WER105-73 - Red Deer Wetlands (Queens Park)\Reporting\Final MDP Report, June 16, 2008\R-20080518-WER105-73-01-QBP-Hazlett MDP report - Final.doc

TABLE CONTENTS

LIST OF FIGURES

DRAWING

APPENDICES

CORPORATE AUTHORIZATION

This document entitled *"Master Drainage Plan for Queens Business Park"* was prepared by Westhoff Engineering Resources, Inc. It is intended for the use of the City of Red Deer and approval authorities for which it has been prepared. The contents of the report represent Westhoff Engineering Resources, Inc.'s best judgment based on available information at the time of preparation. Any use which a third party makes of the report, or reliance on or decisions made based on it, are the responsibilities of such third parties. Westhoff Engineering Resources, Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on the report.

It is assumed that the reader of the document is familiar with hydrology and hydraulics. In particular, familiarity is assumed with drainage terminology and analysis of drainage systems.

Unauthorized use of the concepts and strategies reported in this document and any accompanying drawings and/or figures is forbidden and are the sole intellectual property of the author.

PERMIT TO PRACTICE
WESTHOFF ENGINEERING RESOURCES INC.
Signature
Date June 16 2008
PERMIT NUMBER: P 6305
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

CORPORATE PERMIT

RESPONSIBLE ENGINEER

Report compiled by: Dennis R. Westhoff, M.Eng., P.Eng.

Stormwater Analysis by: Bert van Duin, M.Sc., P.Eng.
Jon Burgart, P.Eng.
Israr Ullah, M.Sc, E.I.T.

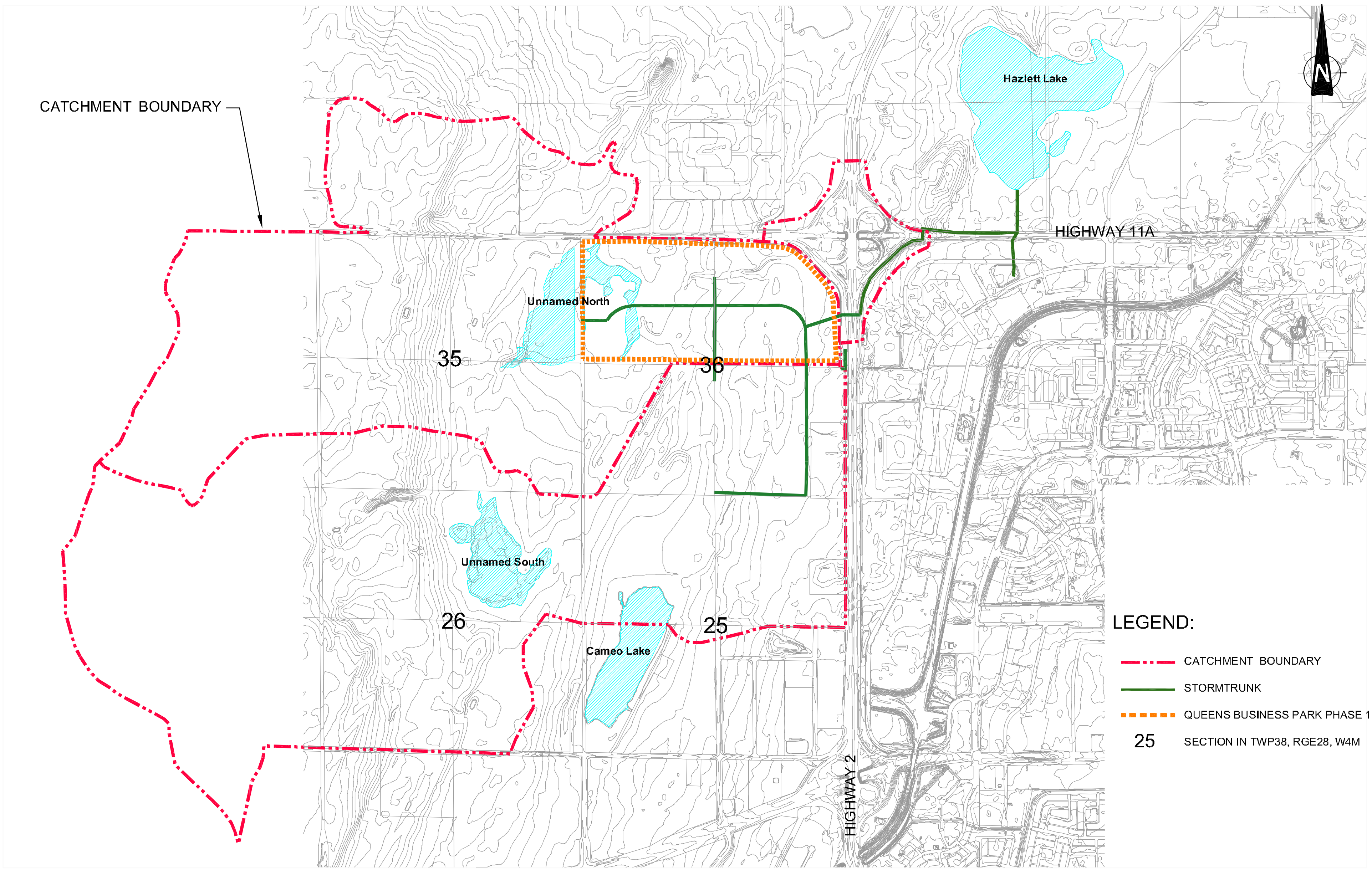
Wetland Assessment by: Misty Bleakley, B.Sc.

Biophysical assessment by: Katie Illian, B.Sc.
Nick Roe, P.Bio.
Laurie Hamilton, C.E.T., P.Bio.
Jodi Kohls, M.E.Des., CEPIT

Report reviewed by: Bert van Duin, M.Sc., P.Eng., and Dennis R. Westhoff, M.Eng., P.Eng.

1.0 INTRODUCTION

Westhoff Engineering Resources, Inc. was retained by the City of Red Deer through Al-Terra Engineering Ltd. (Al-Terra) and EXH Engineering (EXH) to assist in the development of a stormwater servicing plan for Queens Business Park. The business park is situated west of the Queen Elizabeth II Highway (i.e., the former Highway 2) in the County of Red Deer as shown in Figure 1; the area is included within the lands covered by the annexation strategies the City of Red Deer has recently completed.



Client: The City of Red Deer

Westhoff Engineering Resources, Inc.
Land & Water Resources Management Consultants

Project: **QUEENS BUSINESS PARK MASTER DRAINAGE PLAN**

Title:

LOCATION PLAN

Date:	Job No.:	Cad File:	Figure No.:	Rev.
18/05/2007	WER105-52	10552L00.dwg	1	A

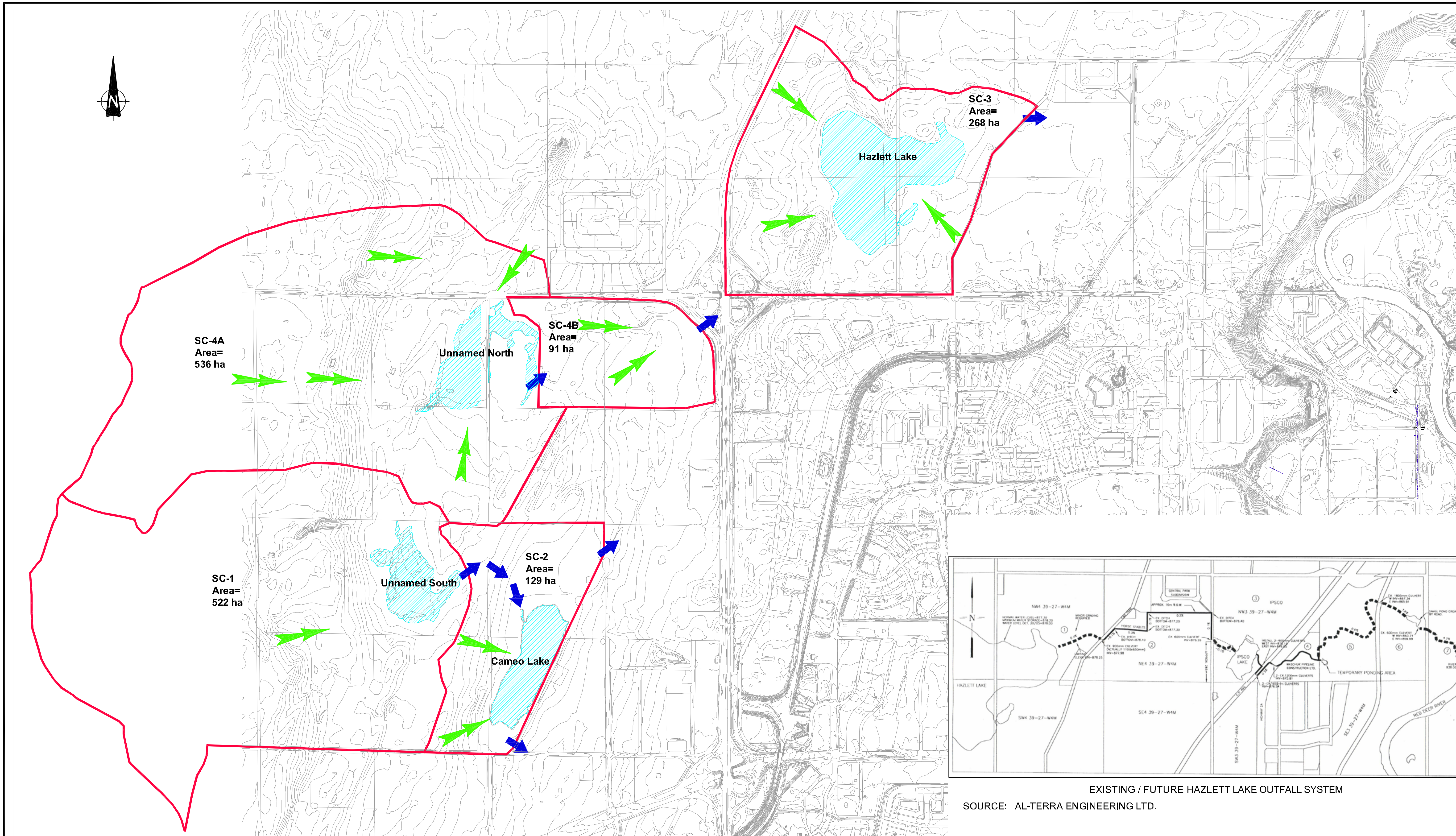
W:\Drafting\2005\WER105-52 - Industrial Development Wetland Assessment Red Deer\AutoCAD\1 May, 31,2007 - 1:14pm lzhao

2.0 STUDY AREA AND EXISTING DRAINAGE CHARACTERISTICS

Queens Business Park – Phase 1 encompasses about 120 ha within a larger development area west of the Queen Elizabeth II Highway (Hwy QE II). The area is currently agriculturally productive and gently rolls from west to east. Several low-lying areas exist, some of which have been classified according to the Stewart and Kantrud wetland classification system (see Appendix A).

The existing drainage of the area west of the Hwy QE II and south of Highway 11A is in a northeast direction towards the interchange. A small catchment area to the north of Highway 11A drains via a culvert road crossing south, joining runoff from the west at an existing wetland located about 800 m west of the Hwy QE II. At the interchange, there are numerous culverts crossing ramps and loops that together make up a complex drainage system that ultimately discharges to the east. These areas are shown in Figure 2.

East of the Hwy QE II and south of Highway 11A is the existing Edgar Industrial Park Subdivision that is serviced by a piped and an overland drainage system. North of Highway 11A is a catchment area that encompasses a large wetland, named Hazlett Lake. Evident from Figure 2 is a local drainage course from the interchange leading to this waterbody while an outlet channel is located on the northeast side of the lake. Similar to the areas to the west of the Hwy QE II, the Hazlett Lake catchment area is currently agriculturally productive.



EXISTING / FUTURE HAZLETT LAKE OUTFALL SYSTEM

SOURCE: AL-TERRA ENGINEERING LTD.

1:25 000

0 500 1000 m

LEGEND:

- CATCHMENT BOUNDARY
- OVERLAND DRAINAGE DIRECTION
- FLOW LEAVING CATCHMENT AREA

Client: The City of Red Deer

Westhoff Engineering Resources, Inc.

Land & Water Resources Management Consultants

Project: QUEENS BUSINESS PARK MASTER DRAINAGE PLAN

Title: HYDROLOGICAL ASSESSMENT PRE-DEVELOPMENT CATCHMENT DELINEATION

Date:	Job No.:	Cad File:	Figure No.:	Rev.
18/05/2007	WER105-52	10552L00.dwg	2	A

2.1 Proposed Storm Servicing Plan

The proposed servicing plan for managing runoff from Queens Business Park – Phase 1 is illustrated in Figure 3 and comprises the following strategies:

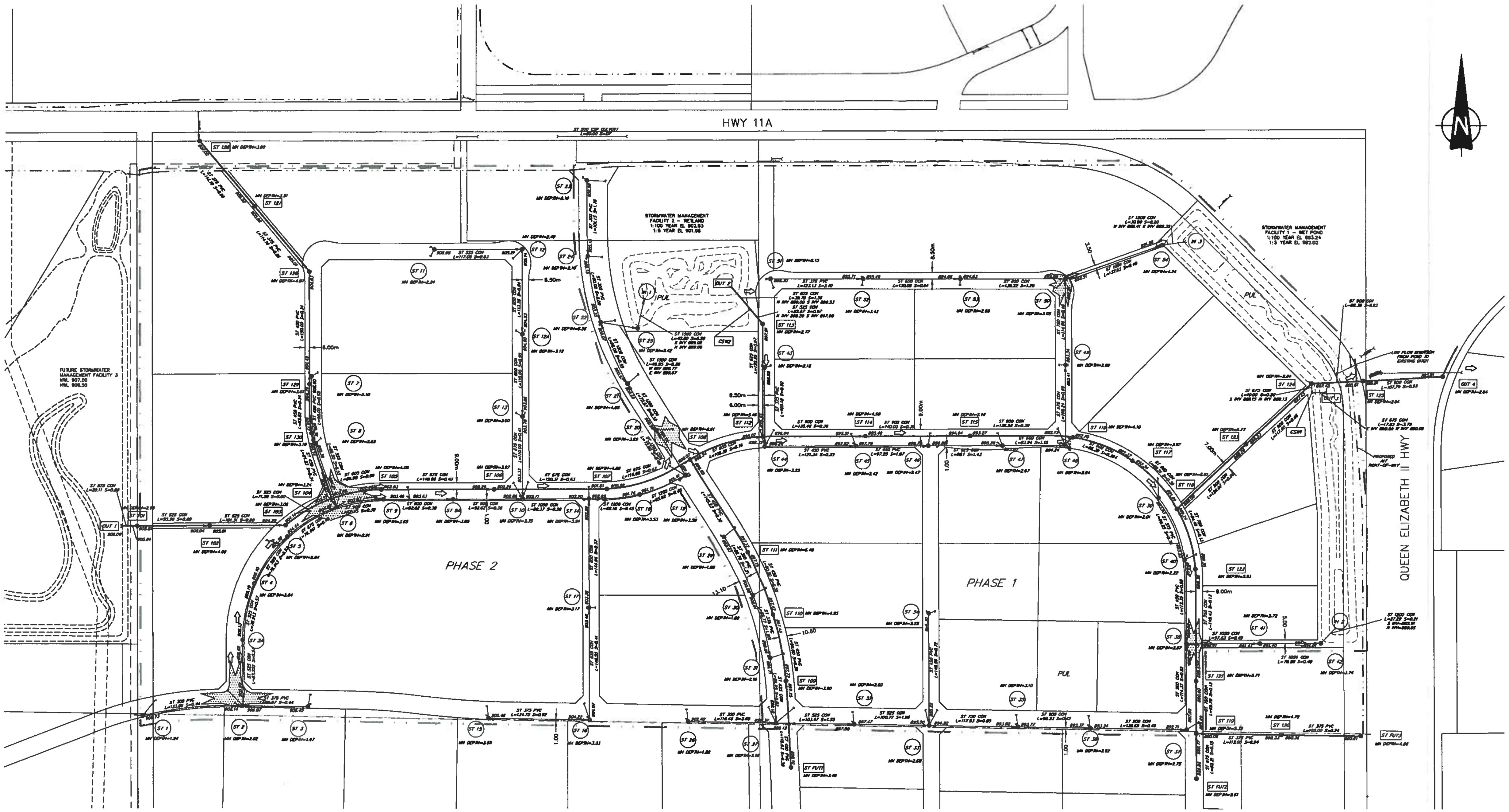
- Stormwater management within the Queens Business Park – Phase 1 area
- A storm sewer trunk for the Queens Business Park catchment area
- Use of the Hazlett Lake as a “surge” storage facility.

The stormwater management strategy within Queens Business Park – Phase 1 area includes the creation of two (2) constructed stormwater wetlands and incorporating a large existing large wetland at the west end. The wetlands included in the first phase of the development are designed to address water quantity and quality in terms of Total Suspended Solids, i.e., 85% reduction of annual loads for particles equal to or larger than 75 microns, and a reduction in nutrients. A minor system is included to service smaller sub-catchments by conveying runoff to the individual stormwater wetlands, all of them placed “off-line” to the regional storm trunk.

Commentary note

The “off-line” design criterion is to address water quality by preventing the phenomena of double or lack of control of water quantity when ponds are placed in series and “on-line” of the trunk system. That is, in the case of the latter configuration, runoff captured in the most upper pond and released into a trunk that would also service the next downstream catchment area would immediately become mixed with polluted runoff en-route to the second pond. The second pond in series must then be sized for so-called flow through of flows released from the upper pond and those generated from the catchment area downstream of the first pond. This complicates the release system for the second pond as the hydrologic response of the second catchment area is much quicker than the time-lagged release hydrograph of the upper catchment area. I.e., just adding the release rate from the upper pond to the release rate for the second catchment area to size the orifice in the control structure of the second pond causes the runoff from the second catchment area to be released quicker as the flow from the upper catchment is lagged. This is particularly sensitive when release rates are low.

The storm sewer trunk for Queens Business Park is planned to service about 750 ha. As shown in Figure 3, several other ponds, which are planned to attenuate runoff peak flows from the various catchment areas, are connected to the trunk system.



Notes:

1. DRAWING PRINTED TO FULL SIZE 22 X 34. IF REPRODUCED AT A DIFFERENT SIZE, ADJUST SCALES ACCORDINGLY.
2. BASE PLAN PROVIDED BY EXH ENGINEERING.
3. ALL LENGTHS AND ELEVATIONS IN METRES.
4. ALL CATCHBASINS TO BE TO CITY OF RED DEER STANDARDS WITH 250 mm DEEP SUMPS.
5. ALL HIGHWAY DRAINAGE (11A AND QE II) TO REMAIN AS IS ALONG EXISTING DITCHES. CULVERT TO BE INSTALLED ALONG HIGHWAY 11A AT THE ENTRANCE TO THE DEVELOPMENT TO ENSURE CONTINUITY OF EXISTING DITCH FLOWS TO THE EAST.
6. SEE DRAWING 006 FOR MAJOR SYSTEM DESIGN DETAILS.
7. THE LOW FLOW DIVERSION FROM STORMWATER FACILITY 1 IS A GATED STRUCTURE THAT CAN BE OPENED AND CLOSED TO PROVIDE FLOW TO THE EXISTING DOWNSTREAM DITCH SYSTEM AS REQUIRED.
8. ALL STORMWATER FACILITIES ARE DESIGNED WITH FOREBAYS TO MAXIMIZE THE REMOVAL OF INCOMING SUSPENDED SEDIMENTS.
9. MINIMUM COVER OF 1.5 M HAS BEEN PROVIDED FOR ALL PIPES.

Legend:

- PIPE SIZE (NOMINAL) AND MATERIAL PIPE LENGTH (M) AND SLOPE (%)
- STORM SEWER MANHOLE ID (COLLECTION SYSTEM)
- STORM SEWER MANHOLE ID (TRUNK SYSTEM)
- PROPOSED MANHOLE
- PROPOSED CATCHBASIN
- PROPOSED SUBDIVISION STORM PIPE
- PROPOSED STORM TRUNK
- PROJECT/PHASE BOUNDARY
- TRAPPED LOW AREAS
- MAJOR SYSTEM DRAINAGE ROUTE

1:3000 0 50 100 m

STORMWATER MANAGEMENT FACILITY 2

ELEVATION-AREA-VOLUME-DISCHARGE			
ELEVATION	AREA(ha)	VOLUME (m^3)	DISCHARGE(L/s)
899.00 BOTTOM	0.059	0	0
900.000	0.330	1709	0
901.00 NWL	0.698	6899	0
902.00	0.994	15253	251
903.00 HWL	1.403	27122	375
903.50	1.627	34698	1147

STORMWATER MANAGEMENT FACILITY 1

ELEVATION-AREA-VOLUME-DISCHARGE			
ELEVATION	AREA(ha)	VOLUME (m^3)	DISCHARGE(L/s)
889.00 BOTTOM	0.634	0	0
890.000	1.020	8260	0
891.000	1.424	20619	0
891.35 NWL	1.910	26452	0
892.350	2.566	48813	20
893.35 HWL	3.250	77871	109
893.850	3.599	94993	878

CLIENT: The City of Red Deer

CONSULTANT:
Westhoff Engineering Resources, Inc.
Land & Water Resources Management Consultants
Suite 601, 1040 - 7th Avenue S. W., Calgary, Alberta, Canada, T2P 3G9
Phone: (403) 264-9366, Fax: (403) 264-8796, Email: werinc@westhoff.ab.ca

PROJECT:
INDUSTRIAL LANDS
RED DEER WEST

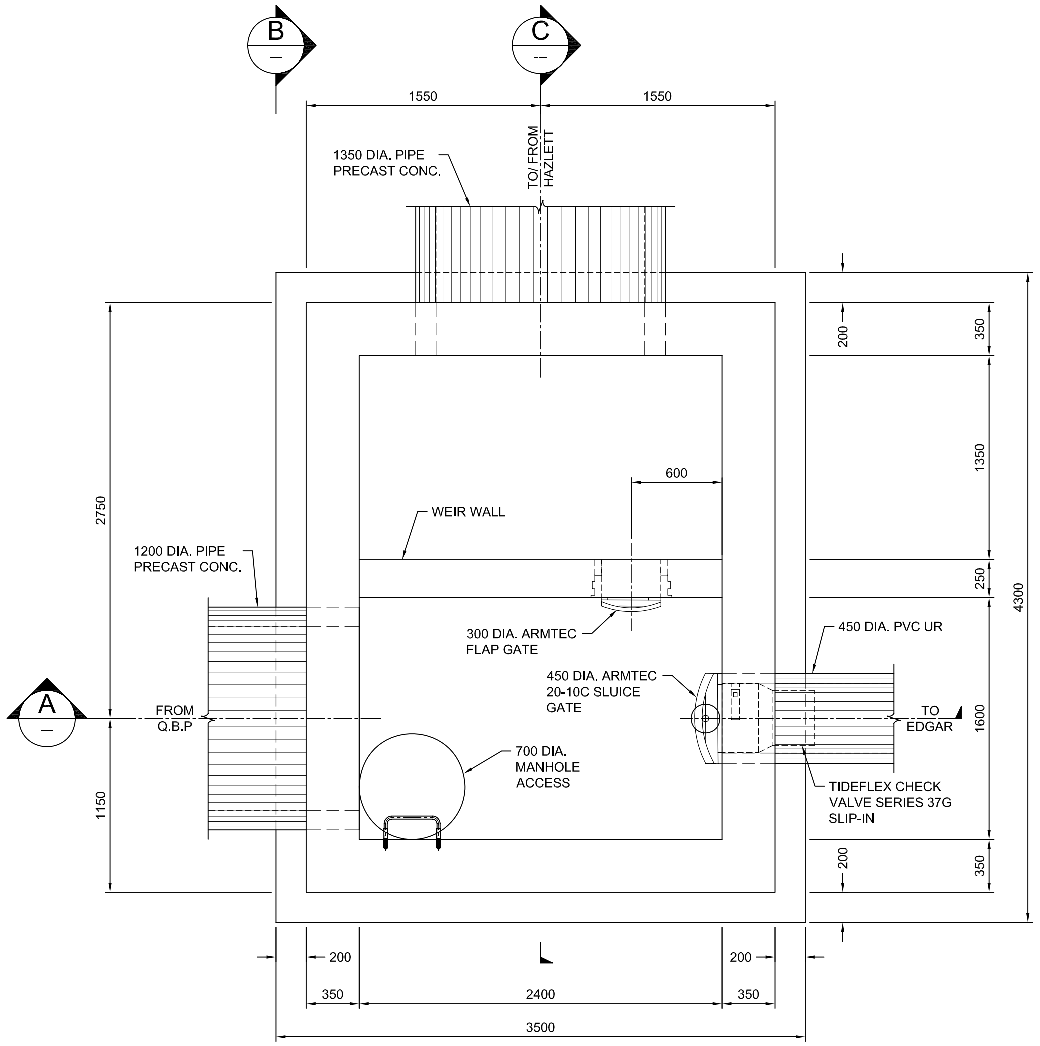
TITLE:
QUEENS BUSINESS PARK STORMWATER MANAGEMENT

DESIGNED:	CHECKED:	PROJECT No:	DATE:	DRAWING No:
JLB	DRW	WER105-73	11-10-07	FIGURE 3
DRAFTED:	APPROVED:	SCALE:	CAD FILE:	SHEET No:
JLB	D. WESTHOFF	AS NOTED	10573J12	–

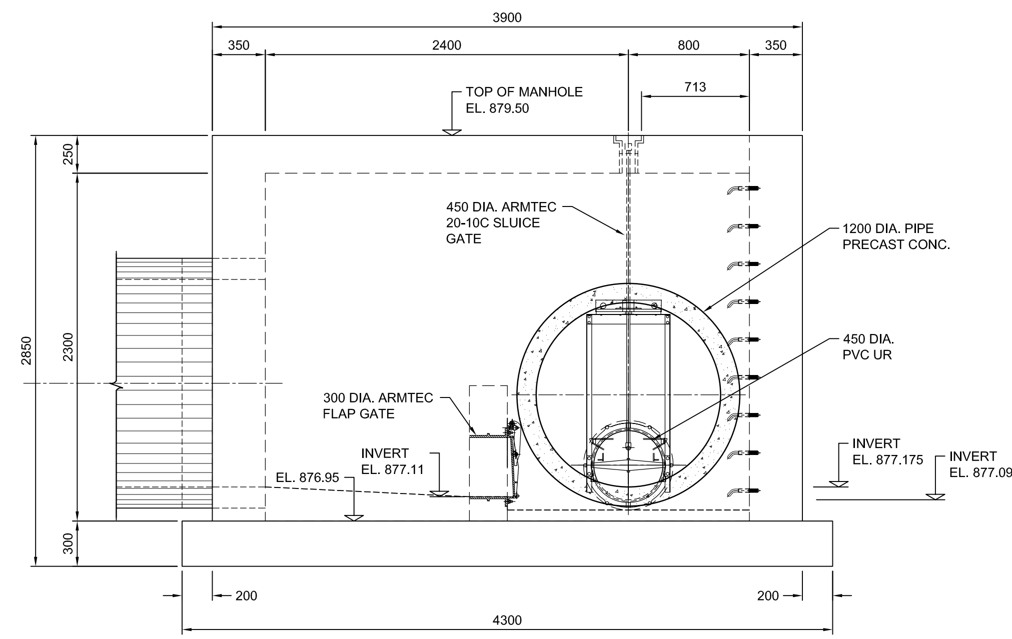
The trunk is connected to the Edgar Industrial Park storm sewer system and has an "overflow" connection to Hazlett Lake. The diversion structure design is illustrated on Drawing WER106-62-01. Note that the diversion system is operable in that closing (or partially closing) the sluice gate on the pipe leading to the Edgar system will cause diversion to Hazlett Lake.

In addition to the traditional stormwater servicing using ponds and a piped system, the development of the Queens Business Park is encouraged to implement Best Management Practices. Examples hereof are illustrated in Figure 4.

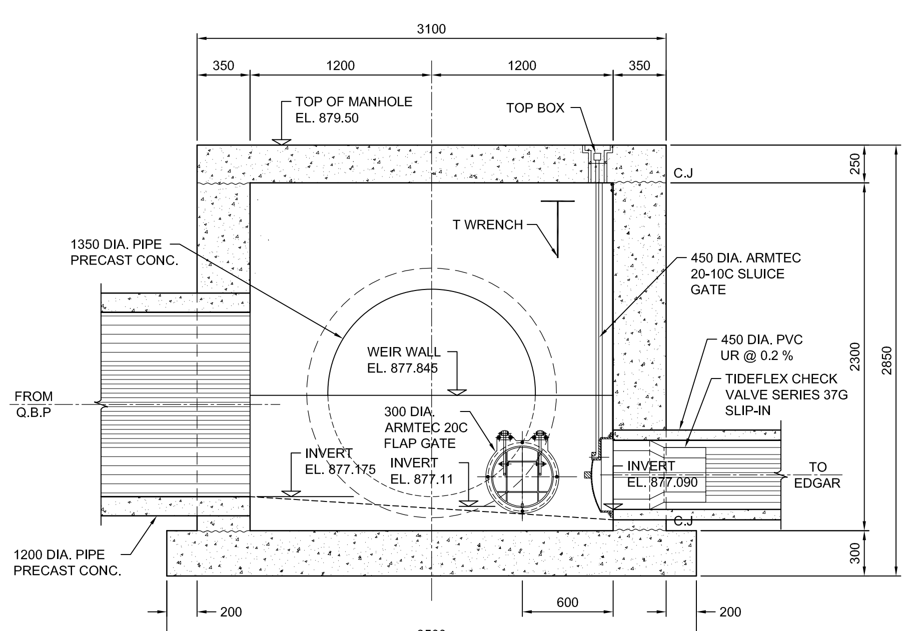
- Rain harvesting and re-use of captured runoff for irrigation is effective to reduce the runoff to the ponds and relying on domestic, treated water supply; significant reduction in cost can be achieved on the long term.
- Green roofs are effective in prolonging the life of roof membranes and research shows factors of 2 to 3 can be achieved.
- A green stormwater management system approach can filter runoff via bioswales and bio-retention areas prior to discharge into the minor system leading to the constructed wetlands. This train treatment is most effective in addressing water quality of stormwater runoff and ensures improved water quality reaching the downstream system, including Hazlett Lake and the Red Deer River.



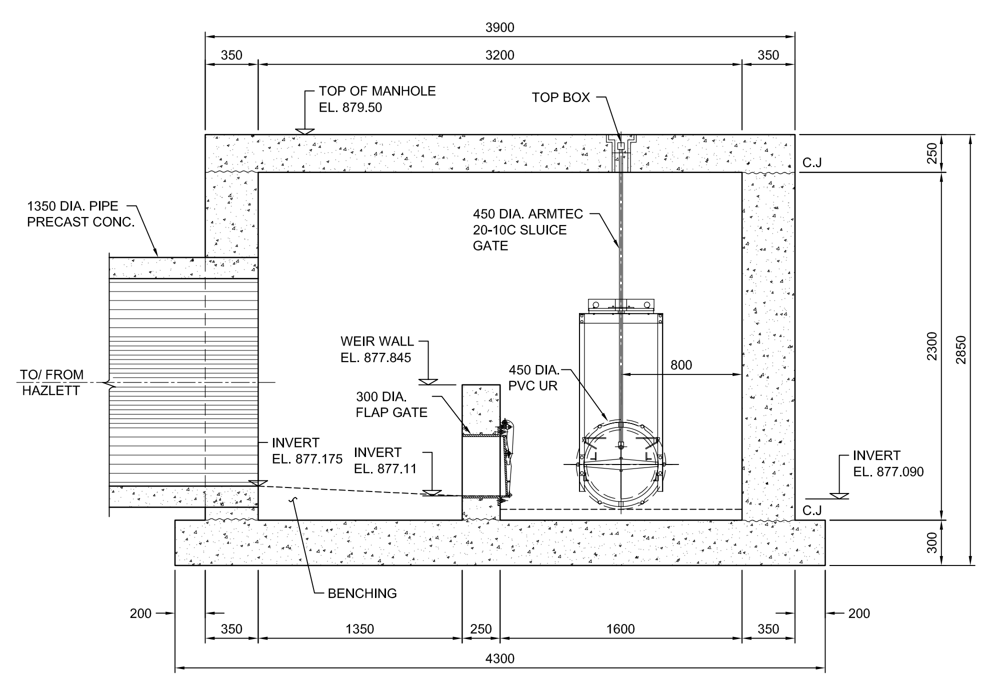
PLAN
SCALE 1:25



SECTION
SCALE 1:25



SECTION
SCALE 1:25



SECTION
SCALE 1:25

1:25 0 0.5 1 m

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, ELEVATIONS ARE IN METERS, UNLESS OTHERWISE NOTED.
2. BASE PLAN PROVIDED IBIGROUP.
3. ALL BACKFILL SHALL BE COMPACTED TO MINIMUM 98% SPMDD, +/- 2% OF OPTIMUM SOIL MOISTURE UNLESS OTHERWISE NOTED. IMPERVIOUS BACKFILL MATERIAL SHALL HAVE A PERMEABILITY OF LESS THAN $1X10^{6}$ CM/S, AND LIQUID LIMIT ABOVE 30% AND MINIMUM PLASTICITY INDEX OF 14%.
4. WITHIN 1000mm OF STRUCTURES OR OTHER ITEMS SUSCEPTIBLE TO COMPACTION INDUCED DAMAGE, REDUCE LIFT THICKNESS, REMOVE STONE LARGER THAN 80mm, COMPACTED FILL MATERIALS WITH HAND OPERATED PNEUMATIC OR MECHANICAL TAMPING EQUIPMENT.
5. FILL DEPTH SHALL BE MAINTAINED APPROXIMATELY EQUAL ON EACH SIDE OF THE STRUCTURE. THE MAX. DIFFERENCE IN ELEVATION SHALL BE 400mm.
6. ANY UNSUITABLE MATERIAL BELOW THE FOUNDATION OF THE STRUCTURE, AS DETERMINED BY A GEOTECHNICAL ENGINEER, SHALL BE EXCAVATED AND REPLACED WITH SUITABLE MATERIAL AS DIRECTED BY THE SAME.

LEGEND:

CONCRETE IN SECTION

REV.	DATE	REVISION DESCRIPTION	DRW	DES	CHK	APPR
5						
4						
3						
2						
1						
0	JULY 2007	ISSUED FOR CLIENT REVIEW	JP	DRW	EL	DRW

ENGINEER'S SEAL:

PROFESSIONAL ENGINEER EDMUND C. LI ALBERTA
ORIGINAL SIGNED DEC. 22, 2006

PERMIT:

PERMIT TO PRACTICE
WESTHOFF ENGINEERING RESOURCES INC.
Signature ORIGINAL SIGNED BY DENNIS WESTHOFF
Date DEC. 22, 2006
PERMIT NUMBER: P 6305
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

CLIENT:

CITY OF RED DEER

CONSULTANT:

Westhoff Engineering Resources, Inc.
Land & Water Resources Management Consultants

PROJECT:

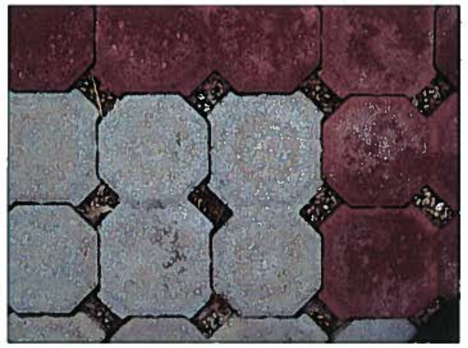
HAZLETT LAKE

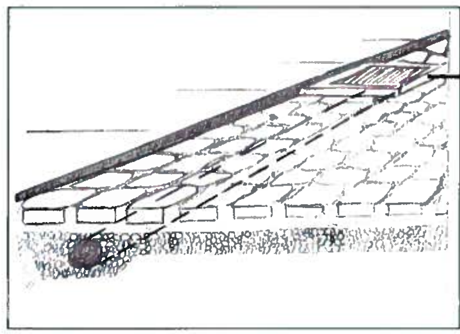
TITLE:

HAZLETT LAKE CONTROL STRUCTURE PLAN, SECTIONS AND DETAIL

DESIGNED:	CHECKED:	DATE:	JOB No.	DRAWING NO.
D. WESTHOFF	E. LI	JULY, 2007	WER106-62	01
DRAFTED:	APPROVED:	SCALE:	CAD FILE:	
J. PHAM	D. WESTHOFF	AS SHOWN	10662P01.dwg	

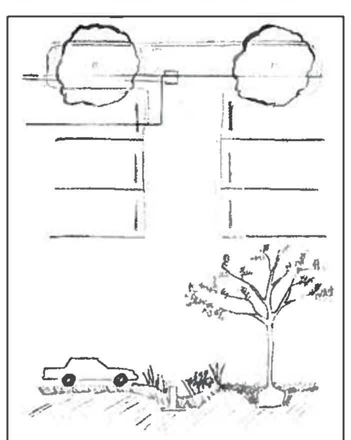
Light Industrial BMPs





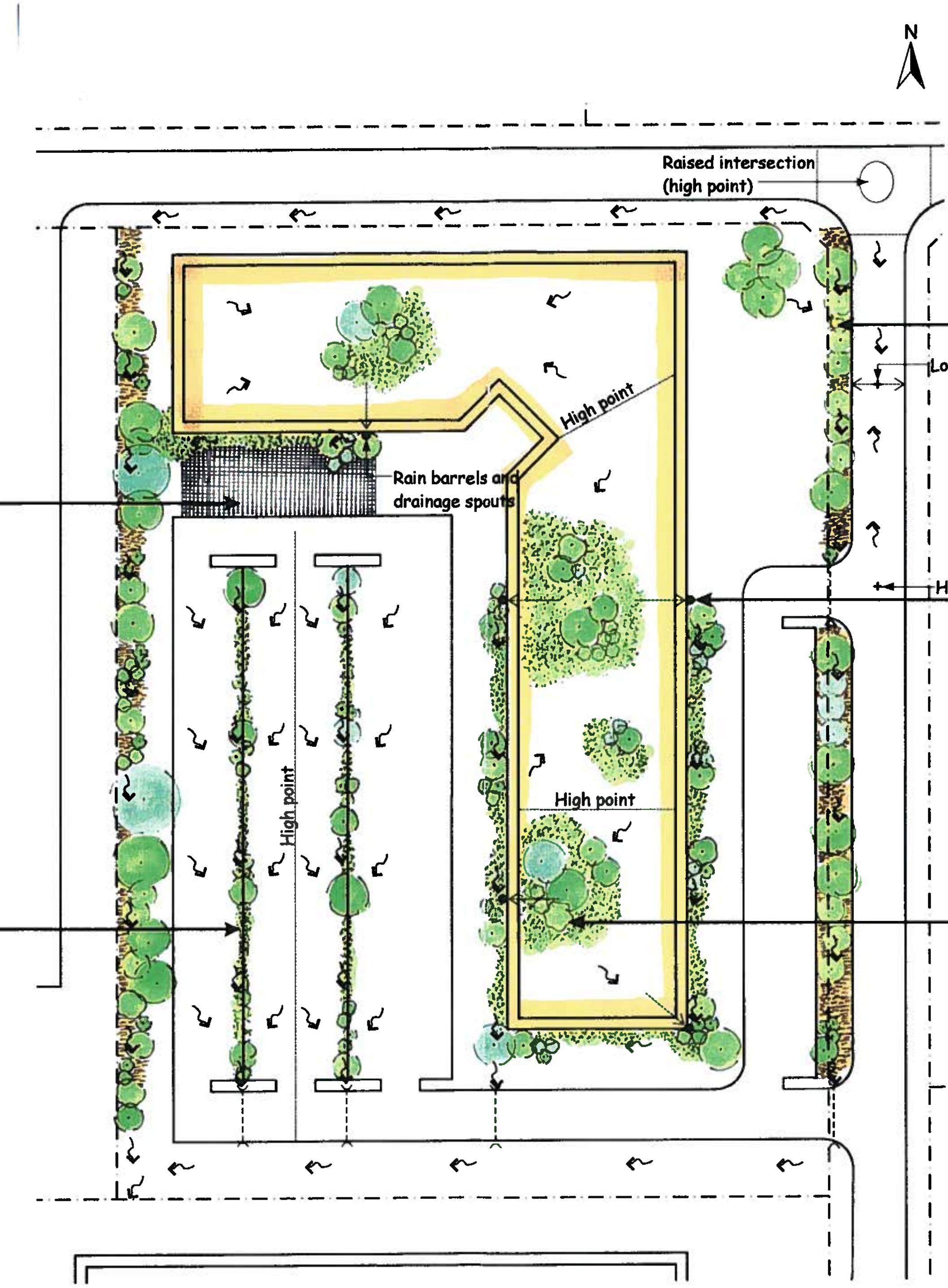
Porous Pavement

Contains void space for stormwater infiltration, thereby reducing runoff



Vegetated Parking Medians

This technique incorporates stormwater quality treatment and flood detention through the vegetation of shallow depressions in medians



Drainage Features and Characteristics

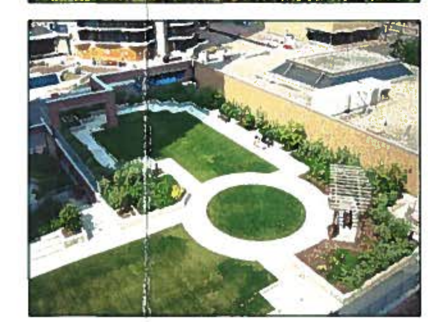
* On site storage requirement is approximately 150-200m³/ha.
* An approximate 20(l)x20(w)x0.5(d) pond is required if no BMPs are in place. This size is of course reduced if more BMPs are incorporated into the development. The current configuration of the site allows for no on site storage pond as the southwest corner of the lot is occupied by a parking lot. The lot configuration should take into respect the required stormwater requirements and be modified accordingly.
* If a pond feature is integrated and also used for water quality then the dead pool volume requirement will be approximately 250m³/ha.

Landscaped Bioswales

Drainage from public roads via bioswales in private/public common areas (as shown). Provide water treatment and conveyance as well as improve site aesthetics

Waterscaping

Water conservation methods can also include artistic designs.



Green Roofs

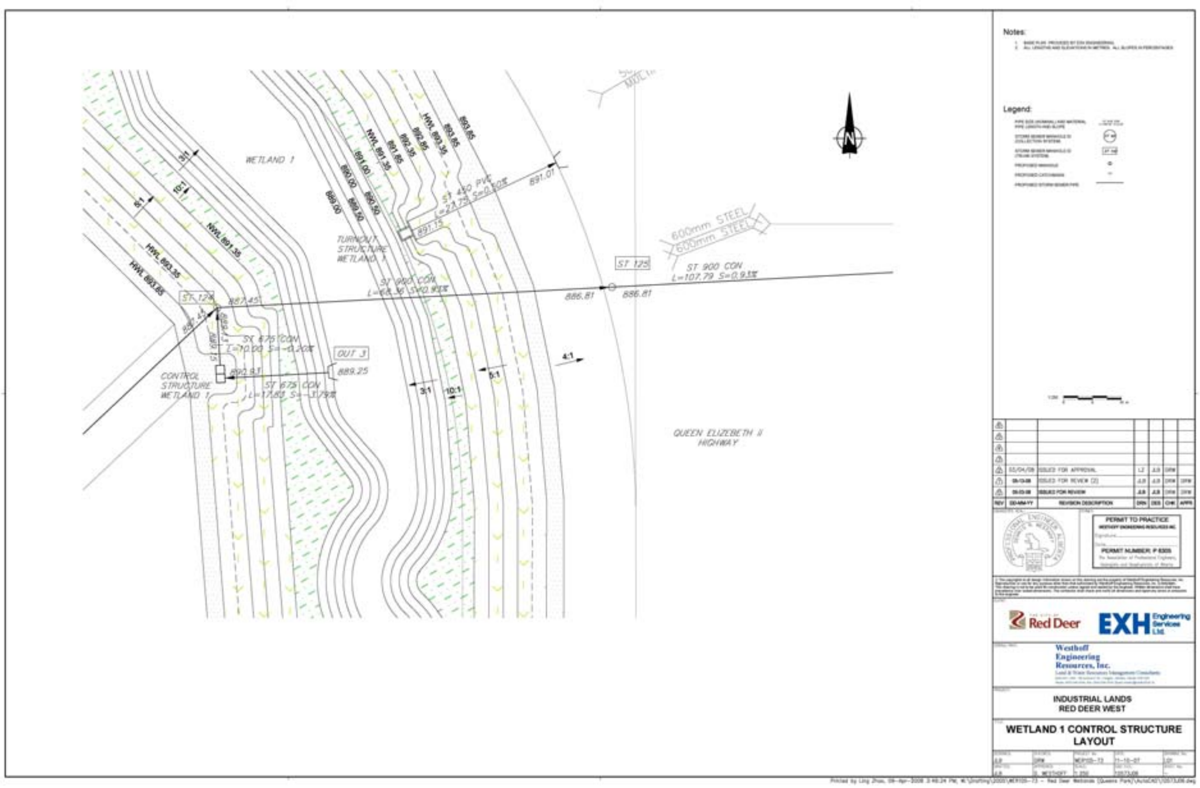
Green roofs contain vegetation to treat and reduce runoff.

CLIENT: The City of Red Deer	PROJECT: QUEENS BUSINESS PARK
©Westhoff Engineering Resources, Inc. Land & Water Resources Management Consultants	TITLE: Conceptual Best Management Practices for Light Industrial Developments
	DATE: June 2008 · JOB No.: WER106-73 · COREL FILE: Light Industrial Concept · FIGURE No.: 4 · REV: 1

Hazlett Lake is included in the configuration of the drainage system for Queens Business Park as an overflow facility that receives runoff from the development area in events that are extremely severe. Most of the time, runoff generated from the Queens Business Park area is controlled on-site to such an extent that the flow conveyed by the trunk is directly discharged into the Edgar storm sewer system. This strategy complements the requirements for the on-site stormwater management system as the most effective way in treating runoff from the business park.

It must be recognized that ultimately, Hazlett Lake will receive runoff from an urban area once development occurs in its tributary catchment area. To protect the lake as much as possible, steps towards developing a Hazlett Lake Management Plan are taken and at the time of the preparation of this report, several investigations have been completed. In addition, Section 4 provides a brief elaboration on the stormwater management strategies for the tributary area surrounding the lake.

It is noted that an operable diversion structure (see below) is integrated in the constructed wetland adjacent to the service road allowing small flows to be released into the maze of culverts and drainage routes at the interchange and ultimately reaching the original channel leading to Hazlett Lake.



3.0 ANALYSIS AND RESULTS

Approach

To develop an understanding of the pre-development hydrologic conditions and in particular to assess what Hazlett Lake receives in term of runoff from the area to the west of the Hwy QE II and its immediate surrounding catchment, a spreadsheet analysis was used. The spreadsheet analysis developed by Westhoff is based on algorithms used by the well-known and widely used QUALHYMO rainfall-runoff model. However, and unlike the QUALHYMO model, the Westhoff water balance spreadsheet allows for flexibility to reflect realistic conditions, including reduced infiltration potential during the winter months, varying evaporation rates pending on climatic conditions and seepage at the low-lying areas, i.e., existing wetlands.

Data included in the spreadsheet analysis includes data from PFRA for median annual runoff quantities which are in the order of 20 - 50 mm for the Red Deer region; flow monitoring data recorded at the Water Survey of Canada station for the Blindman River; and recorded precipitation data by the City of Red Deer at its City Hall and Red Deer North gauges. In addition and for the purpose of validation runs, information of water levels in low-lying areas as recorded by Mr. Grant Moir, the ecological services coordinator for the City of Red Deer and historical air photos proved valuable data to increase the confidence in the magnitude of the parameters selected (e.g., CN, I_a, etc.). Other data used in the analysis included topographic information of the area surrounding Hazlett Lake that was complemented with a bathymetry survey by AL-Terra.

Results of the spreadsheet analysis for the pre-development conditions using the above data yielded very good results. The comparison between the recorded data and the modeled data for water levels in Hazlett Lake showed a variation of less than 0.20 m.

For the post-development analysis, the XP-SWMM model was used, incorporating, where appropriate, parameters determined for pre-development conditions in the model. The model was configured to include the planned infrastructure for the Queens Business Park encompassing approximately six (6) quarter sections and two (2) large external catchment areas (see Figure 3). The preliminary sizing of the trunk was based on an economic evaluation of the cost by AL-Terra and catchment delineation as determined by EXH. In addition, the model incorporated the sizing of the constructed stormwater wetlands as prepared by Westhoff. A unit storage volume approach based on the wetlands for the Phase 1 development area was used for future storage facilities.

An operating water level of Hazlett Lake was established based on observation by Westhoff. In particular, this level was related to the presence of water lilies in Hazlett Lake that are sensitive to water level fluctuations and review of historical air photos. The normal water level thus determined is at elevation 877.60 $\pm$ 0.10 m; the spill at approximately 878.20 m. The design of the trunk system necessitated the lowering of the lake to 877.175 m, i.e., the design invert elevation of the 1350 mm diameter inlet/outlet pipe system at Hazlett Lake. This is the new elevation of the Normal Water Level of the lake.

Results

The storm trunk was sized for a release rate of 4 L/s/ha[1] and the initial runs with XP-SWMM model were made using this unit area rate. Two scenarios were examined based on a single event, i.e., a 24 hour, 1:100 year design event, and a continuous simulation analysis. While these scenarios yielded results that indicated that the on-site ponds were adequately sized, the results for Hazlett Lake showed a maximum rise of the water level up to 878.3 m for the 1:100 year single event; and up to 878.38 m for the continuous simulation using 1999 precipitation (i.e., a wet year), and therefore predicting spill from the lake.

Hence, a different approach was developed by assuming that the first 1.5 m of the maximum 2.0 m active storage depth for the stormwater wetlands in Queens Business Park would be released at the capacity of the Edgar storm sewer system. The combination rate thus established rendered a release rate of 0.36 L/s/ha and 4.0 L/s/ha for the first 1.5 m depth and the remaining 0.5 m depth of the active storage, respectively.

The results of this strategy show that the on-site ponds remain adequately sized for both the 1:100 year single event and the continuous simulation. The updated analysis is based on the final design of the stormwater infrastructure design for the QBP Phase 1 area and the final design of the trunk to Hazlett Lake. The results as presented in Appendix B, show that for the single event, Hazlett Lake would only reach an elevation of 877.42 m; a marginal increase of the normal water level. For the continuous simulation, the results were also reduced with maximum levels estimated at 877.78 (i.e., no spill).

The results from the latter runs are promising as they demonstrate that additional strategies including BMPs for the developments can result in further reducing the “use” of Hazlett Lake compared to the predictions by the current model. The Model schematic and graphical output of the results are presented in Appendix B.

[1] Based on an economic analysis of the trunk system by Al-Terra Engineering Ltd.

4.0 HAZLETT LAKE MANAGEMENT PLAN

Following the preliminary assessment of Hazlett Lake, Westhoff was retained by the City of Red Deer to compile existing information and undertake additional surveys of Hazlett Lake in order to develop adaptive monitoring and management strategies as part of a comprehensive lake management plan. A summary of the efforts completed and those that are scheduled for the 2007 season is presented in Appendix C**.**

Of importance is the need of developing an adaptive management plan based on a long term monitoring program. The current assessment program forms the basis for this and while there are on-going efforts, it is noteworthy to mention that the information of this program will assist in the operation of the drainage system planned for Queens Business Park. The monitoring program for Hazlett Lake could be expanded into developing adaptive management strategies for the operation of the on-site constructed wetlands within the business park area. For example, the development of the first portion of Queens Business Park will include the most easterly constructed wetland and it is possible that runoff from this portion will not "trigger" the need for Hazlett Lake as an overflow storage facility.

It is inevitable that the area surrounding Hazlett Lake will be developed sometime in the future. Best Management Practices and Low Impact Development strategies may be the norm at that time; however, for the purpose of this report, the following drainage strategies are to be considered:

Best Management Practices:

The catchment area surrounding the Hazlett Lake is well suited for implementing the following BMPs:

- **On-site BMPs** comprise measures to capture the precipitation and runoff for re-use, absorbent landscaping for volume control and xeriscaping and rain gardens to reduce water quality impacts (e.g. use of fertilizers). Landscaping designs can not only be most attractive, they can be designed with minimum need for maintenance and effective in handling stormwater runoff. Also, and for example to reduce runoff quantities, pervious pavements for driveways are effective measures to reduce the impact of the site development.

- **Conveyance BMPs** comprises vegetated drainage swales systems and roadside ditches. These system components are effective in sediment removal and provide for some attenuation of peak flows during severe storm events.

- **Storage BMPs** are detention systems that provide for attenuation of the peak flows and water quality improvements. They should be integrated into the green spaces and sized to comply with targets related to pre-development release rates and reduction of Total Suspended Solids (TSS) loadings to receiving streams, i.e., the wetland. Current targets for the latter are set to reduce the annual loadings to 85% for particles of 75 micron in size and larger. Nutrient removal should be targeted as well to minimize the long-term eutrophication of Hazlett Lake.

With regards to Low Impact Development strategies and reflecting the fact that the soil characteristics of the Red Deer region exhibit significant topsoil depth, it is recommended that wherever there is green space – i.e., whether on within the lots, boulevards and other green spaces - the topsoil depth is not altered. In fact, the topsoil should be amended / bio-engineered to provide for significant absorption of runoff quantities. It cannot be overemphasized that these measures demand to think out of the box during the planning of the subdivision. Often, traditional approaches to planning causes designers for stormwater management to deal with SLOAP (Space Left Over After Planning) and many of the needed opportunities to manage the stormwater as a resource are then simply not possible.

Together with these strategies and the on-going efforts that are placed towards the assessment of Hazlett Lake, a comprehensive management plan can be developed for the lake as well as for all other infrastructure components included within the catchment area of Hazlett Lake.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- The development of Queens Business Park can be serviced with a stormwater management system that includes on-site measures and a trunk connected to the existing Edgar subdivision. Hazlett Lake is incorporated as an overflow storage facility.

- For the protection of Hazlett Lake and to minimize the potential impacts, conceptual strategies and design criteria have been developed.

- On-site measures for QBP include constructed wetlands and an operational rule that optimizes these storage facilities from a water quantity and quality perspective.

Recommendations:

- Stormwater management system for Queens Business Park shall be detailed on the basis of measures as outlined in this report including constructed wetlands and BMPs for light industrial / commercial / office parks.

- During the detailed design phase, the operation of the constructed wetlands shall be further investigated to minimize the need for Hazlett Lake to be operated as an overflow storage facility.

- When planning is contemplated for the development of the tributary area now directly discharging into Hazlett Lake, stormwater management strategies shall be considered to be paramount to the development of the neighborhood area structure plan (NASP).

- A committee of stakeholders should develop the long term monitoring program based on and adapted from the program initiated in 2006 to ensure data continues to be collected and used in the development of the Hazlett Lake Management Plan, including adaptive management strategies. The latter should be on the basis of annual reviews of the data collected.

APPENDIX A
Wetland Ecological Assessment

Wetland Ecological Assessment

FOR

2005 Industrial Lands – Sanitary and Storm Trunk Project

Prepared for:

THE CITY OF
Red Deer

Prepared by:

Westhoff Engineering Resources, Inc.
Land & Water Resources Management Consultants

Suite 601
1040 – 7th Avenue S.W.
Calgary, Alberta T2P 3G9
Phone: (403) 264-9366
Fax: (403) 264-8796
Email: werinc@westhoff.ab.ca

November 2005
Final Report

CORPORATE AUTHORIZATION

This document entitled *Wetland Ecological Assessment for 2005 Industrial Lands – Sanitary & Storm Trunk Project* was prepared by Westhoff Engineering Resources, Inc. It is intended for the use of The City of Red Deer and their consultants responsible for the development of the noted property and approval authorities for which it has been prepared. The contents of the report represent Westhoff Engineering Resources, Inc.'s best judgment based on available information at the time of preparation. Any use that a third party makes of the report, or reliance on or decisions made based on it, is the responsibilities of such third parties. Westhoff Engineering Resources, Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on the report.

Unauthorized use of the concepts and strategies reported in this document and any accompanying drawings and/or figures is forbidden; they are the sole intellectual property of the author. Duplication of this report or any portion thereof requires approval from Westhoff Engineering Resources, Inc. and the City of Red Deer.

PERMIT TO PRACTICE
WESTHOFF ENGINEERING RESOURCES INC.
Signature
Date Nov 14, 2005
PERMIT NUMBER: P 6305
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

PROFESSIONAL ENGINEER
DENNIS R. WESTHOFF
ALBERTA

CORPORATE PERMIT

RESPONSIBLE ENGINEER

Report Preparation by
Misty Bleakley, B.Sc.

Reviewed by
Dennis R. Westhoff, P.Eng., M.Eng.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Purpose

Westhoff Engineering Resources, Inc. was retained as a sub-consultant by AL-Terra, consultant for The City of Red Deer, to conduct a preliminary wetland assessment in northwest Red Deer. This report documents three wetlands identified by the City of Red Deer as part of the planning stage for servicing studies for approximately 518 hectares (1200 acres) of land northwest of the current City limits. This preliminary ecological assessment is part of Task 1 of our assignment; a hydrotechnical analysis will further characterize these wetlands to complete our assignment.

1.2 Wetland Classification

As part of the wetland assessment, the project wetlands will be assigned a class following the Stewart and Kantrud (1971) Wetland Classification Methodology. The wetland classes as designated by Stewart and Kantrud are as follows:

- Class I – Ephemeral Ponds: wetland-low-prairie zone dominates the deepest part of the pond basin
- Class II – Temporary Ponds: wet meadow zone dominates the deepest part of the wetland area, a peripheral low-prairie zone is usually present
- Class III – Seasonal Ponds and Lakes: shallow-marsh zone dominates the deepest part of the wetland area, peripheral wet-meadow and low-prairie zones are usually present
- Class IV – Semi-permanent Ponds and Lakes: deep-marsh zone dominates the deepest part of the wetland area, shallow-marsh, wet-meadow, and low-prairie zones are usually present, and isolated marginal pockets of fen zones occasionally occur
- Class V – Permanent Ponds and Lakes: permanent-open-water zone dominates the deepest part of the wetland area, peripheral deep-marsh, shallow-marsh, wet-meadow, and low-prairie zones are often present, and isolated marginal pockets of fen zone occasionally occur

It should be noted that wetland class level is not related to environmental significance or function (i.e. a higher class does not automatically indicate higher function or environmental significance).

The environmental significance of the wetlands will also be assessed following The City of Calgary's *Wetland Conservation Plan* (2004). The Environmental Significance Assessment (ESA) takes into consideration the following aspects: flora, fauna, flood and erosion control, and hydrological function. The categories of significance, from highest to lowest are: environmentally significant wetland, major wetland, and supporting wetland.

1.3 Method of Assessment

Site visit conducted July 23, 2005. The areas of study were walked and photographs and notes were taken. Three wetlands were assessed as requested by The City of Red Deer. The wetlands are identified on the aerial photos on the following pages.

The unnamed wetland in the northwest study area has been analyzed as two separate wetlands. It is split by a local N-S road and the two sides have different ecological characteristics. If it is shown that they remain connected from a hydrological perspective, they will be treated as a single wetland in the hydrologic analysis.

1.4 Aerial Photographs

The aerial photos on the following pages were provided by The City of Red Deer. The wetlands documented in this Wetland Assessment are identified on the photos.

Figure 1 Aerial Photograph SW of Jct 2-11A

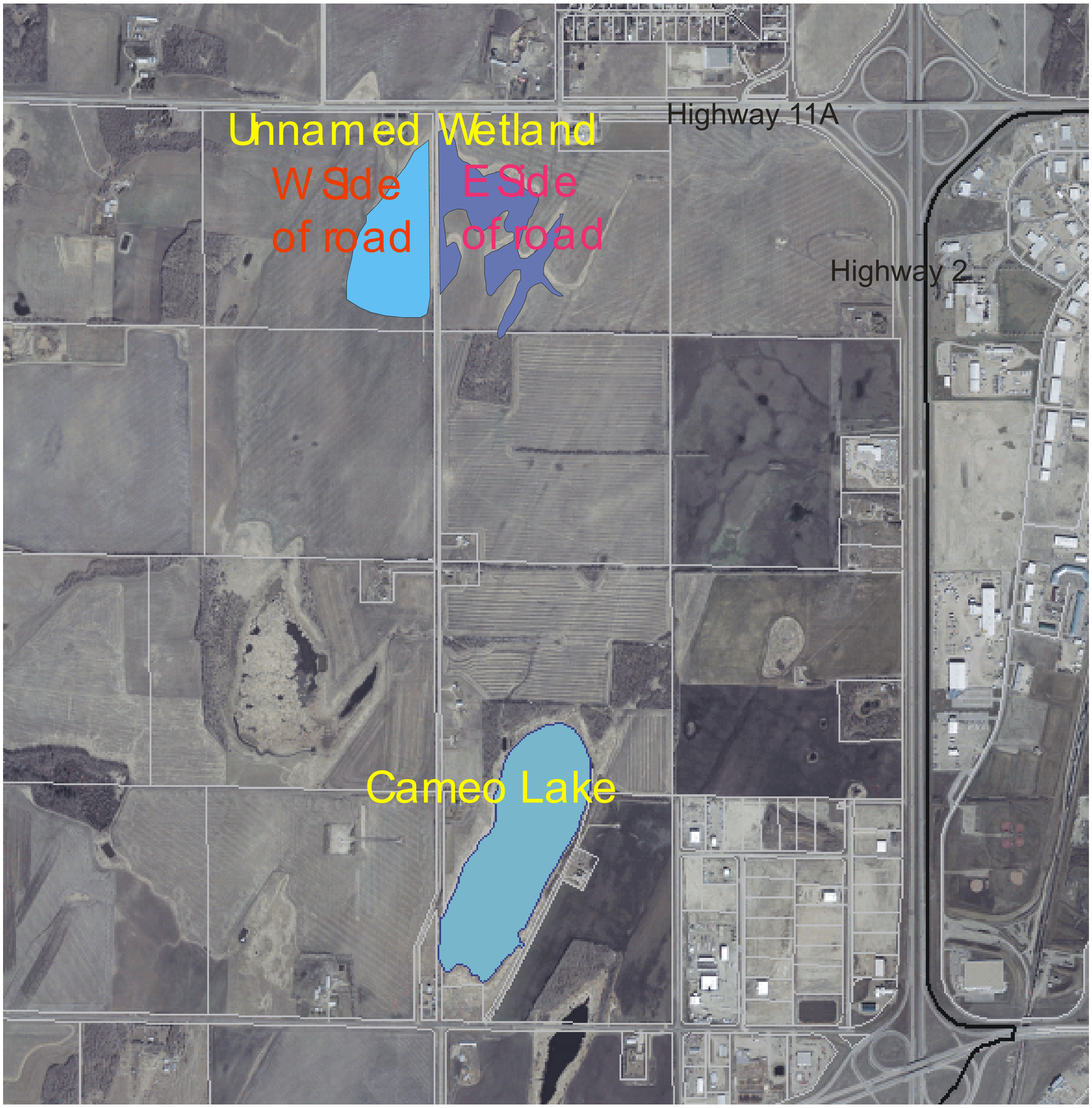


Figure 2 Aerial Photograph NE of Jct 2-11A

2.0 WETLAND ECOLOGICAL ASSESSMENT RESULTS AND CONCLUSIONS

2.1 Wetland Ecological Assessment Results

The following table summarizes the classification and environmental significance assessment (ESA) for the identified wetlands in the 2005 Industrial Lands Project area. The detailed notes and photographs for the wetland assessment can be found in Appendix A.

Table 1 Wetland Assessment Results Summary

Wetland	Class	Environmental Significance
Cameo Lake	V – Permanent Lake	Major Wetland
Unnamed Wetland Area 1 – W of road	IV – Semi-permanent Pond	Supporting Wetland
Unnamed Wetland Area 1 – E of road	III – Seasonal Pond	Supporting Wetland
Hazlett Lake	V – Permanent Lake	Major Wetland

2.2 Wetland Riparian Area Discussion

In the design and development of the Industrial Lands, consideration should be given to the wetland riparian areas. It should be noted that Cameo Lake and Hazlett Lake have wide riparian zones; these areas are very sensitive and are of high ecological value. Based on field surveys and analysis of aerial photos provided, the treed riparian areas surrounding the lakes vary and are approximately 30-35 m wide surrounding Cameo Lake and 30-45 m wide surrounding Hazlett Lake. The Unnamed Wetlands are more marsh-type wetlands with willows and shrubs surrounding; they are more difficult to delineate from aerial photos. The farmland setback surrounding the Unnamed Wetlands varies from approximately 15-35 m. Further studies to delineate the wetlands and riparian areas are needed prior to any planning and design involving encroachment upon the wetlands.

2.3 Wetland Ecological Assessment Conclusions

This study characterizes the current ecological state and features of three wetlands northwest of The City of Red Deer. The wetlands range from a seasonal pond to permanent lakes and low to moderate environmental significance. The incorporation of these wetlands in a stormwater management plan is preferred to destruction or severe alteration as they impart ecological benefits including providing wildlife habitat and contributing to flood control and long-term maintenance of the local hydrological regime. From an ecological perspective, the study wetlands may all be suitable for stormwater management purposes, provided that they are protected from excessive inputs of sediments and other pollutants.

In a City of Red Deer Council resolution, April 5, 2004, Council resolved to: “adopt a conservation and reduction policy throughout all levels of the organization” and directed that “environmental strategies be brought forward for consideration…and given a high priority”. Considering these directives, conservation of the study wetlands should be a priority in design and development of the Industrial Lands, which may include incorporation in stormwater management planning

3.0 REFERENCES

City of Calgary. 2004. *Wetland Conservation Plan.* Cerlox, Calgary, AB.

Stewart, R.E. and H.A.Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online.

Appendix A

2005 Industrial Lands Detailed Wetland Assessments

DETAILED WETLAND ASSESSMENTS

Cameo Lake

- Large wetland, significant area of open water
- Cattails, tall grasses and willows surrounding
- Wide riparian zone ~ 30m in some areas
- Songbirds heard, waterbirds likely use for nesting area
- Environmental Significance: **Major Wetland** – moderate to little disturbance evident, predominantly native vegetation, may act as staging area for wildlife movement, moderate contribution to flood and erosion control, moderate contribution to long-term maintenance of hydrological regime beyond its boundaries
- Class V – Permanent Pond/Lake

Unnamed Wetland, Area 1

Note: Wetland is split by local N-S road

West side of local road




- Standing water in ditch
- Cattails dominant, sedges, willows and poplar surrounding
- Pipeline has been put through wetland, obvious soil/vegetation change but affected area relatively small
- Songbirds heard
- Environmental Significance: **Supporting Wetland** - moderate disturbance evident, low importance for wildlife staging area, provides habitat for wildlife, low to moderate contribution to flood and erosion control
- Class IV – Semi-permanent Pond

Unnamed Wetland, Area 1

Note: Wetland is split by local N-S road

East side of local road

- Standing water in ditch, ducks seen in ditch
- Shallow-marsh vegetation dominant, grasses surrounding
- Environmental Significance: **Supporting Wetland** – moderate disturbance evident, low importance for wildlife staging area, provides habitat for wildlife, low to moderate contribution to flood and erosion control
- Class III – Seasonal Pond

Hazlett Lake


- Large wetland, significant area of open water
- Wide riparian zone, willows, tall grasses on periphery
- Songbirds heard, likely used by waterbirds
- Environmental Significance: **Major Wetland** – moderate to little disturbance evident, predominantly native vegetation, may act as staging area for wildlife movement, moderate contribution to flood and erosion control, moderate contribution to long-term maintenance of hydrological regime beyond its boundaries
- Class V – Permanent Pond/Lake

APPENDIX B
Technical Memorandum, June 15, 2008
Queens Business Park – Red Deer – XPSYMM Analysis

Westhoff Engineering Resources, Inc.

APEGGA Permit No. P6305

Land & Water Resources Management Consultants

June 15, 2008
WER 105-52.104

Attention: **Dennis Westhoff, P.Eng.**[1]
From: **Israr Ullah, M.Sc., E.I.T.**

TECHNICAL MEMORANDUM

RE: **Queens Business Park – Red Deer – XPSWMM Analysis**

This Technical Memorandum is intended to summarize the results of the XPSWMM analysis for the Queens Business Park in Red Deer, based on the latest design information provided to Westhoff Engineering Resources, Inc. by Al-Terra Engineering Ltd. (Al-Terra) an EXH Engineering Ltd. This memorandum serves as an update to the information presented in the Master Drainage Plan for Queens Business Park document, dated May 2007.

General Description

The storm sewer trunk for Queens Business Park is to service about 772 ha (see page 3 of this TM - Drawing WER105-73-001-rev 7). This system conveys captured runoff from stormwater wetlands/ponds 1, 2, 3, SC7, SC8, SC8A and SC10A to the Edgar drainage system with overflow temporary diverted to Hazlett Lake.

Technical Approach

The following drainage system components have been incorporated in the XPSWMM model for 1:100 year, 24 hour design storm event and for continuous simulation using 1999 as a wet year:

1) A two stage release system from the stormwater wetlands/ponds is proposed with different flow rates. The first 1.5 m of the maximum 2.0 m active storage depth would be released at 0.36 L/s/ha. The rate is low enough so that Edgar system will be able to handle the business park runoff due to frequent events. In the event of severe or long duration rainfall events, runoff captured and stored in the active depth zone between 1.5 of 2.0 m above NWL, will be released at a flow rate of 4.0 L/s/ha.
2) The storm sewer trunk is connected to the Edgar Industrial Park storm sewer system and has an “overflow” connection to Hazlett Lake.
3) The provision of Tideflex Check Valve at the diversion structure ensures that there will be no back flow from Edgar storm sewer system draining into the Hazlett Lake. Details are provided and shown on Drawing WER106-62-01 *Hazlett Lake Control Structure Plan, Sections and Detail* (page 4 of this TM).

[1] Internal May 01, 2008 version edited by Dennis Westhoff, June 15, 2008

W:\Projects\2005\WER105-52 - Industrial Development Wetland Assessment Red Deer\Reporting\TM20080422-WER105-52-XPSWMM Analysis-IU to DRW1-rev1.doc

Suite 601, 1040 – 7th Avenue S.W., Alberta, CANADA T2P 3G9
Phone: (403) 264-9366 Fax: (403) 264-8796 E-mail: werinc@westhoff.ab.ca

The results of the XPSWMM analysis are summarized in the following tables for the 1:100 year design storm and the continuous simulation, respectively.

Table 1 Results for the 24 Hour, 1:100 Year Analysis

External Wet Ponds	Design NWL (m)	Design HWL (m)	Computed HWL (m)	Maximum Computed Active Depth (m)	Permissible Discharge[2] (l/s)	Computed Discharge (l/s)
Wetland 1	891.350	893.350	893.234	1.884	5.4/60.5	125.5
Wetland 2	901.000	903.000	902.930	1.930	0.8/9.3	334.0
Wetland 3	907.000	909.000	908.176	1.176	145.5/1617.2	57.6
Pond SC7	901.000	903.000	902.635	1.635	14.2/158.0	17.0
Pond SC 8	892.800	894.800	894.576	1.776	16.3/180.8	20.0
Pond SC 8A	893.500	895.500	895.249	1.749	7.1/78.4	11.3
Pond 10 A	894.000	896.000	895.765	1.765	10.4/115.2	15.3

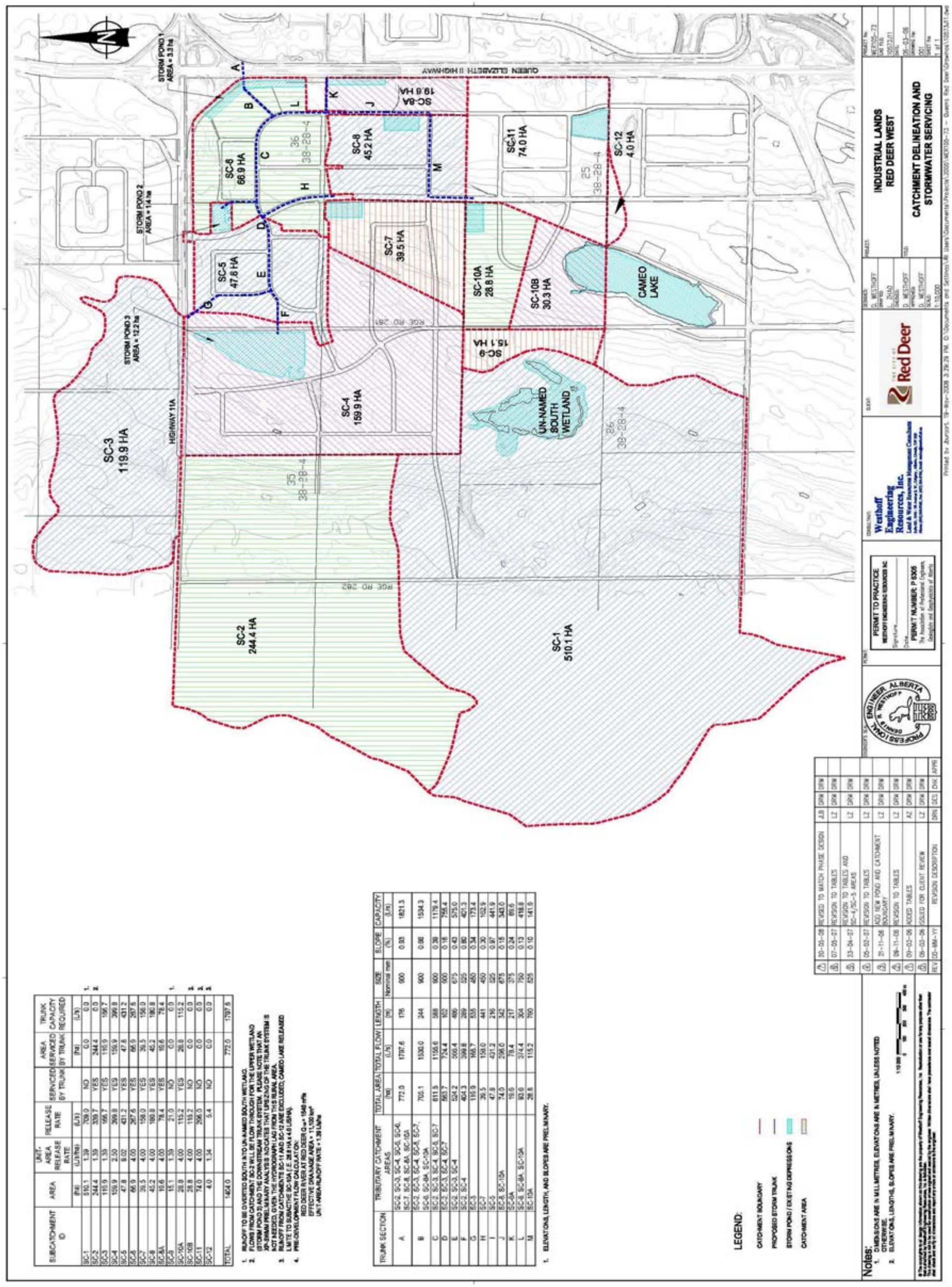
Table 2 Results for the Continuous Simulation Analysis

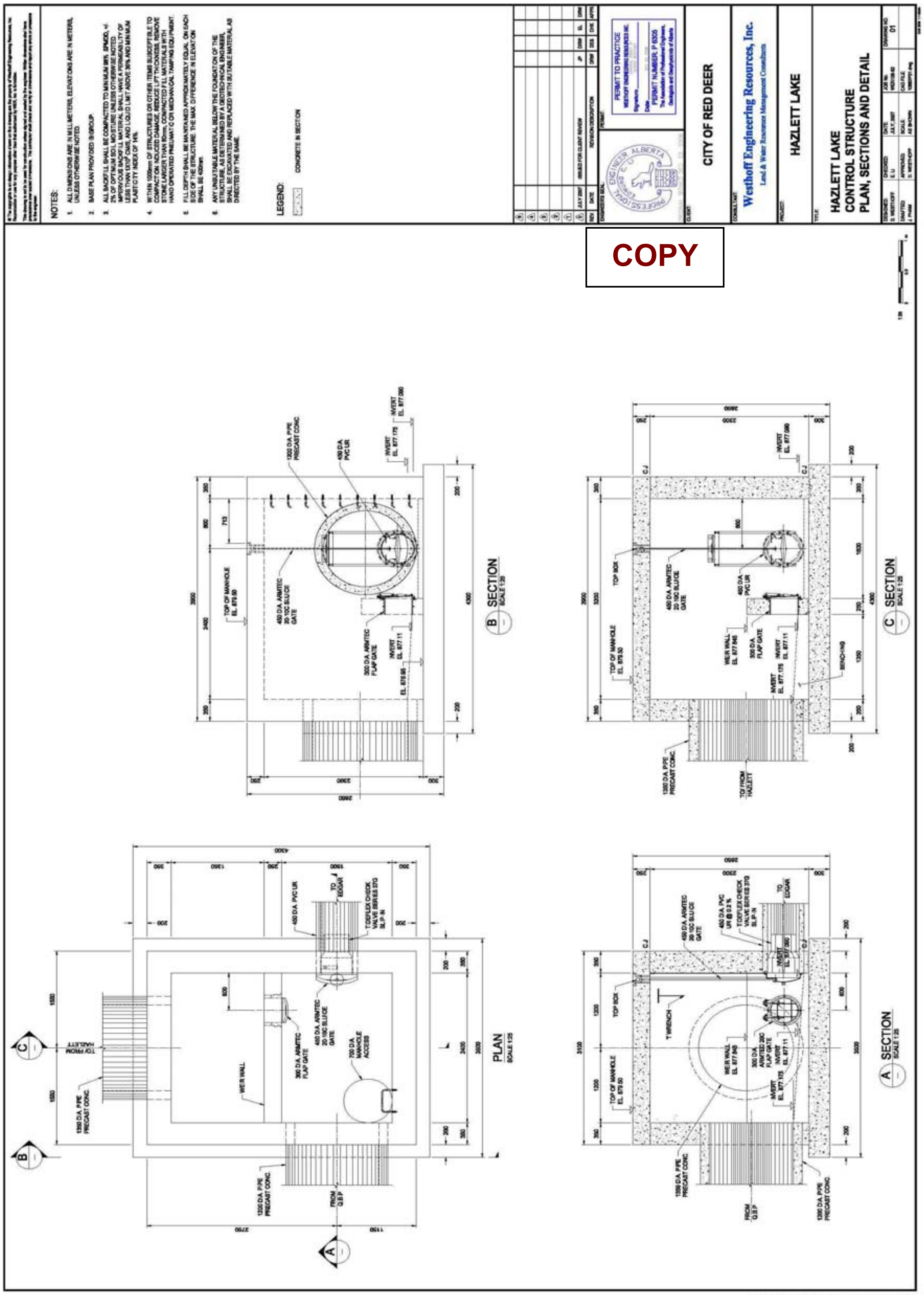
External Wet Ponds	Design NWL (m)	Design HWL (m)	Computed HWL (m)	Maximum Computed Active Depth (m)	Permissible Discharge (l/s)	Computed Discharge (l/s)
Wetland 1	891.350	893.350	893.490	2.140	5.4/60.5	271.5
Wetland 2	901.000	903.000	902.344	1.344	0.8/9.3	267.3
Wetland 3	907.000	909.000	909.254	2.254	145.5/1617.2	57.6
Pond SC7	901.000	903.000	902.740	1.740	14.2/158.0	17.6
Pond SC 8	892.800	894.800	894.843	2.043	16.3/180.8	21.8
Pond SC 8A	893.500	895.500	895.431	1.931	7.1/78.4	12.0
Pond 10 A	894.000	896.000	895.973	1.973	10.4/115.2	16.4

With the provision of two different flow rates, the results for Hazlett Lake shows NWL elevation of 877.18 m and a maximum rise of the water level up to 877.42 m and 877.78 m for the 1:100 year, 24 hour design storm and for the continuous simulation using 1999 storm (i.e., a wet year), respectively. This maximum HWL (877.78m) is almost the same as calculated HWL (877.76m) in the Master drainage Plan for Queens Business Park of May 2007.

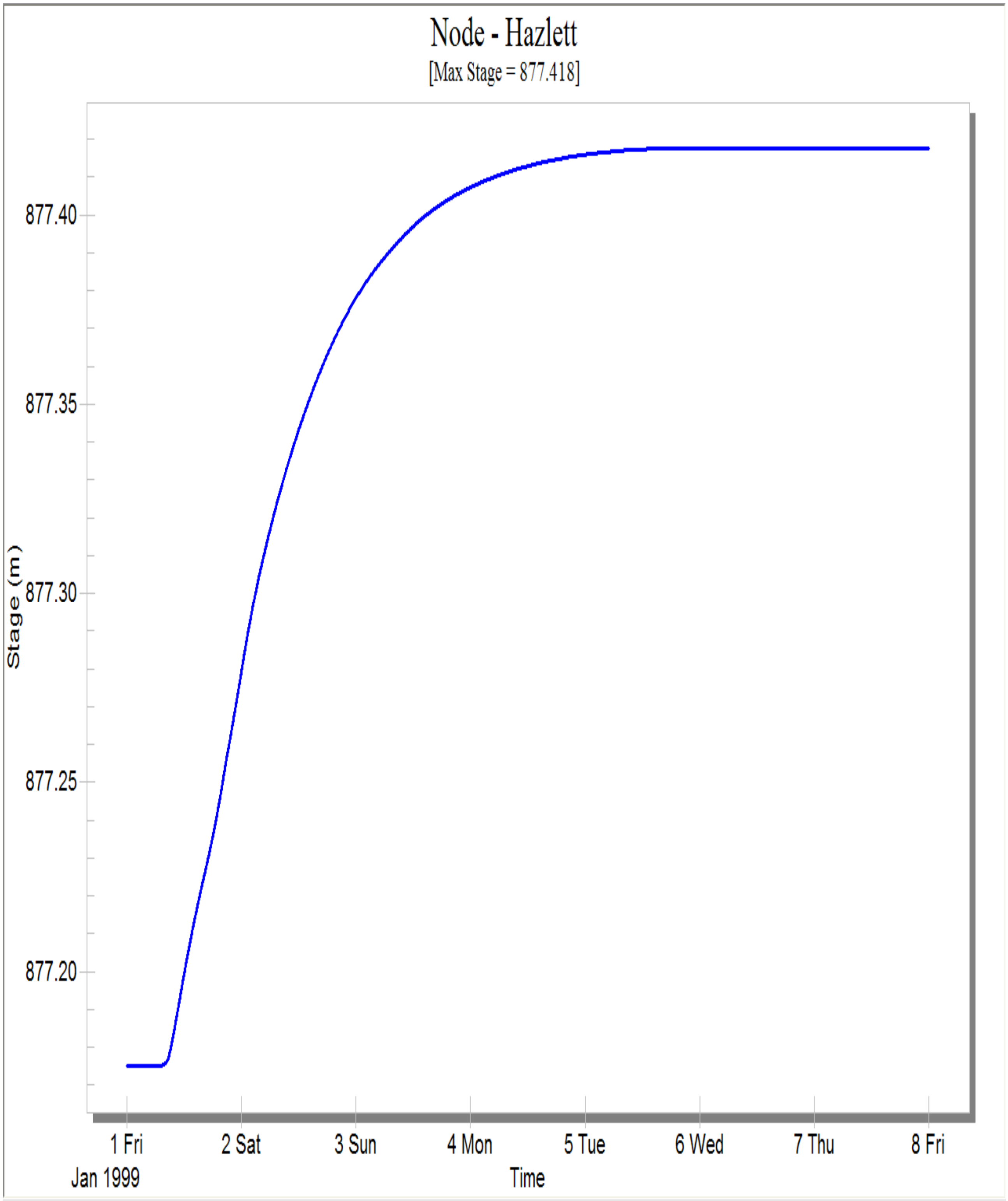
The results of the analysis shows that the peak diversion rates into Edgar storm sewer system is 125.3 L/s for 1:100 year, 24 hour storm and 127.7 L/s for 153 days for 1999 storm. The graphic representation of the results of the analysis for single event storm and continuous simulation is presented following hereafter. It is noted that additional strategies including BMPs for the developments can result in further reducing the “use” of Hazlett Lake compared to the estimates by the current model.

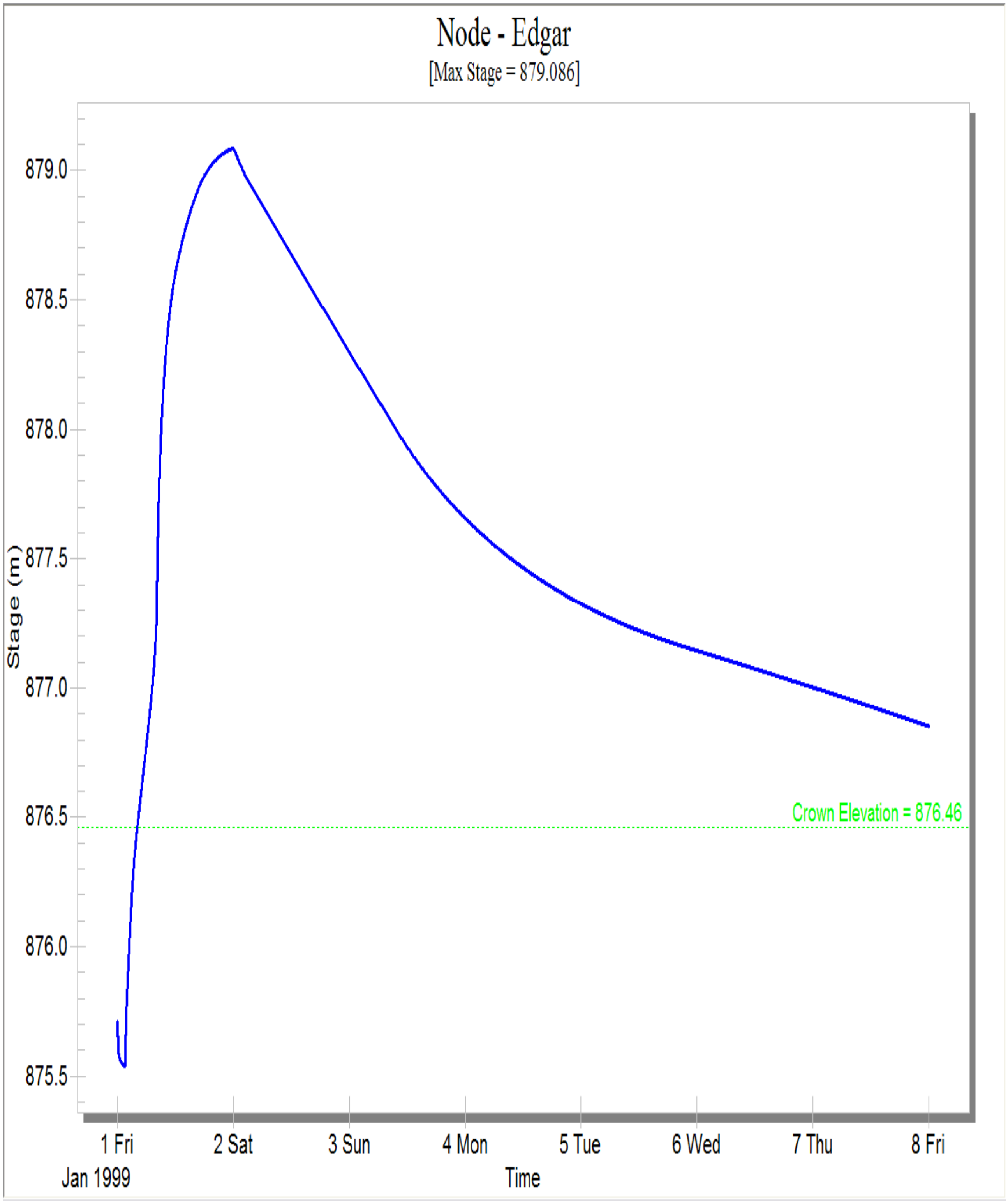
[2] Notation x/y is for release rate at 0.36 L/s/ha and 4.0 L/s/ha for active depths between 0 and 1.5 m, and above 1.5 m, respectively.

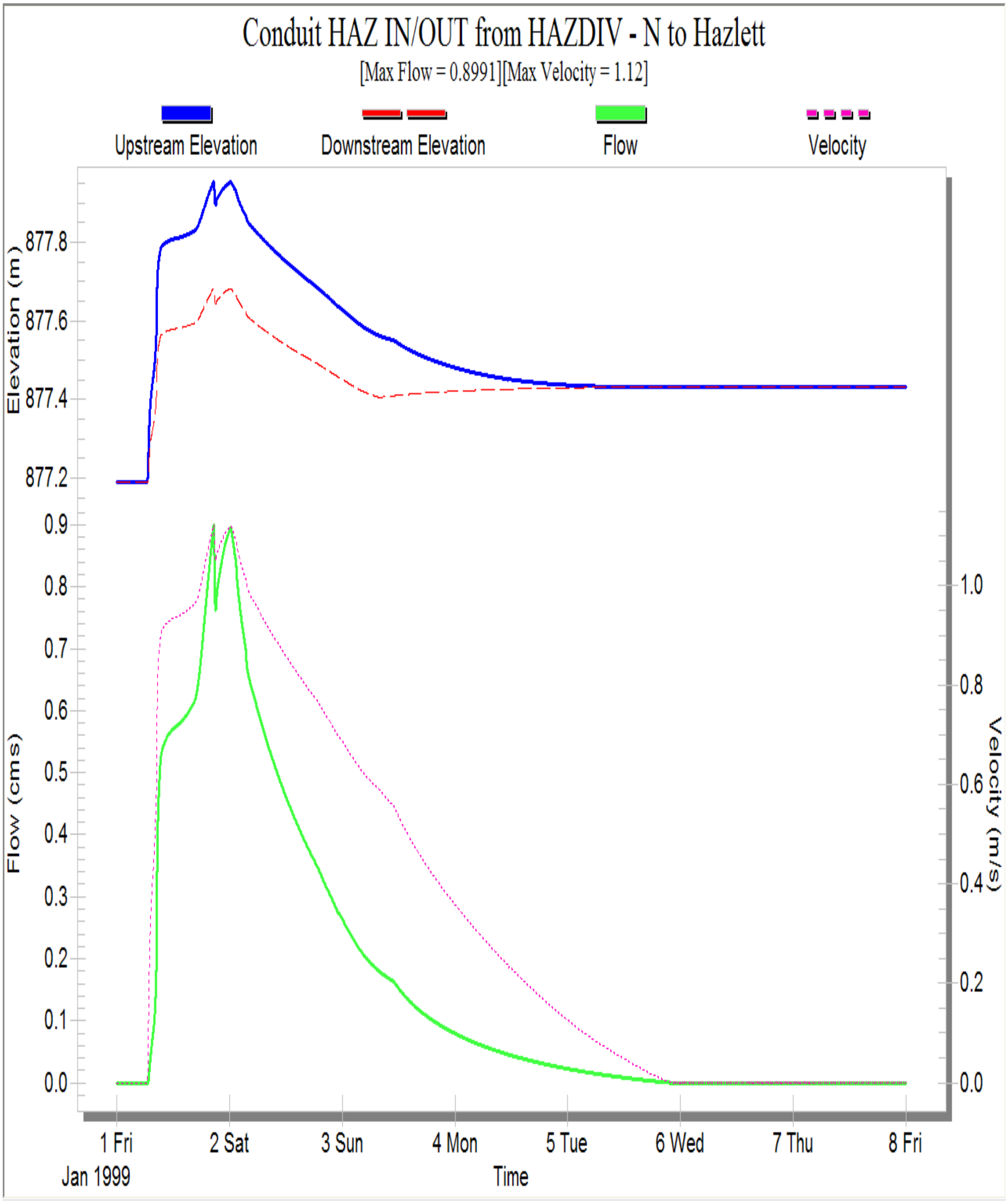

QUEEN ELIZABETH II HIGHWAY
HIGHWAY 11A
SC-1
510.1 HA
SC-2
244.4 HA
SC-3
119.9 HA
SC-4
159.9 HA
SC-5
47.6 HA
SC-6
66.9 HA
SC-7
39.5 HA
SC-8
45.2 HA
SC-8A
19.6 HA
SC-9
15.1 HA
SC-10A
28.8 HA
SC-10B
30.3 HA
SC-11
74.0 HA
SC-12
4.0 HA
CAMEO LAKE
UN-NAMED SOUTH WETLAND
STORM POND 3
AREA = 12.2 ha
INDUSTRIAL LANDS
RED DEER WEST
CATCHMENT DELINEATION AND STORMWATER SERVICING
LEGEND:
CATCHMENT BOUNDARY
PROPOSED STORM TRUNK
STORM POND / EXISTING DEPRESSIONS
CATCHMENT AREA
Red Deer

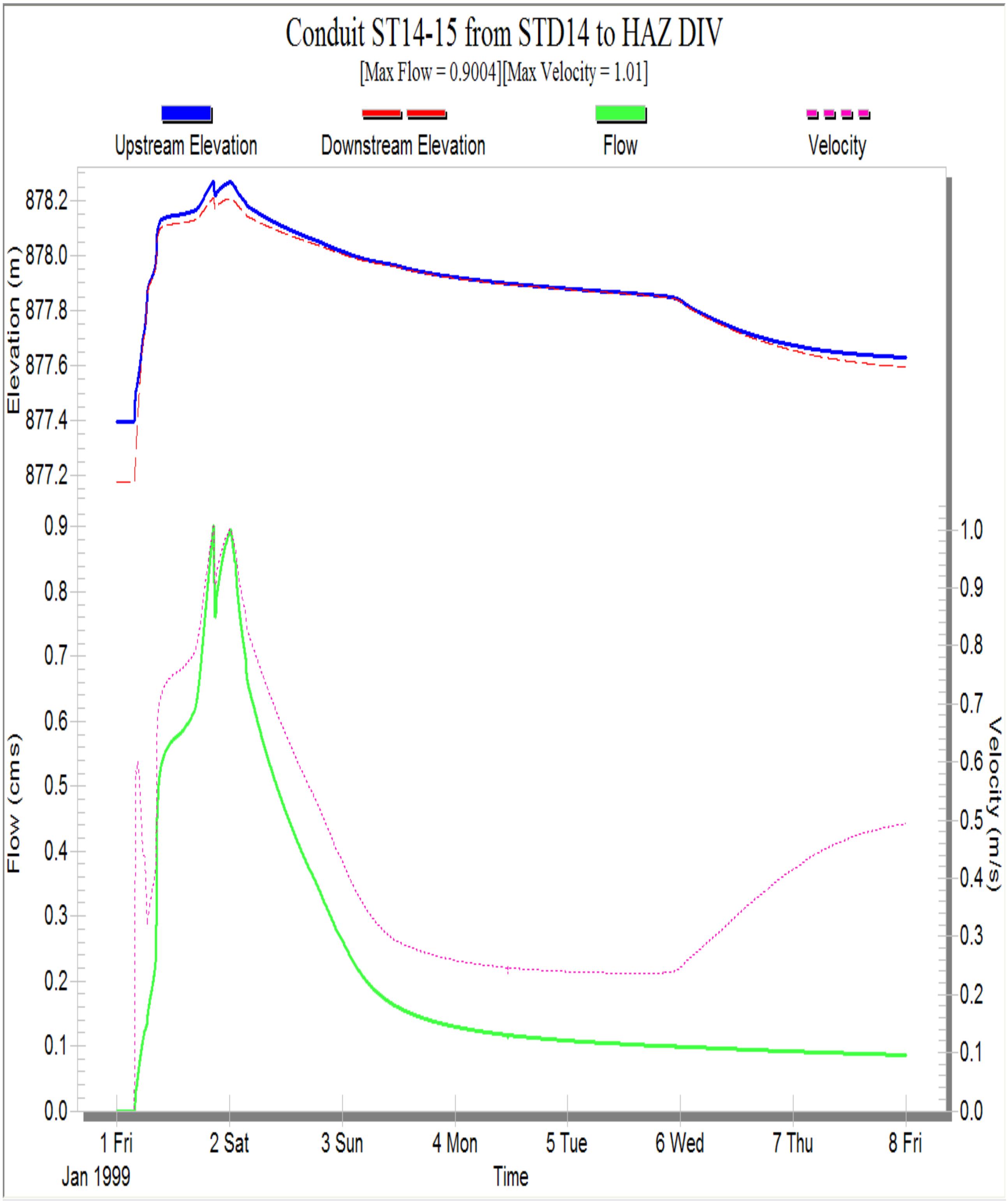

COPY
CITY OF RED DEER
Westhoff Engineering Resources, Inc.
HAZLETT LAKE
HAZLETT LAKE
CONTROL STRUCTURE
PLAN, SECTIONS AND DETAIL
PLAN
SECTION
SECTION
SECTION
NOTES:
LEGEND:

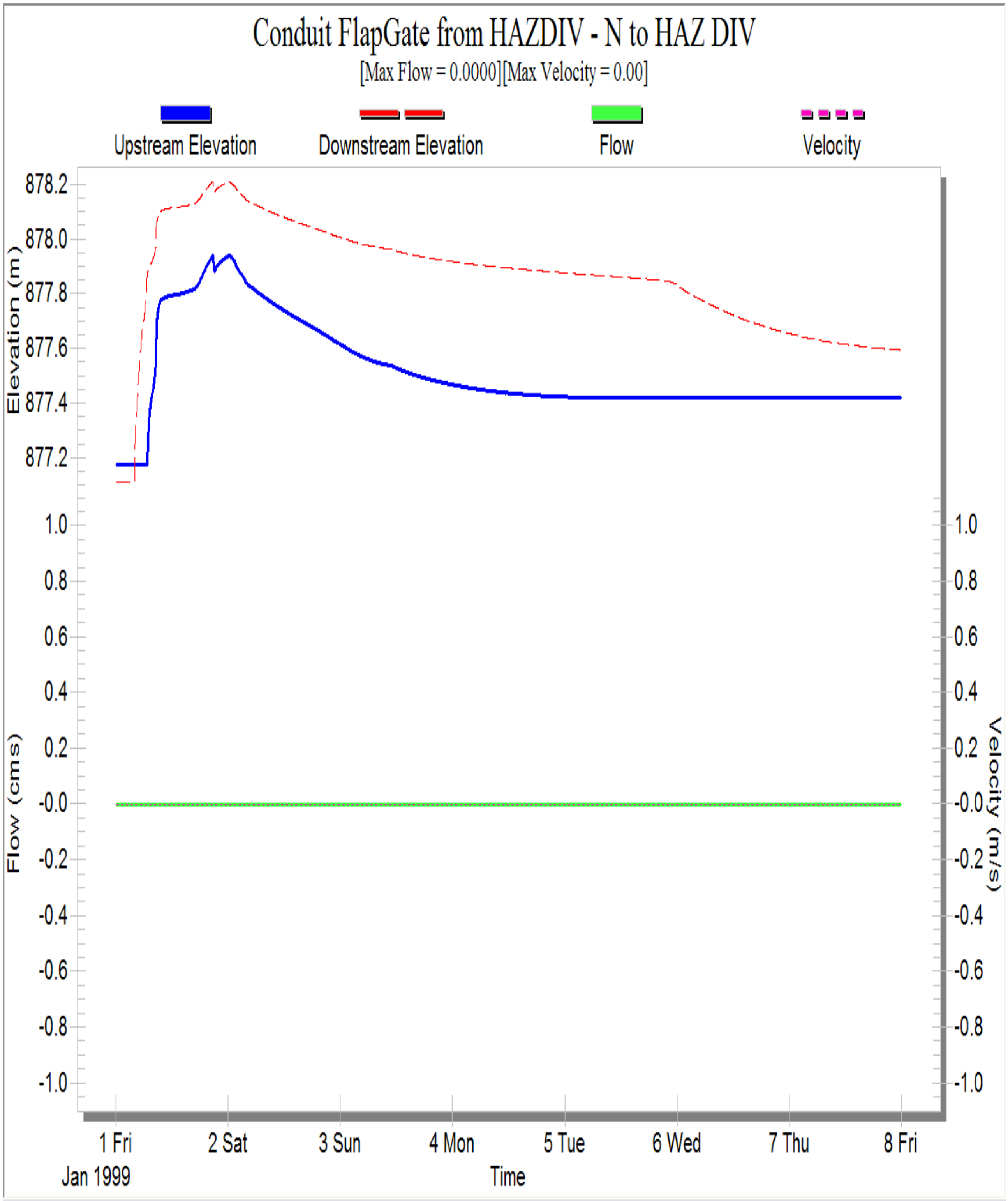
Results of 1:100 Year – 24 Hour Design Storm

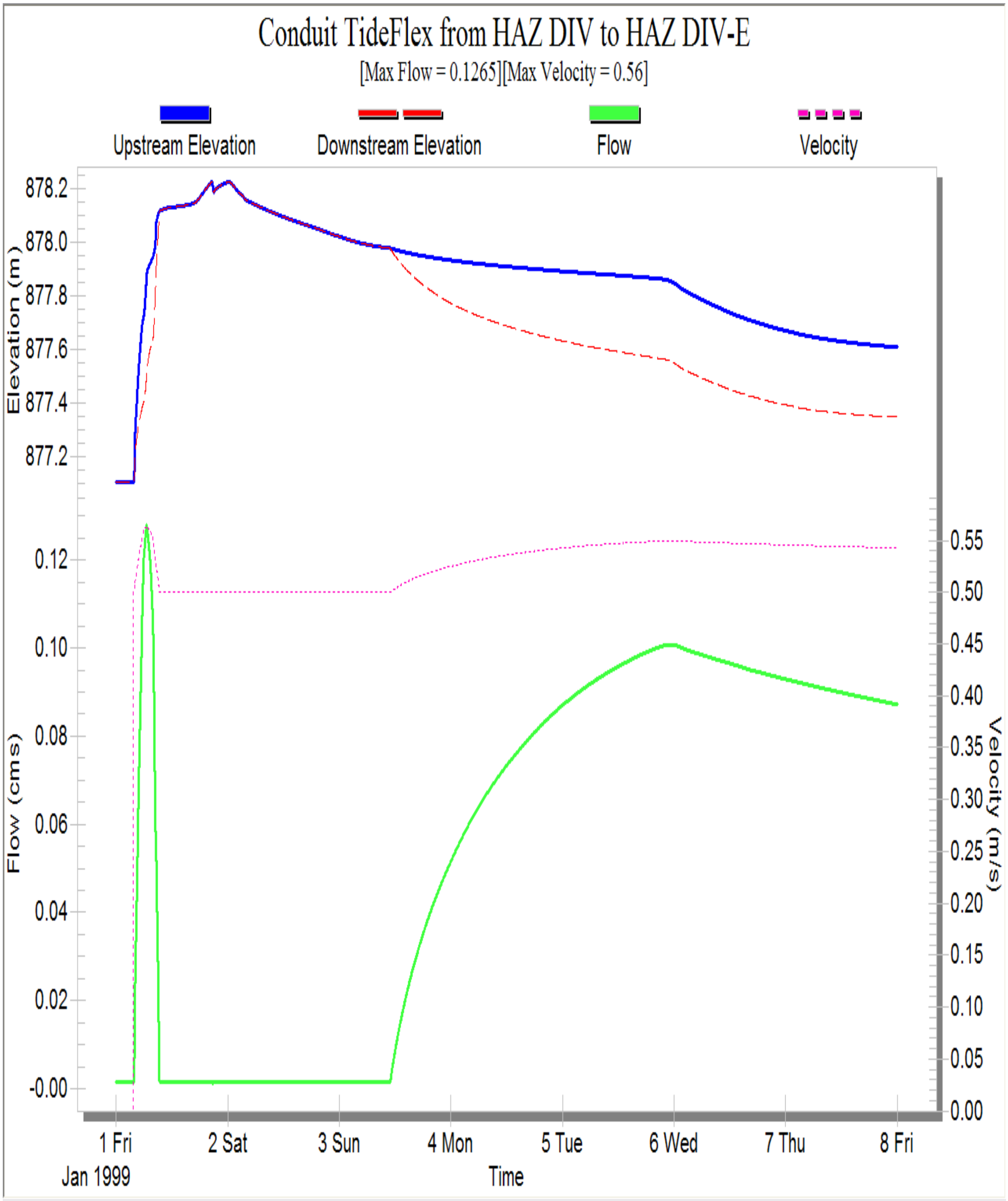

Node - Hazlett
[Max Stage = 877.418]
Stage (m)
877.40
877.35
877.30
877.25
877.20
1 Fri
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Jan 1999
Time

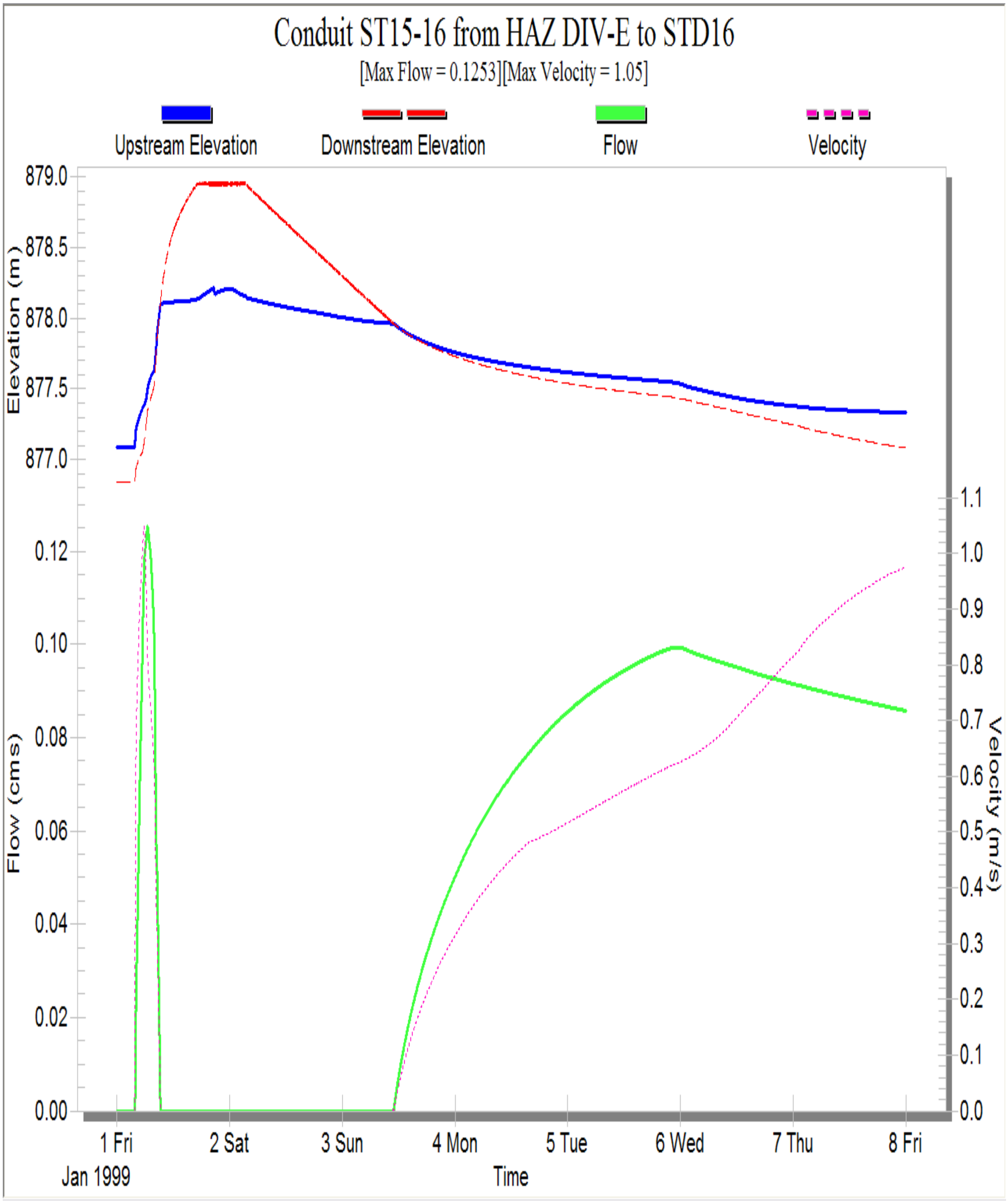

Node - Edgar
[Max Stage = 879.086]
Stage (m)
879.0
878.5
878.0
877.5
877.0
876.5
876.0
875.5
Crown Elevation = 876.46
1 Fri
Jan 1999
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Time


Conduit HAZ IN/OUT from HAZDIV - N to Hazlett
[Max Flow = 0.8991][Max Velocity = 1.12]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
877.8
877.6
877.4
877.2
Flow (cms)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Velocity (m/s)
1.0
0.8
0.6
0.4
0.2
0.0
1 Fri
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Jan 1999
Time

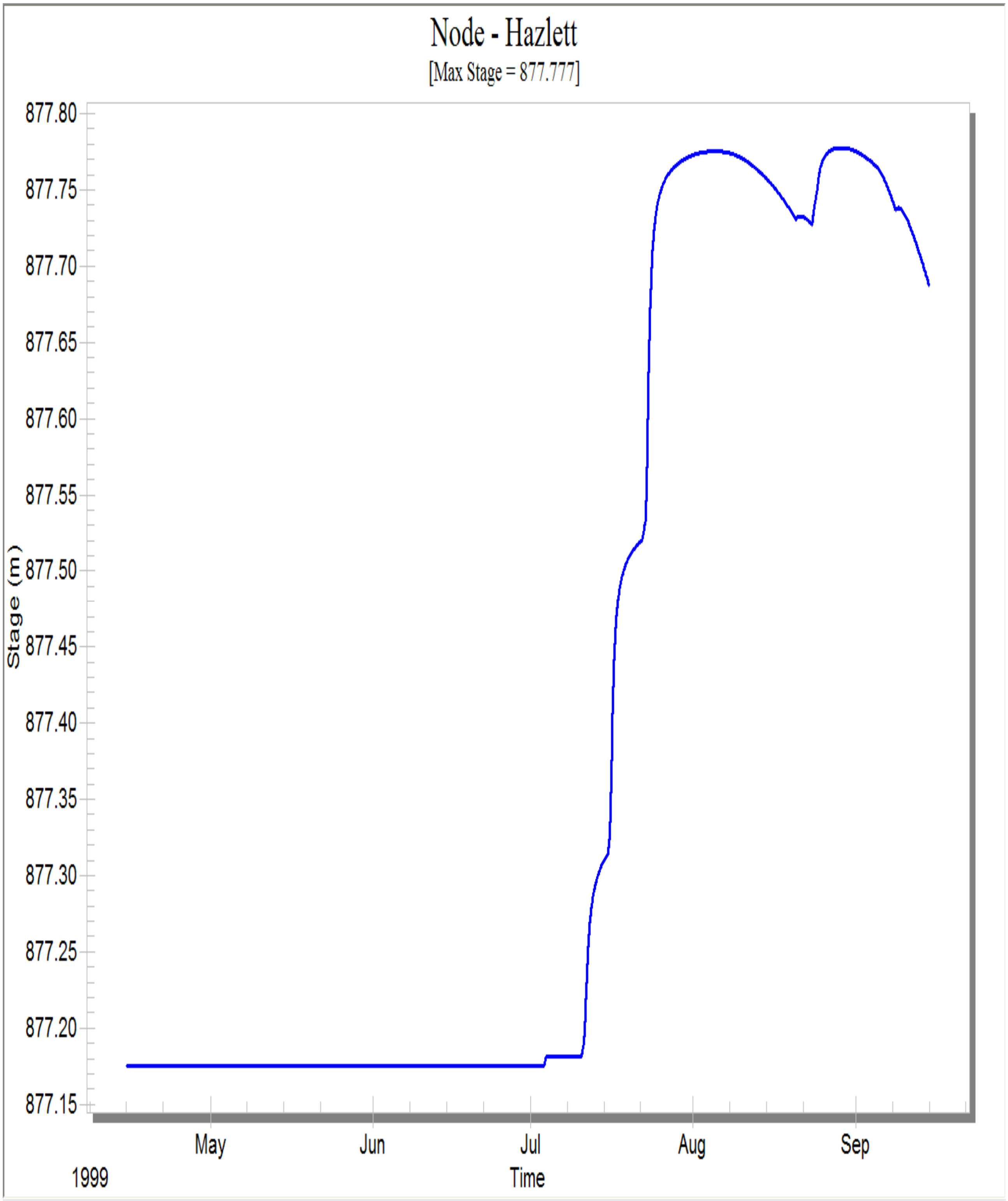

Conduit ST14-15 from STD14 to HAZ DIV
[Max Flow = 0.9004][Max Velocity = 1.01]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.2
878.0
877.8
877.6
877.4
877.2
Flow (cms)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Velocity (m/s)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 Fri
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Jan 1999
Time

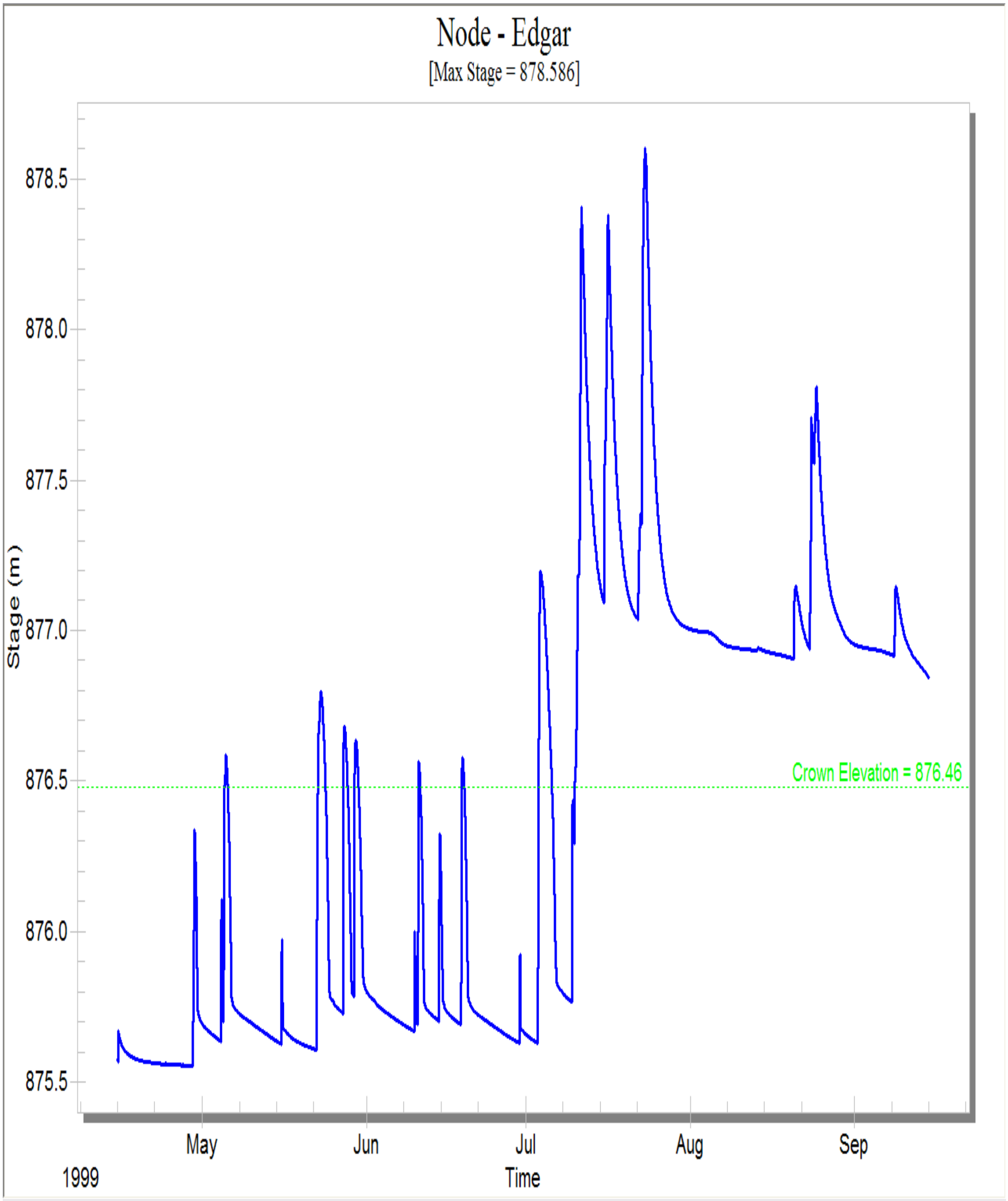

Conduit FlapGate from HAZDIV - N to HAZ DIV
[Max Flow = 0.0000][Max Velocity = 0.00]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.2
878.0
877.8
877.6
877.4
877.2
Flow (cms)
1.0
0.8
0.6
0.4
0.2
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Velocity (m/s)
1 Fri
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Jan 1999
Time

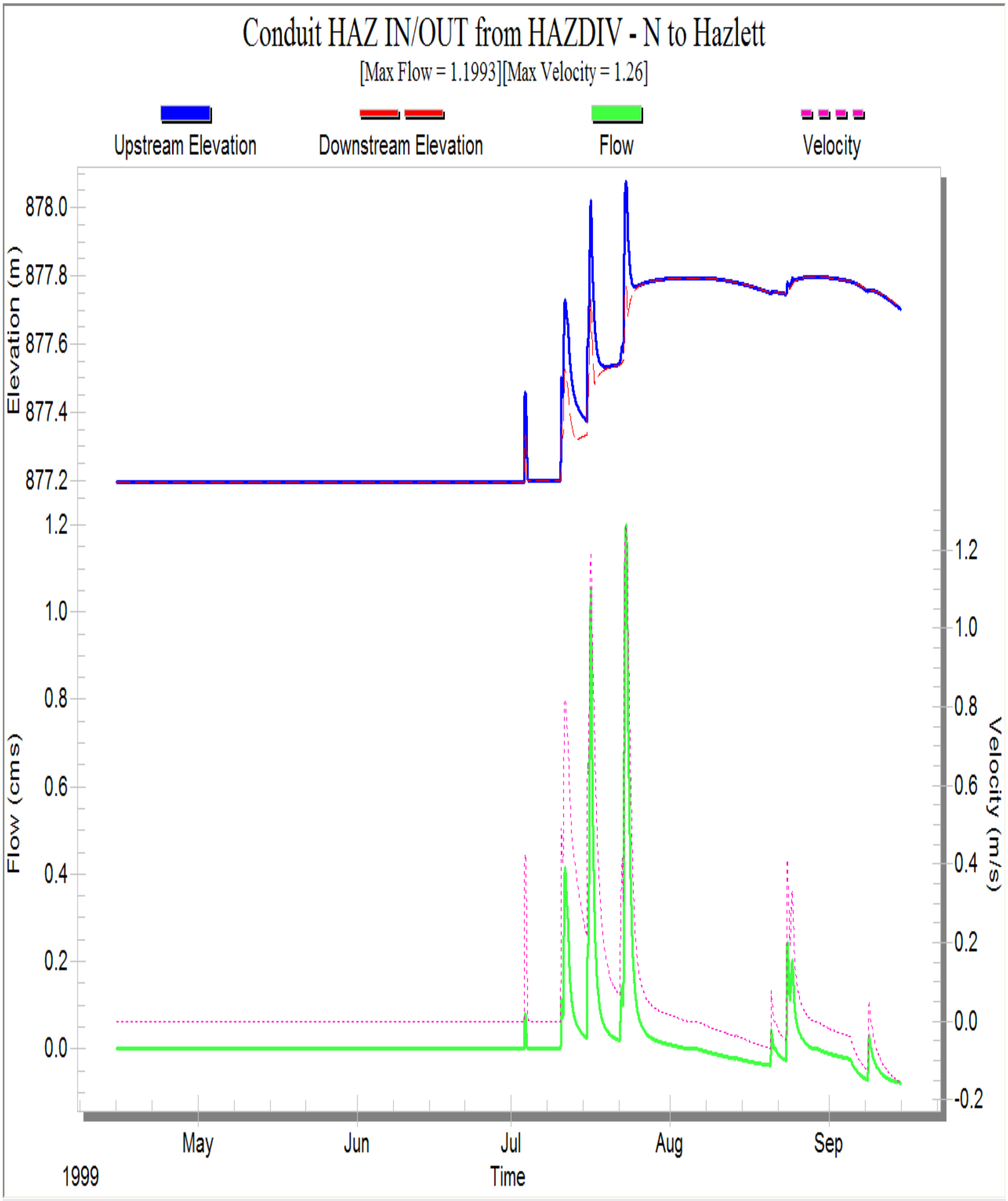

Conduit TideFlex from HAZ DIV to HAZ DIV-E
[Max Flow = 0.1265][Max Velocity = 0.56]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.2
878.0
877.8
877.6
877.4
877.2
Flow (cms)
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
Velocity (m/s)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 Fri
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Jan 1999
Time

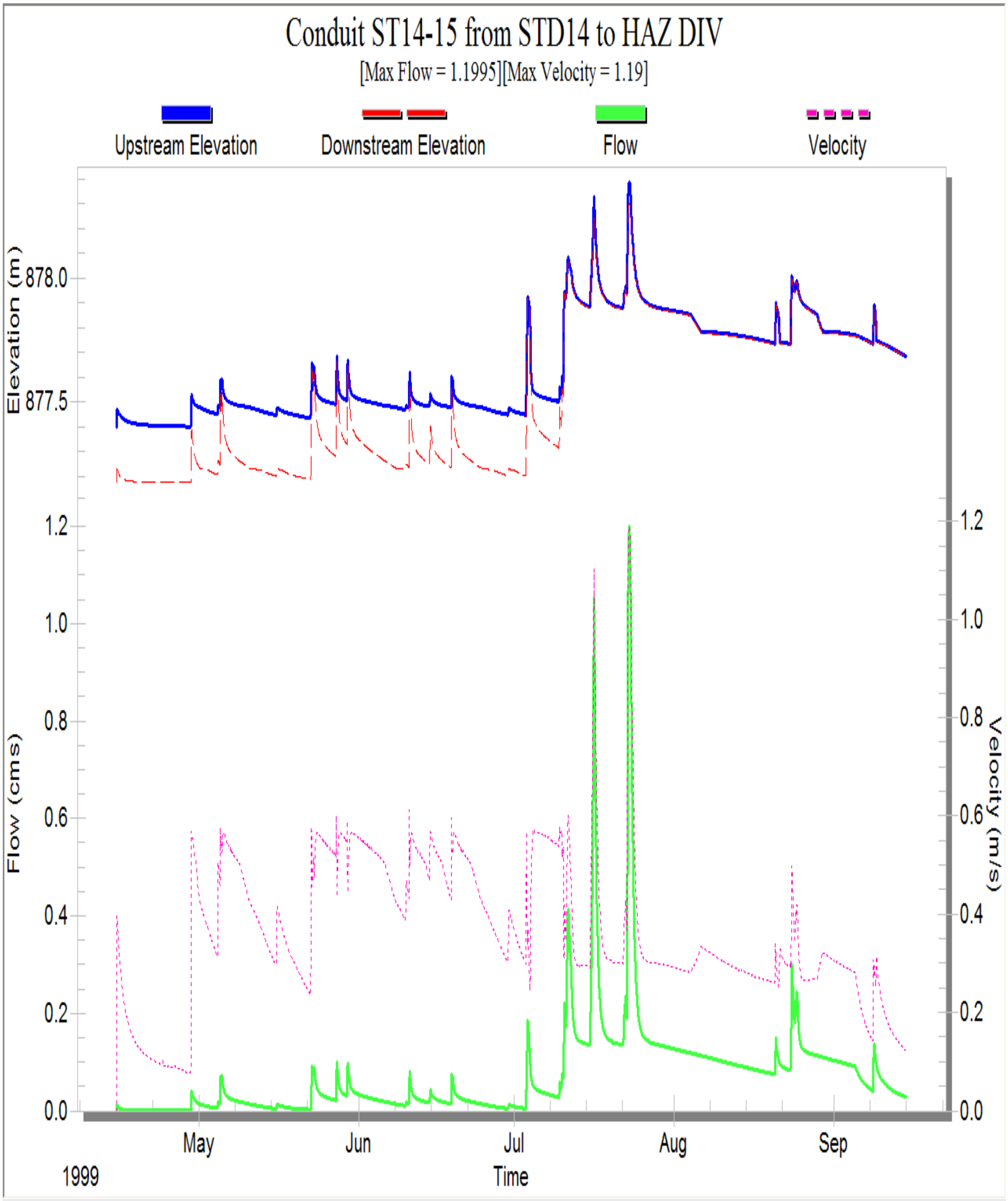

Conduit ST15-16 from HAZ DIV-E to STD16
[Max Flow = 0.1253][Max Velocity = 1.05]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
879.0
878.5
878.0
877.5
877.0
Flow (cms)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Velocity (m/s)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 Fri
2 Sat
3 Sun
4 Mon
5 Tue
6 Wed
7 Thu
8 Fri
Jan 1999
Time

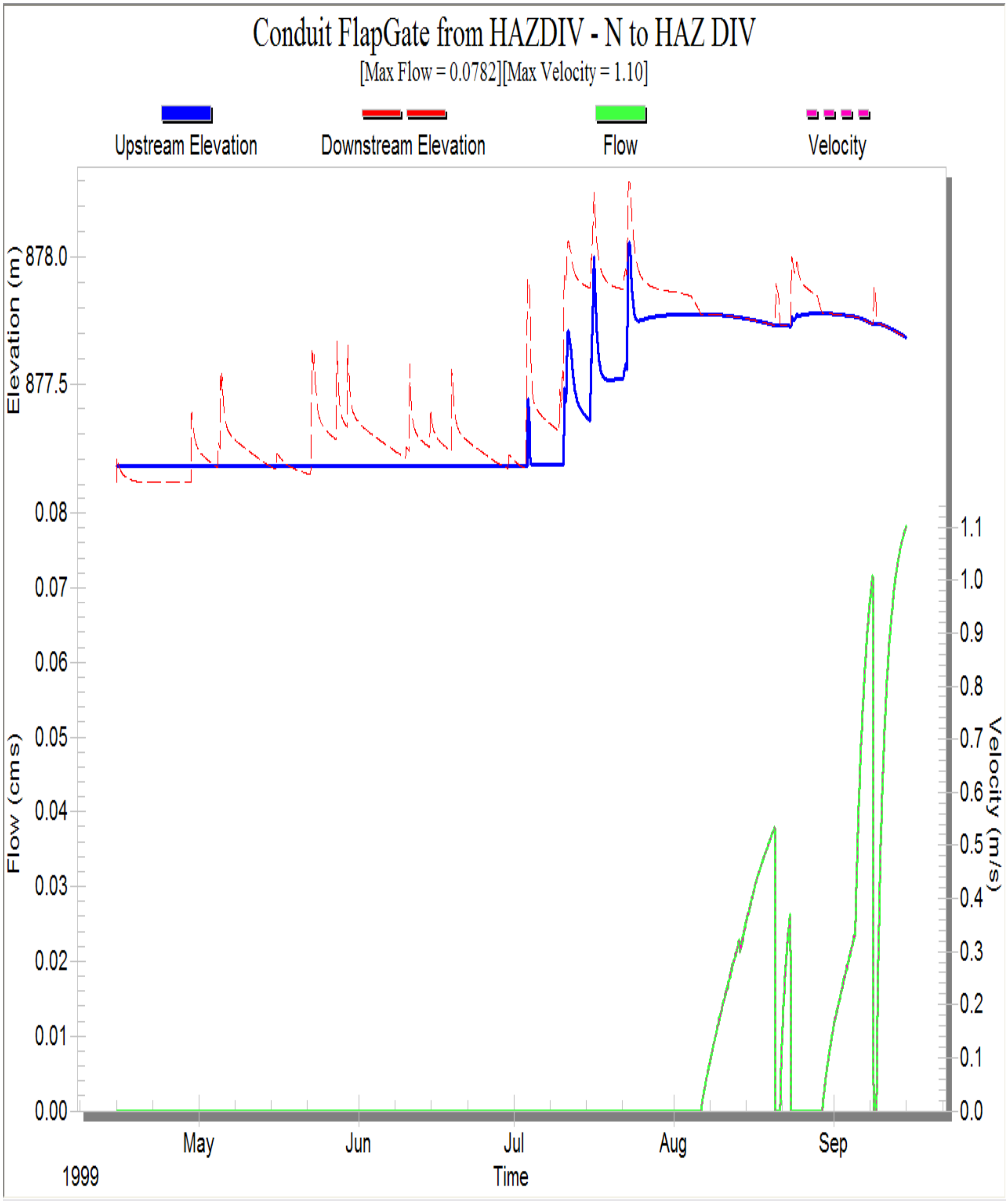
Results of Continuous Simulation – 1999 Design Storm (Wet Year)

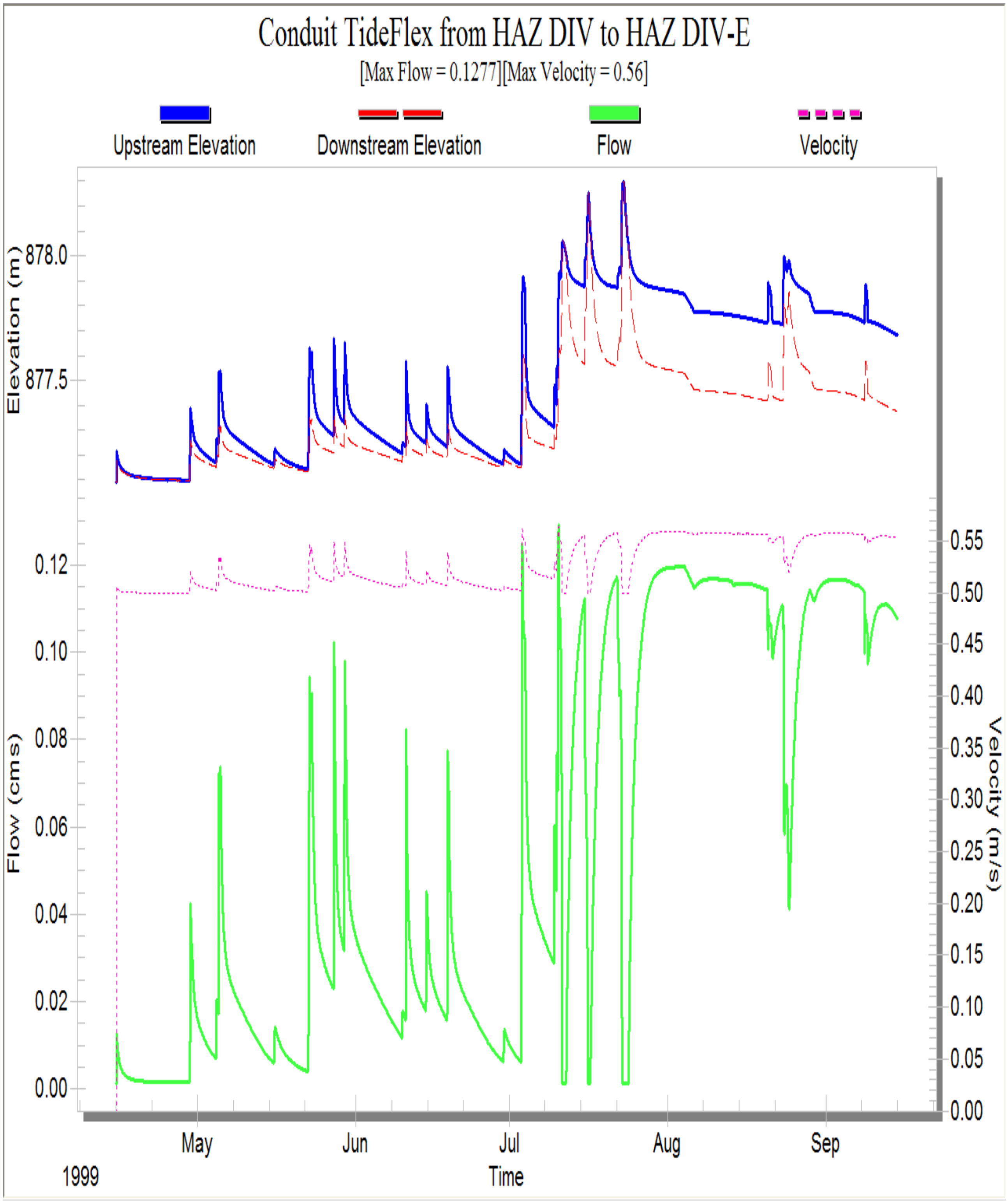

Node - Hazlett
[Max Stage = 877.777]
877.80
877.75
877.70
877.65
877.60
877.55
877.50
877.45
877.40
877.35
877.30
877.25
877.20
877.15
Stage (m)
May
Jun
Jul
Aug
Sep
1999
Time

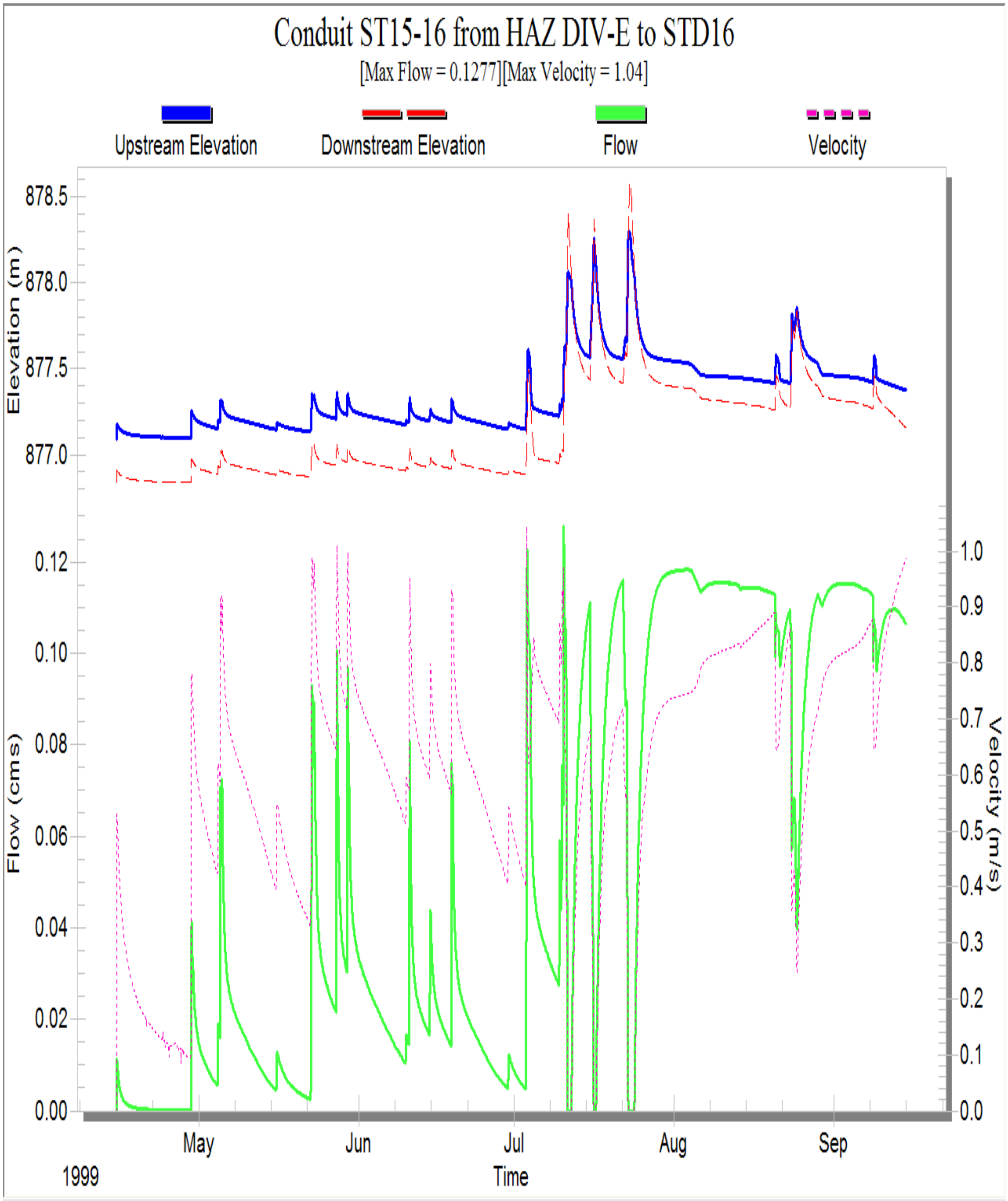

Node - Edgar
[Max Stage = 878.586]
Stage (m)
878.5
878.0
877.5
877.0
876.5
876.0
875.5
Crown Elevation = 876.46
May
Jun
Jul
Aug
Sep
1999
Time


Conduit HAZ IN/OUT from HAZDIV - N to Hazlett
[Max Flow = 1.1993][Max Velocity = 1.26]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.0
877.8
877.6
877.4
877.2
Flow (cms)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Velocity (m/s)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
May
Jun
Jul
Aug
Sep
1999
Time


Conduit ST14-15 from STD14 to HAZ DIV
[Max Flow = 1.1995][Max Velocity = 1.19]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.0
877.5
Flow (cms)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Velocity (m/s)
May
Jun
Jul
Aug
Sep
1999
Time


Conduit FlapGate from HAZDIV - N to HAZ DIV
[Max Flow = 0.0782][Max Velocity = 1.10]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.0
877.5
Flow (cms)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Velocity (m/s)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
May
Jun
Jul
Aug
Sep
1999
Time


Conduit TideFlex from HAZ DIV to HAZ DIV-E
[Max Flow = 0.1277][Max Velocity = 0.56]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.0
877.5
Flow (cms)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Velocity (m/s)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
May
Jun
Jul
Aug
Sep
1999
Time


Conduit ST15-16 from HAZ DIV-E to STD16
[Max Flow = 0.1277][Max Velocity = 1.04]
Upstream Elevation
Downstream Elevation
Flow
Velocity
Elevation (m)
878.5
878.0
877.5
877.0
Flow (cms)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Velocity (m/s)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
May
Jun
Jul
Aug
Sep
1999
Time

1.0 INTRODUCTION

1.1 General Background

Hazlett Lake is a prairie pothole wetland that is located just north of the City of Red Deer limits. It is a large wetland-lake system with a relatively small direct catchment area of about 268 ha in size, see Figure 1. The total watershed area, however, is considerably larger as another 91 ha west of Highway 2 drains into Hazlett Lake via the existing swales and culverts at the Highway 2 / Highway 11A interchange. In addition, spillover flows from an unnamed wetland further west make their way to Hazlett Lake as well. Prior to development of the Edgar Industrial Park subdivision south of Highway 11A spillover flows from an additional 209 ha drained north into Hazlett Lake.

A preliminary assessment of the area was conducted by Westhoff Engineering Resources, Inc. (Westhoff) in 2005. This assessment found Hazlett Lake to be environmentally significant in that it shows moderate to little disturbance and it consists of predominantly native vegetation. The lake has been classified as a Class V wetland according to the Stewart and Kantrud (1971) Wetland Classification Methodology.

Westhoff was subsequently retained by the City of Red Deer to compile existing information and undertake additional surveys of Hazlett Lake and develop adaptive monitoring and management strategies as part of a comprehensive lake management plan. In addition, a more detailed assessment of the hydrology of Hazlett Lake was carried out. This briefing is a compilation of the findings of all previous investigations.

1.2 Existing Conditions

The area surrounding Hazlett Lake is currently dominated by agricultural land uses. However, north of the lake is a large mixed stand of trees dominated by Balsam poplar (*Populus balsamifera*) and Trembling aspen (*Populus tremuloides*) (Kershaw et al., 1998). Another stand is located to the southwest of the lake. There are also several supporting wetlands found along the outer edges of the catchment to the southeast where Highway 2A and Highway 11A.

The riparian area and wetland consists of low prairie, wet meadow, shallow marsh and deep marsh as outlined below. Some of the non-native plant species that were found around the lake are: Curly dock (*Rumex crispus*), Canada thistle (*Cirsium arvense*), Smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*) and Perennial sow thistle (*Sonchus arvensis*) (Kershaw et al., 1998).

The deep marsh area is occupied by a species of yellow pond lily (*Nuphar spp*) and pondweed (*Potamogeton spp*). This band varies in width but forms almost a complete ring around the lake. The lilies that inhabit Hazlett Lake are of importance as they indicate the lake has remained relatively stable in its water level or the water levels have changed gradually over time. Water lilies are reported to be sensitive to fluctuations in water level. They prefer slow moving or even still water. They also require fresh, nutrient-rich water as well as water of enough depth to ensure the root tubers do not freeze during the winter. The clarity of the water is a limiting factor for this lily species (Lahring, 1993; Biodiversity Plants website, date unknown; B.C. Adventure, 2006; MSU, 2004).

It was reported that species such as American coots (*Fulica americana*), Canada Geese (*Branta canadensis*), Ring-billed gulls (*Larus delawarensis*), as well as other migratory waterfowl, utilize the lake throughout the year and during their migration south (Alsop, 2002; Moir, 2006). Other bird species that were observed around the lake were Black-capped chickadees (*Poecile atricapilla*), Dark-eyed Juncos (*Junco hyemalis*) and many different species of sparrows, which use the willows and poplar and aspen stands as shelter and feeding areas (Wilson, 2007; Wilson, 2007; Alsop, 2002). Some evidence of deer (*Odocoileus spp*.) and coyote (*Canus latrans*) were also noted (sightings of mule deer, scat, and tracks) (Sheldon, 1997).

1.2.1 Water Quantity

Little information exists about the historical fluctuations of Hazlett Lake except for historical airphotos and anecdotal evidence that the lake has spilled on several occasions in the past. The date, duration and spillover volumes of these events however are unknown.

In order to get an appreciation of the fluctuations in water level at Hazlett Lake, a water balance spreadsheet was developed by Westhoff of both Hazlett Lake and the “Unnamed Wetland to the West”, whose spillover flows make their way to Hazlett Lake. The water balance spreadsheet analysis is an enhancement of the well-known Qualhymo/QHM rainfall-runoff model; however, it is upgraded to reflect the variation in runoff conditions between cold weather and warm weather periods. It can therefore be adapted more closely to hydrological conditions in the Prairie Provinces, for which high water levels and high runoff potentials tend to occur in the spring, in part due to the snowmelt process and frozen soil conditions. During the warm months, a runoff volume generation procedure and soil moisture accounting system similar to the SCS/API method is applied to the pervious component of the catchments, while on impervious surfaces, the entire precipitation depth, less the assigned impervious area initial abstraction depth is presumed to run off. In essence, this method is an enhancement of the standard SCS runoff volume computation used in the Qualhymo/QHM model.

The water balance spreadsheet analyses are based on a daily timestep, using historical daily precipitation records at the Red Deer Airport as well as historical lake evaporation data published for Lacombe. Several methods were used to calibrate and validate the results of the water balance spreadsheet analyses. Median annual runoff volumes compared favourably to both the *Isopleths of Median Annual Unit Runoff* published by PFRA and the median annual runoff volume for the Battle River between Bluffton and Blackfalds. In addition, the variation in water level at the “Unnamed Wetland to the West”, see Figure 2, compared favourably to recorded variations in water level based on monitoring data by the City of Red Deer Parks Department. A minor seepage loss of only about 27 mm/month was introduced to mimic the recession curve of the recorded variations in water level.

Figure 3 compares computed water levels in Hazlett Lake with estimated water levels based on comparison of extent of coverage from historical airphotos with survey and bathymetry data for Hazlett Lake. Please note that the error in estimated water levels is likely in the order of about 0.20 m and 2 months. Based on Figure 3, one can deduct that historical fluctuations have been in the order of 1.0 metre, with most fluctuations in the order of 0.60 metre. The occurrence of spillover events was confirmed by the hydrologic analysis. Although the spreadsheet analysis assumes a major snowmelt event in early spring it is believed that the historical variations in water level have been relatively gradual, i.e., over the course of several weeks to months.

Similar to the "Unnamed Wetland to the West", a seepage loss of only about 19 mm/month was introduced to produce the water level curve of Figure 3.

1.2.2 Water Quality

Water and soil samples were obtained in the fall 2006 to gain an appreciation of existing water and soil quality. Water samples, only, were also taken in January 2007 in one location close to Mrs. Hazlett's residence. The lab results determined that both water and soil quality were generally within the surface water quality guidelines and soil quality guidelines set by Alberta Environment and The Canadian Council of the Ministers of Environment. The only exceptions were, in the soil, boron, and in the water, chromium, phosphorus, aluminum (fall 2006), and manganese, TDS, total phosphorus, aluminum and ammonia nitrogen (January 2007). The exact sources of these pollutants are uncertain, however, the agricultural activities in the surrounding catchment could be one possible source. How these contaminants as well as others affect the Hazlett Lake system is still unknown as the information that has been gathered only reveals a snap shot of the system and does not portray the system's processes over a space of time.

2.0 POTENTIAL IMPACTS

2.1 Hydrology

Hydrology is the most important parameter that influences wetlands (Zedler and Leach, 1998; Mitsch and Gosselink, 1993). Urbanization, including stormwater runoff and drainage from the surrounding watershed, can lead to changes in the hydrologic cycle (Guntenspergen and Dunn, 1998; Stormwater management, Alberta Environment, 1999). Peak flows, flow volumes and changes in water quality can result from changes in runoff (Stormwater management, Alberta Environment, 1999). These factors can ultimately threaten the ecological sustainability of wetland systems (Guntenspergen and Dunn, 1998).

Changes in a wetland's hydrology can dramatically impact the wetland's physical condition such as its depth, duration and frequency of inundation. This can happen very quickly and can be quite severe. Increases in surface runoff can subsequently increase the velocity of the inflow into the wetland. This increase in flow can disturb wetland biota as well as scour the wetland substrate. Increases in runoff can alter water level response time, depths and the retention time of water in the wetland (Reinelt et al., 1998).

2.2 Wildlife and Vegetation

Changes to the hydrology of a wetland system, the degradation of vegetation, habitat and habitat corridors, food resources, shelter and breeding and nesting sites can all have a detrimental impact on wildlife. There are many causes that directly or indirectly impact wildlife.

2.3 Nutrients

Introduction of excessive amounts of nutrients or eutrophication can have an indirect impact on wetland bird communities by way of altering the vegetation community structure as well as the availability of food. In some cases, a moderate increase in the amount of nutrients entering the system can actually be beneficial to the waterfowl because it can cause an increase in the growth of submersed macrophytes that some duck species require for food as well as supporting some forms of aquatic insects that other bird species eat (Adamus et al., 2001).

Increased algal growth is one concern as a result of the excessive nutrient input into the system. This increase in the growth of algae can lead to the death of many species of fish and other aquatic organisms as well as decrease macrophyte growth which ultimately decreases available food sources (Adamus et al., 2001 Murkin et al., 1991). Oxygen depletion is another consequence of increased algal growth, which can be very detrimental and in some cases lethal to aquatic organisms (Adamus et al., 2001).

2.4 Sedimentation

Sedimentation is a natural process in wetland systems. However, increased rates of sedimentation can be harmful to the system. Sedimentation can alter habitat, kill submerged vegetation and alter the abundance and availability of food which in turn can affect birds (Admaus et al., 2001). Many species of invertebrates found in wetlands are tolerant of occasional sedimentation; however, more severe sedimentation can cause major changes to the invertebrate community (Adamus et al., 2001). The process of sedimentation can be the source of sediment born pollutants that can have negative affects on vegetation, invertebrates, and wildlife. Sedimentation can also cause changes in the community structure of wetland plant communities by changing the available suitable habitat.

2.5 Inundation or Dehydration

Hydrological manipulation of wetlands has been found to cause a decline in many species of wetland birds (David, 1994; DeAngelis et al., 1997). Draining wetlands reduces the areas available for nesting and brooding and can expose nests to increased predation due to the reduction in vegetation cover and density. Inundation during nesting periods can result in the mortality of eggs and young of many waterfowl species (U.S.E.P.A., 1993; Rotella, and Ratti, 1992a, b).

Wetland invertebrate communities experience dramatic changes when wetlands that seldom experience surface water begin to have input from pools and channels that were not connected to it previously or when wetlands that normally do not experience periods of complete dryness suddenly are subject to drought or drawdowns (Eyre, 1992). Variations in composition and richness of plant communities are influenced not only by the topography of the area but by the frequency of saturation and the rate of water level fluctuation (Adamus et al., 2001). Inundation of soils that were not previously inundated can result in physical, chemical and biological processes taking place that can alter the soil's capacity to support plant growth (Kozlowski, 1997).

2.6 Stormwater Management Analyses

In view of the shortage in serviced industrial lands in the Red Deer, the City of Red Deer wishes to move forward with six quarter sections of land southwest of the Highway 2 / Highway 11A Interchange, see Figure 4. These lands are envisioned to be serviced by a local storm sewer system draining into a series of wet ponds and constructed stormwater wetlands as illustrated on Figure 4. These ponds and stormwater wetlands, in turn, are to drain into a storm sewer trunk running east along Highway 11A. In the near future when the lands around Hazlett Lake will be developed this storm sewer trunk will be extended to the Red Deer River. Until that time, however, it is proposed to tie this storm sewer trunk into the existing storm sewer system servicing Edgar Industrial Park. Given the limited capacity of the existing storm sewer system, an overflow into Hazlett Lake is proposed for extreme events.

The performance of the drainage system was examined with the XP-SWMM simulation model, a sophisticated rainfall-runoff model that allows for the hydraulic analysis of the backwater, surcharge and reverse flow conditions that are expected in the drainage system. In addition, the performance can be analyzed for both extreme conditions such as a 24 hour, 1:100 year event and long-term operation for e.g. dry, normal or wet years. The following paragraphs describe the findings of a preliminary analysis for two scenarios, (1) discharge from the lands west of Highway 2 at the ultimate permissible unit area discharge rate of 4 L/s/ha, and (2) a reduced discharge from the lands west of Highway 2.

2.6.1 Discharge at 4.0 L/s/ha

Because the capacity of the tie-in to the Edgar Industrial Park storm sewer system at about 145 L/s is an order of magnitude smaller than the 1.623 m^3/s design flow from the lands west of Highway 2, it is expected that most storm events would result in an overflow to Hazlett Lake. In fact, it appears that a flow reversal occurs from the Edgar Industrial Park storm sewer system into Hazlett Lake reflecting the overall higher elevation of Edgar Industrial Park, see Figure 5A for a 24 hour, 1:100 year event. A flap gate would have to be provided if this flow reversal were considered unacceptable.

From a hydraulic perspective, this scenario is inefficient because the storage provisions west of Highway 2 have little bearing on the amount of water diverted to Hazlett Lake.

Figure 5B illustrates the fluctuation in water levels at Hazlett Lake for the wet year 1999 based on continuous simulation. As expected, most storm events result in a diversion to Hazlett Lake. In addition, a significant volume of water, i.e., about 240,000 m^3 or 18% of all runoff generated during the summer of 1999 would spill over at the northeast corner of Hazlett Lake. A similar response at Hazlett Lake is seen for the 24 hour, 1:100 year event, see Figure 5C. As shown in Figure 5C, Hazlett Lake would take about five weeks to drain down to the assumed normal water level of 877.60 m. Please note that this normal water level can be adjusted if so desired.

2.6.2 Discharge at Reduced Rate

In order to reduce the impacts of the stormwater flows on Hazlett Lake and improve the efficiency of the drainage system, a second scenario was investigated where the discharge from the lands west of Highway 2 was reduced to the capacity of the tie-in to the Edgar Industrial Park for most events. The additional storage requirements in the lands west of Highway 2 were incorporated by allowing an additional 0.50 m rise in water level for extreme conditions. The permissible unit area discharge rate from these lands was thus reduced to 0.36 L/s/ha up to the original design High Water Level in the wet ponds and constructed wetlands; in case of extreme events the permissible unit area discharge rate would increase to 4.0 L/s/ha for when the water level would exceed the original design High Water Level.

Whereas a flow reversal from the Edgar Industrial park storm sewer system into Hazlett Lake would still occur for extreme runoff events, see Figure 6A, the total volume diverted to Hazlett Lake is significantly reduced. As illustrated in Figures 6B and 6C, no overflow would occur from Hazlett Lake during either the wet year 1999 or during a 24 hour, 1:100 year event. As a result, the system has a greater capability to change the normal water level in Hazlett Lake if so desired.

This scenario is considerably more efficient than the first scenario because stormwater would typically not have to be stored twice, i.e., once within the wet ponds and constructed stormwater wetlands west of Highway 2 and another time in Hazlett Lake. The added benefits are the level of stormwater treatment in the wet ponds and constructed stormwater wetlands west of Highway 2 is considerably greater because of the longer detention times. As a result, it is expected that the potential contaminant loadings from the urbanized areas to Hazlett Lake would be significantly reduced, (a) because of the reduced volumes diverted to Hazlett Lake and (b) because of the increased level of treatment west of Highway 2. A secondary benefit is that most runoff events in late summer and fall, when vegetation in the constructed stormwater wetlands starts to die off and phosphorus might be discharged, do not result in diversions into Hazlett Lake. Similarly, runoff events during the winter months when runoff might be contaminated with chlorides would be allowed to bypass Hazlett Lake as well.

Please note that different scenarios can be further examined, if so desired. For example, the integration of Hazlett Lake in an urban setting shall require a plan that searches for a balance between the functionality of the system and the urban encroachment.

3.0 POTENTIAL CONSIDERATIONS FOR MITIGATION

3.1 Nutrient overloading and Algal growth

Algal blooms are just one of many problems that can be associated with excessive nutrient input. Algal blooms are also one contributing factor to other problems in wetlands such as reduced dissolved oxygen levels, and turbidity. In order to control the growth of algae it is imperative that the quality of water entering the system is known and the cycling process of nutrients in the wetland system are understood (Holdern et al., 2001).

Algae need both light and nutrients in order to grow. In order to control algae you need to control these parameters either physically, chemically or biologically. Shading of the algal blooms through turbidity, plants or even the algal growth itself are just a few of the ways that the light reaching the algae can be controlled. Often limiting the abundance of essential nutrients such as phosphorus is a way to control the nutrient input into algae growth. There are many other ways to control the amount of light reaching the algae. Some examples are dyes, artificial circulation, as well as selective planting. Some techniques to reduce nutrient input are aeration, dilution and flushing, drawdown, dredging, phosphorus inactivation and selective withdrawal.

3.2 Sedimentation

Sediment entering a system can come from a number of sources such as erosion, construction, shoreline collapse, and urban drainage. Increases in the build up sediment can cause decreases in the volume of wetlands as well as an increase in shallow areas found there in (Holdern et al., 2001). Increases in shallow areas can cause a subsequent increase in the amount of nuisance vegetation growing in the wetland. Inputs of sediment can also carry nutrients that may trigger the growth of algae. This can lead to more anoxic conditions as dissolved oxygen levels decrease, not to mention the possibility of releasing toxins and pathogens into the water column that potentially could be carried in with the sediment.

It is important to try and deal with any sedimentation issues prior to it entering the wetland system in question. But even such measures may not ensure that the water entering the system is free of such problems. One solution is to either introduce a detention pond, such as the wet ponds and constructed stormwater wetlands in the lands west of Highway 2, prior to the water entering the natural area or reserve a portion of the wetland as a detention area that will allow settling to occur. Maintenance of this area will need to be conducted, of course, so that the pond does not fill in entirely. This forebay area will have to be quite large in order to trap some of the finer particles before the water is allowed to enter the rest of the wetland. However, as this is more of a preventative measure and not a restorative one, partitioning off part of the wetland or lake may not be entirely acceptable to all involved.

3.3 Alternative Nesting Areas

To help to mitigate the potential loss of some nesting sights for different species of birds there are some alternative or artificial nests that can be constructed at different areas around Hazlett Lake that these birds can utilize. Some examples of alternative nesting areas are nesting boxes, floating nests/floating docks, post nest structures, and constructed islands.

4.0 OTHER MITIGATION MEASURES

Stormwater management in Canada is a relatively young science that is still evolving. Whereas, in the past, it was solely the responsibility of a select group of engineers, it has now increasingly become clear that a multi-disciplinary approach is required that could involve engineers, planners, landscape architects, terrestrial and aquatic biologists, water chemists, architects, etc., depending on the location and complexity of the drainage system.

The limitations of conventional stormwater design and 'end-of-pipe' treatment facilities can be overcome by introducing, adding or enhancing pollution prevention strategies in stormwater system design. Pollution prevention strategies include low-impact development practices, stormwater BMPs, erosion and sediment control programs, stormwater harvesting and reuse, retrofits, and educational programs.

Ultimately, the type and extent of BMPs and source controls to be implemented depends on the value that society places on the water resources in the Red Deer area. When selecting and designing any form of stormwater BMP, there is an important need to incorporate both water quantity and quality concerns (Stormwater Management, Alberta Environment, 1999; WER 103-17, BMP and Source Control manual – Draft, 2005; USEPA, 1996; UD&FCD, 2005; Minnesota, 2005).

5.0 MONITORING PROGRAM

Monitoring of a system, in relation to stormwater, should occur "if a municipal water supply, recreational area or particularly sensitive biological resource is likely to be affected" (Stormwater Management, Alberta Environment, 1999). Monitoring of Hazlett Lake and its processes is very important especially in an attempt to try and sustain this particular wetland community and to ensure that the wetland does not fill up with sediment over time, reverting to a shallower wetland dominated by cattails. It is suggested that water sampling, soil sampling, vegetation mapping, wildlife observations and depth profiles be conducted in addition to taking photographs. Monitoring these components will allow us to know whether the BMPs that were put in place are working properly. It will also alert us to any potential problems that may arise during construction and after construction is complete.

5.1 Photo Reference Points

A key component of any monitoring program is visual evidence of the area in question. Photographs are a good way to gain this type evidence. As part of a monitoring program for Hazlett Lake it is suggested that photographs be taken to capture the lake at different times of the year as well as year to year in order to map out any changes to the lake that could be attributed to the introduction of stormwater to the system.

It is also suggested that colour air photos be taken a few times a year to gain an aerial perspective of the possible changes to the lake system. The air photos can be used to map out any changes in vegetation composition as well as any changes in water level and shoreline definition. Using a combination of photo reference points and colour air photos will help to establish the lake's response to the introduction of stormwater into its system. It will also show any changes to the vegetation communities that are currently present as well as any other potential impacts to the system.

5.2 Water Quality, Depth and Soil Quality

Water samples, depth and soil samples should be taken from the middle of each of the three lobes of the lake, the stormwater pipe inlet, the seasonal stream inlet and the outlet. The water samples should be tested for levels of pH, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), all forms of nitrogen, total phosphorus, and total metals (Holdern et al., 2001). Soil samples should be taken using a grab sampler or an auger from each of the locations stated above, but at a shallower water depth and after the water samples have been taken. The soil samples can be used to monitor changes in the soil composition, concentrations of metals, nutrients and other pollutants. These locations should also be marked to allow for sampling to occur at the same location each time.

5.3 Vegetation Changes

To assess changes in vegetation composition and range, transects should be established in a somewhat radial pattern around the lake. Each transect should be subdivided into plot sites located at even intervals along the transect line (Adamus et al., 2001). The start of each transect should be located in the upland areas and travel towards an area of open water. The starting location should be marked using a stake and a GPS and the direction traveled should also be noted for future inventories. Notes should be taken on the width and composition of vegetation zones and the presence of open water.

Sampling, photographs and mapping should be done within the same time period and as close together as possible to get a more accurate presentation of the lake's characteristics at that time. Monitoring should occur at least a few times a year initially and perhaps reduced to once or twice a year after a certain period of time following the implementation of the stormwater pipe.

6.0 CONCLUSIONS

Class V wetlands, along with all other wetland classes, are very complex systems. It is very difficult to predict how they will react to changes to their system and surrounding area (Tourbier and Westmacott, 1992). It is apparent in the historical air photographs that Hazlett Lake has changed in water level over the past five decades. This observation makes us aware to the fact that Hazlett Lake perhaps is more sensitive to changes in inflowing water than perhaps was initially thought.

There is a definite need to conduct further investigations and studies as the wetland functions and how it will react to changes in land use and to human influence are still not fully understood. That is why it is recommended that some more detailed investigations into Hazlett Lake should be undertaken such as rare plant surveys and a more detailed wildlife survey; hydrogeology study to determine the characteristics of groundwater in the area, especially closer to the lake; and an assessment of the potential impacts to the downstream system as a result of diverting stormwater into Hazlett Lake. Once these investigations have been completed, an adaptive management plan needs to be developed that is specific to the site, the changing land use and the invested interests involved.

A monitoring program should be incorporated in to the adaptive management plan that would comment on the conditions of Hazlett Lake on a yearly basis. The monitoring program should be implemented for a period of time no shorter than 3 years and should be adjusted according to any new changes in the surrounding catchment or changes in the functionality and sustainability of the lake itself.

7.0 REFERENCES

Adamus, P., T.J. Danielson, and A. Gonyaw. 2001. Indicators of Monitoring Biological Integrity of Inland, Freshwater Wetlands. A Survey of North American Technical Literature (1990-2000). U.S. Environmental Protection Agency. Office of Water. Wetland Division. Washington, D.C. http://www.epa.gov/owow/wetlands/bawwg/monindicators.pdf

Agriculture, Food and Rural Development, 2005-2006. http://www2.agric.gov.ab.ca/icons/acis/agricultural_land_resource_atlas_of_alberta Governmental of Alberta.

Agriculture, Food and Rural Development. Irrigation Branch. Unknown Date. Agricultural Impacts on Surface Water Quality in the Irrigated Areas of Alberta. Government of Alberta.

Alberta Environment Protection. Environmental Protection and Enhancement Act.

Alberta Environment Protection. 1999. Stormwater Management Guidelines for Alberta. Municipal Program Development Branch. Environmental Sciences Division. Environmental Service. Edmonton, Alberta.

Alberta Environment Protection. 1999. Water Act.

Alberta Environment Protection. 1993. Wetland Policy – Wetland Management in the Settled Area of Alberta.

Alberta Sustainable Resources Development. Public Lands Act.

Alsop, F.J. 2002. Birds of Canada. Dorling Kindersley Handbooks. Doling Kindersley Limited. Toronto, Ontario.

B.C. Adventure. 2006. Yellow Water lily. Interactive Broadcasting Corporation. http://www.bcadventure.com/adventure/wilderness/wildflowers/yellow.htm

Bellrose, F.C., 1976. *Ducks, geese & swans of North America*--3rd ed. (1980). The Stackpole Co., Harrisburg, Pa., & Wildl. Manage. Inst., Washington, D.C. 540 p.

Biodiversity Plants. Unknown. The Water Lily Family (Nymphaeceae). http://www.naturegrid.org.uk/biodiversity/plants/fplily.html

Bow Point Nursery Ltd. 2006. Nursery Tour.

Cornell Lab of Ornithology. 2003. All About Birds. www.**birds**.cornell.edu/**All**About**Birds**

David, P.G. 1994. The effects of regulating Lake Okeechobee water levels on flora and fauna. Lake and Reservoir Management. 9(2): 67.

DeAngelis, D.L., W.F. Loftus, J.C. Trexler and R.E. Ulanowcz. 1997. Modeling fish dynamics and effects of stress in a hydrologically pulsed ecosystem. Journal of Aquatic Ecosystem Stress and Recovery. 6(1): 1-13.

Department of Fisheries and Oceans Canada (DFO). Fisheries Act.

Environment Canada. 1992. Environmental Assessment Act.

Environment Canada. 1994. Migratory Birds Act.

Eyre, M.D. 1992. The effects of varying site-water duration on the distribution of water beetle assemblages, adults and larvae (Coleoptera: Haliplidae, Dytiscidae, Hydrophilidae). Arch. Hydrobiol. 124(3): 281-291.

Guntenspergen, G.R. and C.P. Dunn. 1998. Introduction: Long-term ecological sustainability of wetlands in urbanizing landscapes. Urban Ecosystems. 2: 187-188.

Holdern, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. North American Lake Management Society and Terrene Institute, in cooperation with the Office of Water, Assessment and Watershed Protection Division of U.S. Environmental Protection Agency, Madison, Wisconsin.

Kershaw, L., A. MacKinnon, and J. Pojar. 1998. Plants of the Rocky Mountains. Lone Pine Field Guide. Lone Pine Publishing. Edmonton, Alberta.

Kozlowski, T.T. 1997. Responses of woody plants to flooding and salinity. Tree Physiology Monograph No. 1 Heron Publishing – Victoria, Canada

Lahring, H. 2003. Water and Wetland Plants of the Prairie Provinces. Canadian Plains Research Centre. University of Regina.

McComas, S. 1993. Lake Smarts. Terrene Institute, Alexandra, VA.

McGillivray, W.B. and G.P. Semenchuk. 1998. Field Guide to Alberta Birds. Federation of Alberta Naturalists. Edmonton, Alberta.

Mississippi State University Extension Service. 2004. Yellow Water Lily: Description. http://msucares.com/wildfish/fisheries/farmpond/veg/yelllily.html

Mitsch, W.J., and J.G. Gosselink. 1993. Wetlands: Second Edition. Van Nostrand Reinhold, New York.

Moir. G. 2006. Hazlett Lake Inventory – Draft. City of Red Deer parks.

Murkin, H.G., J.A. Kadlec and E.J. Murkin. 1991. Effects of prolonged flooding on nektonic invertebrates in small diked marshes. Canadian Journal of Fisheries and Aquatic Sciences 48: 2155-3264.

Pisces Environmental Consulting Services Ltd. 2006. Assessment of the Fisheries Habitat Potential of Hazlett Lake.

Reinelt, L., R. Horner, and A. Azous. 1998. Impacts of urbanization on palustrine (depressional freshwater) wetlands – research and management in the Puget Sound Region. Urban Ecosystems. 2: 219-236.

Rotella, J.J., and J.T. Ratti. 1992a. Mallard brood movements and wetland selection in southwestern Manitoba. Journal of Wildlife Management. 56: 508-515.

Rotella, J.J. and J.T. Ratti. 1992b. Mallard brood survival and wetland habitat conditions in southwestern Manitoba. Journal of Wildlife Management. 56: 499-507.

Sadler, T. November, 2006. Correspondence. Setbacks for nesting waterfowl.

Schueler, T.R. 1992. Design of Stormwater Wetland Systems: Guidelines for creating diverse and effective stormwater wetlands in the mid-Atlantic Region. Metropolitan Washington Council of Governments. Washington, D.C.

Sheldon, I. 1997. Animal Tracks of the Rockies. Lone Pine Publishing. Edmonton, Alberta.

Sowls, L.K., 1955. *Prairie ducks-a study of their behavior, ecology and management*. The Stackpole Co., Harrisburg, Pa., & Wildl. Manage. Inst., Washington, D.C. 193 p.

Spirit of Alberta Wetland and Pond study – Checklist of wetlands birds in Alberta. 2006. 2Learn.ca Education Society.

Stewart, R.E. and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online.

Tourbier, J.T., and R. Westmacott. 1992. Lakes and Ponds. Second Edition. Washington, D.C.: ULI – the Urban Land Institute.

University of Florida, Department of Fisheries and Aquatic Science. 2003. Plant Management in Florida Waters: Invasive plants and related issues for lakes, rivers, springs, marshes, swamps and canals. http://plants.ifas.ufl.edu/guide/silica.html

Unknown. 2005. Minnesota Stormwater Manual –Minnesota, (in progress).

U.S. Army Corps of Engineers. 2006. Habitat Enhancement. http://raystown.nab.usace.army.mil/LandManagement/habitat_enhancement2.htm

U.S. Environmental Protection Agency. 1993. Natural Wetlands and Urban Stormwater: Potential Impacts and Management. Office of Wetlands, Oceans and Watersheds. Wetlands Division. Washington, D.C. http://abe.msstate.edu/Tools/csd/referncces/stormwat.html

U.S. Environmental Protection Agency. 1996. Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices. Office of Water. Washington, D.C.

U.S. Geological Survey. 2006. Homemade Nest Sites for Giant Canada Geese. Floating Nesting Platform. Northern Prairie Wildlife Research Center. http://www.npwrc.usgs.gov/resource/birds/goosnest/floating.htm

U.S. Geological Survey. 2006. Water Science for Schools. http://ga.water.usgs.gov/edu/characteristics.htm

U.S. Geological Survey. 2006. 2006. Wood Duck (*Aix sponsa*) Nest Boxes. Northern Prairie Wildlife Research Center. http://www.npwrc.usgs.gov/resource/birds/woodduck/wdnbox.htm

Warrence, N.J., J.W. Bauder, and K.E. Pearson. 2006. Salinity, Sodicity and Flooding Tolerance of Selected Plant Species of the Northern Cheyenne Reservation. http://waterquality.montana.edu/docs/methane/cheyenne_highlights.shtml

Westhoff Engineering Resources, Inc. 2005. Ecological Assessment.

Westhoff Engineering Resources, Inc. November, 2005. Hydrologic Assessment: 2005 Industrial lands – Sanitary and Storm Trunk Project.

Westhoff Engineering Resources, Inc. 2005. WER 103-17, BMP and Source Control manual – Draft.

Wilson, B. 2007. Clay-coloured sparrow. Weaselhead: Talk about wildlife. http://weaselhead.org/profile/index.php?s=300

Wilson, B. 2007. Le Conte's sparrow. Weaselhead: Talk about wildlife. http://weaselhead.org/profile/index.php?s=309

Zedler, J.B and M.K. Leach. 1998. Managing urban wetlands for multiple use: research, restoration and recreation. Urban Ecosystems. 2: 189-204.

APPENDICES

Table 1: Potential impacts of incorporating a stormwater system evaluation matrix

Components	Hydrology	Bathymetry	Hydrogeology	Biogeochemistry	Vegetation	Wildlife	Water Quality and Nutrients
Existing Conditions	* Average potential evaporation for Lacombe for the period of 1912 to 1985 for the months of May to September = 144 mm, 155 mm, 171mm, 140 mm, 84 mm * Average Lake evaporation for Lacombe for the same time periods = 106, 123, 141, 111, 56 mm * Avg potential evapotranspiration for the same time period in Lacombe = 142, 151, 166, 136, 82 mm * Avg areal evapotranspiration for Lacombe for the same time period = 58, 83, 102, 73, 22 mm * Avg potential evaporation for Lacombe during the period from 1986 to 1992 from May to September = 145, 157, 170, 141, 86 mm * Avg lake evaporation for Lacombe over the same time periods = 107, 124, 141, 111, 56 mm * Avg potentail evapotranspiration for Lacombe over the same time period = 143, 153, 164, 136, 83 mm * Avg areal evapotranspiration for Lacombe over the same time period = 59, 84, 104, 73, 22 mm	* HWL = 878.20 m * WL = 878.00 m * NWL = 877.30 m * average depth around 2 m	* **Test Hole # 39:** ground elevation 879.23 m * Aug 22, 873.13 m - groundwater depth * Aug 29, 873.13 m - groundwater depth * Sept 15, 873.03 m - groundwater depth * Oct 13, 873.23 m - groundwater depth * **Test Hole # 40:** ground elve 879.21 * Aug 22, 873.51 m - groundwater depth * Aug 29, 873.61 m - groundwater depth * Sept 15, 873.71 m - groundwater depth * Oct 13, 873.81 m - groundwater depth * groundwater tables were 5.5 grade to 6.2 m below * soil profile was topsoil over silty clay * topsoil thickness was 0.3 to 0.5 m * was moderately organic, black and moist * was considered weak and compressible under load * lacustrine deposits of silty clay found under topsoil extending to a depth of 9.1 m (depth of drilling) * 20 to 35% moisture content * stiff to very stiff consistency and low to medium plasticity	* Boron levels in all four sample sites were well above the CCME Agricultural Guidelines for soil. * Available nitrate: NW and NE = 16.3 mg/kg, South = 2.61 mg/kg, inlet = 11.5 mg/kg * Available phosphorus: NW = 0.6 mg/kg, NE = < 0.3, S = 2.61, I = 11.5 * Organic matter: I = 44.7%, S = 7.69%, NE and NW = 9.35% * pH: NW = 6.8, NE = 7.69, S = 7.76, I = 7.09 * EC: NW = 1.19, NE = 1.21, S = 0.66, I = 0.42 mS/cm * PCB's: NW = < 0.5 ug/g, NE = < 0.05, S = < 0.05, I = < 0.05 * Oil content: NW = 0.04%, NE = 0.08%, S = 0.60%, I = 0.05%	* floating, submerged and emergent vegetation * balsam poplar and trembling aspen to N & NE, and SW * willow species encircles most of the lake * some non-native spp such as Canada thistle, perennial sow thistle and smooth brome. **Plant Tolerances** * **cattail:** tolerant of inundation up to a year but not tolerant of permanent inundation; max depth 12 to 18 inches; inundation can occur anywhere from 10 to 30 times a year * **soft stem bulrush:** inundation up to 1 ft; inundation can occur anywhere from 10 to 30 times a year; tolerant of long term inundation for a year or more but not tolerant of permanent inundation. * **pondweed:** inundation tolerant * **sedges:** tolerant, not permanent; up to 3 inches in depth; inundation can occur anywhere from10 to 30 times a year * **soft rush:** inundation up to 3 in; inundation can occur anywhere from 10 to 30 times a year * **sandbar willow:** moist sites, can survive some severe flooding; stems can stand being under water for days at a time during a flood with little damage due to their flexibility; tolerant of long term flooding for up to a year but not tolerant of permanent inundation * **snowberry:** tolerant of inundation for up to a year but not of permanent inundation * **trembling aspen:** tolerant of flooding for a year or more but not of permanent inundation * **stinging nettle:** intolerant, less than 2 weeks * **common yarrow:** intolerant, less than 2 weeks * **rose spp:** med tolerant, 2 weeks * **wild licorice:** tolerant of flooding up to a year but not of permanent flooding * **red-osier dogwood:** moderately tolerant of flooding but only up to 2 weeks * **water lilies:** prefer slow moving waters with little water level fluctuation.	* Canada Geese, American Coots, Ring-billed, gulls, sparrow spp, black-capped chickadees, American bitterns, Western grebe, Trumpeter swan, American wigeon, Blue-winged teal, mallards, Sandhill crane, American white pelican, American avocet, black tern, etc. * Mule deer, moose, coyote, small mammals, muskrat, etc.	* PCB's: < 0.2 ug/L * Aluminum: NW = 0.02 mg/L, NE = 0.46, S = 0.012, I = 0.013; CCME Freshwater Aquatic Life Guideline: level should not exceed 0.005 mg/L if pH= less than 6.5. 0.1 mg/L if pH= greater than 6.5. * Chromium: NW = 0.00264 mg/L, NE = 0.00174, S = 0.00278, I = 0.00182; CCME Freshwater Aquatic Life Guideline: chromium III = 8.9 ug/L, chromium VI = 1.0 ug/L * Phosphorus: NW = 0.11 mg/L, NE = <0.08, S = 0.25, I = 0.08; AB Enviro Chronic Water Quality Guideline for the Protection of Freshwater Aquatic Life: 0.05 mg/L * pH: NW = 8.25, NE = 8.36, S = 8.69, I = 9.13; CCME Freshwater Aquatic Life Guideline: 6.5 – 9; AB Enviro water quality guidelines: 6.5 - 8.5 * Alkalinity: 180 mg/L to 192 mg/L * EC: 634 to 691 uS/cm * TDS: 390 - 425 mg/L; CCME Guideline: 500 mg/L * BOD: 7 - 13 mg/L * COD: 95 - 116 mg/L * Ammonia nitrogen: <0.05 - 1.03 mg/L; CCME Freshwater Aquatic Life Guideline: 1.37 mg/L at pH 8, 2.20 mg/L at pH 6.5 * Turbidity: < 0.1 - 93.1 NTU * TSS: 12 mg/L - 182 mg/L

Components	Hydrology	Bathymetry	Hydrogeology	Biogeochemistry	Vegetation	Wildlife	Water Quality and Nutrients	Monitoring
Water Level Increase Up To 0.5 m	* changes in response time * changes in water level * changes in detention time * greater water level fluctuations * More pronounced and frequent inundation variations * increased water velocity * decrease in infiltration to groundwater	* change in shoreline * potential spill over into connecting wetland to the southeast * increase in sedimentation that could cause a decrease in volume and an increase in shallow areas	* do not have enough information to know for certain whether the groundwater is connected to the lake or not. Further study is required. * potential increase in groundwater holding capacity and replenishment	* soil saturation * increased anaerobic conditions * increase in BOD, and COD * decrease in DO * potential release of chemicals from inundated soils * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system * exposure to NaCl can inhibit soil bacteria at concentrations as low as 90 mg/L * compromise the soil structure and reduces erosion control * lead to increases in turbidity due to the changes in soil conditions * possible erosion of wetland soils * flooding of soils can result in physical, chemical and biological changes to the ability of soils to support plant growth. * inundation can lead to the breakdown of aggregates, the deflocculation of clays and the destruction of cementing agents in the soil.	* Vegetation that likes "constant" water levels will likely disappear * Landowner concerns that there may be a potential impact to the poplar and aspen clusters * inundation of terrestrial plants * root growth will decrease should inundation cause the voids in the soil to be 90% full of water * potential shifting of vegetation communities * species such as cattails and *Phragmites* indicate degraded wetlands subject to nutrient loading and/or salt contamination * sediment loadings can affect plant communities * nitrogen and phosphorus can increase vegetative productivity which will result in increased rates of decay and higher community respiration rates * lead can alter species distribution and decrease growth and respiration rates * oil and grease and other hydrocarbons can reduce species diversity * heavy metals can alter species distribution * the water lilies present prefer slow moving waters with little water level fluctuation. They may not be able to adapt to changes in water level. * increase in water level may reduce riparian habitat * potential increase in aquatic biodiversity * potential decrease in poplar stand to the north * change in species richness	* Wildlife dependent on the existing habitat characteristics will likely disappear Creation of a monoculture state in some areas resulting in lower diversity – this will be confirmed in the wildlife assessment * could impact invertebrates, amphibians, and birds whose shelter shrubs are now inundated and perhaps dead * nesting areas for waterfowl species might be impacted * possible reduction or loss of food source for certain species of water fowl * potentially an increase in salt and chloride concentration in the lake * behaviourial and toxicological impacts * toxicity responses of aquatic organisms to NaCl vary * salt tolerances for fish range from 400 to 30000 mg/L * benthic diversity decreases as salinity increases * stresses periphyton which benthic grazers feed on and inhibits the microbial processing of leaf litter * can release toxic metals from the sediment which can impair distribution and cycling of oxygen and nutrients * suspended solids can clog bottom sediments which can interfere with fish spawning and smother benthic invertebrates * change species richness	* decrease in DO due to the break down of organic matter * potential release of pollutants from newly inundated soils and potentially from the stormwater * increase in turbidity * increase in BOD and COD * potential increase of nutrients in water * potential increase of algae growth should there be and increase in nitrate and phosphorus in the water * potential changes in pH could impact nutrient release rates * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system * potential increases in runoff temperature during the summer which would lower dissolved oxygen. * potential decrease in runoff temperature in the winter * changes in circulation and flushing characteristics * Pre-treated runoff is released from stormwater wetland. Quality will have to be monitored very closely and proper ESC practices and monitoring in the catchment area during construction are key to safeguarding the lake from sediment loadings. * prolonged retention of salt in streambeds or lakebeds decreases dissolved oxygen and can increase nutrient loading, which can promote eutrophication * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system; salt can also disrupt the uptake of plant nutrients and inhibits long term growth	*Enhance operations and treatment levels in upstream SWM facilities and "enforce" BMPs and LID in tributary areas. Proper ESC practices and regular monitoring in the catchment area * photo plots and colour airphotos to map out the changes in water level and vegetation. * collect water samples from the middle of each lobe of the lake, the storm pipe inlet, the seasonal stream inlet and the outlet to test for pH, TDS, TSS, EC, nitrogen, phosphorus, total metals, dissolved oxygen and stratification (temperature profiles). * monitoring the changes in depth of the lake. * take soil samples at the same areas as the water samples but in shallower water to monitor changes in soil composition and the presence of pollutants and the concentration of nutrients * also use transects to determine the extent of any vegetation change

Components	Hydrology	Bathymetry	Hydrogeology	Biogeochemistry	Vegetation	Wildlife	Water Quality and Nutrients	Monitoring
Water Level Increase Over 0.5 m	* changes in response time * changes in water level * changes in detention time * greater water level fluctuations * More pronounced and frequent inundation variations * increased water velocity * decrease in infiltration to groundwater	* increase in shoreline * potential spill over into connecting wetland to the southeast * increase in sedimentation that could cause a decrease in volume and an increase in shallow areas	* do not have enough information to know for certain whether the groundwater is connected to the lake or not. Further study is required. * potential increase in groundwater holding capacity and replenishment	* soil saturation * increase in anaerobic conditions * increase in BOD, and COD * decrease in DO due to organic matter break down * potential release of chemicals from the now inundated soils * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system * exposure to NaCl can inhibit soil bacteria at concentrations as low as 90 mg/L * this can compromise the soil structure and reduces erosion control * could lead to increases in turbidity due to the changes in soil conditions * possible erosion of wetland soils	* Vegetation that likes "constant" water levels will likely disappear * Landowner concerns that there may be a potential impact to the poplar and aspen clusters * inundation of terrestrial plants * root growth will decrease should inundation cause the voids in the soil to be 90% full of water * potential shifting of vegetation communities * species such as cattails and *Phragmites* indicate degraded wetlands subject to nutrient loading and/or salt contamination * sediment loadings can affect plant communities * nitrogen and phosphorus can increase vegetative productivity which will result in increased rates of decay and higher community respiration rates * lead can alter species distribution and decrease growth and respiration rates * oil and grease and other hydrocarbons can reduce species diversity * heavy metals can alter species distribution * increase in water level may reduce riparian habitat * potential increase in aquatic biodiversity * potential decrease in poplar stand to the north * change in species richness	* Wildlife dependent on the existing habitat characteristics will likely disappear Creation of a monoculture state in some areas resulting in lower diversity – this will be confirmed in the wildlife assessment * changes in water level could have an impact on invertebrates, amphibians, and birds whose shelter shrubs are now inundated and perhaps dead * nesting areas for waterfowl species might be impacted, especially should emergent vegetation begin to change, some species use emergent vegetation to construct their nesting areas * possible reduction of loss of food source for certain species of water fowl * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system * degradation to wildlife habitat due to the damage done to vegetation which can destroy food resources, habitat corridors, shelter and breeding/nesting sites * behaviourial and toxicological impacts * "While wildlife impacts might not be construed as directly relating to water quality impacts, kills and population declines among salt-sensitive species can be indicators of salt toxicity in aquatic ecosystems * prolonged retention of salt in streambeds or lakebeds decreases dissolved oxygen and can increase nutrient loading, which can promote eutrophication * toxicity responses of aquatic organisms to NaCl vary * salt tolerances for fish range from 400 to 30000 mg/L * benthic diversity decreases as salinity increases * stresses periphyton which benthic grazers feed on and inhibits the microbial processing of leaf litter * can release toxic metals from the sediment which can impair distribution and cycling of oxygen and nutrients * suspended solids can clog bottom sediments which can interfere with fish spawning and smother benthic invertebrates * change in species richness	* decrease in DO due to the break down of organic matter * potential release of pollutants from newly inundated soils and potentially from the stormwater * increase in turbidity * increase in BOD and COD * potential increase of nutrients in water * potential increase of algae growth should there be and increase in nitrate and phosphorus in the water * potential changes in pH could impact nutrient release rates * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system * potential increases in runoff temperature during the summer which would lower dissolved oxygen. * potential decrease in runoff temperature in the winter * changes in circulation and flushing characteristics * Pre-treated runoff is released from stormwater wetland. Quality will have to be monitored very closely and proper ESC practices and monitoring in the catchment area during construction are key to safeguarding the lake from sediment loadings. * potentially an increase in salt and chloride concentration in the lake which can negative impacts on the entire system; salt can also disrupt the uptake of plant nutrients and inhibits long term growth	*Enhance operations and treatment levels in upstream SWM facilities and "enforce" BMPs and LID in tributary areas. Proper ESC practices and regular monitoring in the catchment area * photo plots and colour airphotos to map out the changes in water level and vegetation. * collect water samples from the middle of each lobe of the lake, the storm pipe inlet, the seasonal stream inlet and the outlet to test for pH, TDS, TSS, EC, nitrogen, phosphorus, total metals, dissolved oxygen and stratification (temperature profiles). * monitoring the changes in depth of the lake. * take soil samples at the same areas as the water samples but in shallower water to monitor changes in soil composition and the presence of pollutants and the concentration of nutrients * also use transects to determine the extent of any vegetation change

Components	Hydrology	Bathymetry	Hydrogeology	Biogeochemistry	Vegetation	Wildlife	Water Quality and Nutrients	Monitoring
Water Level Decrease Up To 0.5 m	* changes in response time * changes in water level * changes in detention time * greater water level fluctuations * More pronounced and frequent inundation variations * increased water velocity * decrease in infiltration to groundwater	* decrease in shoreline * potential cause of the drying up of connected wetland to the southeast	* do not have enough information to know for certain whether the groundwater is connected to the lake or not. Further study is required.	* will dry out a lot of soil * The soil will be exposed to oxygen which may facilitate the break down of organic material present in the soil. This chemical break down may result in the release of any pollutants in the soil into the air. * potential compaction of the soil	* Vegetation that likes “constant” water levels will likely disappear * Landowner concerns that there may be a potential impact to the poplar and aspen clusters * many wetland plant spp will die off because of the lack of water * may have an affect on some of the riparian plant species as well. * A reduction in water level may induce the current community of cattails to increase in size * the water lilies present prefer slow moving waters with little water level fluctuation. They may not be able to adapt to changes in water level. * change in species richness	* potential death of aquatic invertebrates * Wildlife dependent on the existing habitat characteristics will likely disappear. Creation of a monoculture state in some areas resulting in lower diversity – this will be confirmed in the wildlife assessment * change in species richness	* potential increase in water temperature * changes in pH * impact on DO, COD and BOD * changes in nutrient concentrations * more significant water loss due to evaporation * potential increases in runoff temperature during the summer which would lower dissolved oxygen. * potential decrease in runoff temperature in the winter * Pre-treated runoff is released from stormwater wetland. Quality will have to be monitored very closely and proper ESC practices and monitoring in the catchment area during construction are key to safeguarding the lake from sediment loadings. * low flow conditions experienced in developed areas limits available aquatic habitat and may concentrate contaminants through increased deposition	*Enhance operations and treatment levels in upstream SWM facilities and “enforce” BMPs and LID in tributary areas. Proper ESC practices and regular monitoring in the catchment area * photo plots and colour airphotos to map out the changes in water level and vegetation. * collect water samples from the middle of each lobe of the lake, the storm pipe inlet, the seasonal stream inlet and the outlet to test for pH, TDS, TSS, EC, nitrogen, phosphorus, total metals, dissolved oxygen and stratification (temperature profiles). * monitoring the changes in depth of the lake. * take soil samples at the same areas as the water samples but in shallower water to monitor changes in soil composition and the presence of pollutants and the concentration of nutrients * also use transects to determine the extent of any vegetation change

Components	Hydrology	Bathymetry	Hydrogeology	Biogeochemistry	Vegetation	Wildlife	Water Quality and Nutrients	Monitoring
Water Level Decrease Over 0.5 m	* changes in response time * changes in water level * changes in detention time * greater water level fluctuations * More pronounced and frequent inundation variations * increased water velocity * decrease in infiltration to groundwater	* decrease in shoreline * potential cause of the drying up of connected wetland to the southeast	* do not have enough information to know for certain whether the groundwater is connected to the lake or not. Further study is required. * Need hydrogeologic investigation to confirm	* will dry out a lot of soil * The soil will be exposed to oxygen which may facilitate the break down of organic material present in the soil. This chemical break down may result in the release of any pollutants in the soil into the air. * potential compaction of the soil	* Vegetation that likes “constant” water levels will likely disappear * Landowner concerns that there may be a potential impact to the poplar and aspen clusters * many wetland plant spp will die off because of the lack of water * may have an affect on some of the riparian plant species as well. * A reduction in water level may induce the current community of cattails to increase in size * the water lilies present prefer slow moving waters with little water level fluctuation. They may not be able to adapt to changes in water level. * change in species richness	* potential death of aquatic invertebrates * Wildlife dependent on the existing habitat characteristics will likely disappear Creation of a monoculture state in some areas resulting in lower diversity – this will be confirmed in the wildlife assessment * change in species richness	* potential increase in water temperature * changes in pH * impact on DO, COD and BOD * changes in nutrient concentrations * more significant water loss due to evaporation * potential increases in runoff temperature during the summer which would lower dissolved oxygen. * potential decrease in runoff temperature in the winter * Pre-treated runoff is released from stormwater wetland. Quality will have to be monitored very closely and proper ESC practices and monitoring in the catchment area during construction are key to safeguarding the lake from sediment loadings. * low flow conditions experienced in developed areas limits available aquatic habitat and may concentrate contaminants through increased deposition	*Enhance operations and treatment levels in upstream SWM facilities and “enforce” BMPs and LID in tributary areas. Proper ESC practices and regular monitoring in the catchment area * photo plots and colour airphotos to map out the changes in water level and vegetation. * collect water samples from the middle of each lobe of the lake, the storm pipe inlet, the seasonal stream inlet and the outlet to test for pH, TDS, TSS, EC, nitrogen, phosphorus, total metals, dissolved oxygen and stratification (temperature profiles). * monitoring the changes in depth of the lake. * take soil samples at the same areas as the water samples but in shallower water to monitor changes in soil composition and the presence of pollutants and the concentration of nutrients * also use transects to determine the extent of any vegetation change

Table 2: Best Management Practices (BMPs) and mitigation measures for negative impacts

Problems	Water Quality	Flood Control	Hydrology	Hydroperiod	Soils	Vegetation	Wildlife	Primary Productivity	Nutrient Cycling/Availability	Erosion Control
Nonstructural BMPs										
Pollution Prevention	Beneficial	Neutral	Neutral	Neutral	Beneficial	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Neutral
Watershed Planning	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Permitting Programs	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Preventive Construction Techniques	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Maintenance Activities	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Educational Programs	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Riparian Areas	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Structural BMPs										
Infiltration Basins	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Infiltration Trenches	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Sand Filters	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Vegetated Filter Strips	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Vegetated Buffer Areas	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Grassed Swales	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Open Spaces	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial
Extended Detention Dry Basins	Beneficial with certain limitations	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Wet Ponds	Beneficial with certain limitations	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Construction Wetlands	Beneficial with certain limitations	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Porous Pavement and Concrete Grid Pavement	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Oil/Grit Separators or Water Quality Inlets	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Level Spreaders Associated with Gabions	Beneficial with certain limitations	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial	Neutral	Neutral	Beneficial	Beneficial
French Drains	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Dry Wells or Roof Downspout Systems	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
Exfiltration Trenches	Beneficial	Beneficial	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial
BMPs in Series	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations	Beneficial with certain limitations

Source: U.S. EPA, 1996.

Table 3: BMP Advantages and Disadvantages

BMP	Advantages	Disadvantages
Wet pond	Capable of removing soluble as well as solid pollutants Provides erosion control Habitat, aesthetic, and recreation opportunities provided Relatively less frequent maintenance schedule	More costly than dry ponds Permanent pool storage requires larger land area Could have negative downstream temperature impacts Could be constrained by topography or land designations Sediment removal relatively costly when required
Dry pond	Batch mode has comparable effectiveness to wet ponds Not constrained by land area required by wet ponds Can provide recreational benefits	Potential re-suspension of contaminants More expensive O&M costs than wet ponds (batch mode)
Wetlands	Pollutant-removal capability similar to wet ponds Offers enhanced nutrient-removal capability Potential ancillary benefits, including aviary, terrestrial, and aquatic habitat	Requires more land area than wet ponds Could have negative downstream temperature impacts Could be constrained by topography or land designations Potential for some nuisance problems
Infiltration trenches	Potentially effective in promoting recharge and maintaining low flows in small areas May be appropriate as secondary facility where maintenance of groundwater recharge is a concern No thermal impact No public safety concern	Appropriate only to small drainage areas (<2 ha) and residential land uses Constrained by native soil permeabilities Usually requires pretreatment device Potential contamination of groundwater must be investigated Generally ineffective for water quantity control High rate of failure due to improper siting and design, pollutant loading, and lack of maintenance
Infiltration basins	Potentially effective in promoting recharge and maintaining low flows in small areas May be appropriate as secondary facility where maintenance of groundwater recharge is a concern No thermal impact No public safety concern	Appropriate only to relatively small drainage areas (<5 ha) and residential land uses Constrained by native soil permeabilities Pretreatment is recommended Potential contamination of groundwater must be investigated Generally ineffective for water quantity control High rate of failure due to improper siting and design, pollutant loading, and lack of maintenance
Filter strips	Water quality benefits may be realized if part of overall SUM plan (i.e., as secondary facility) Effective in filtering out suspended solids and intercepting precipitation May reduce runoff by reducing overland flow velocities, increasing time of concentration, and increasing infiltration Can create wildlife habitat No thermal impact	Limited to small drainage areas (<2 ha) with little topographic relief Uniform sheet flow through vegetation difficult to maintain Effectiveness in freeze/thaw conditions questionable
Sand filters	Generally effective in removing pollutants, are resistant to clogging and are easier/less expensive to retrofit compared to infiltration trenches	Not suitable for water quantity control Generally applicable to only small drainage areas (<5 ha) Do not generally recharge groundwater system May cause aesthetic/odour problems O&M costs generally higher than other end-of-pipe facilities
Oil/grit separators (3-Chamber Separator)	• Offline, 3-chamber (oil, grit, discharge) separators may be appropriate for commercial, industrial, large parking, or transportation-related areas less than 2 ha	• Scour and resuspension of trapped pollutants in heavy rainfall events • Difficult to maintain Relatively high • O&M costs • Online design of 3-chamber separators has resulted in poor pollutant removal performance
Oil/Grit Separators (Bypass Separator)	• Bypass prevents the scouring and resuspension of trapped pollutants in heavy rainfall events Effective in removing sediment load when properly applied as a source control for small areas • Effective in trapping oil/grease from run off	• Relatively high capital costs compared to manholes • Applicable for drainage areas less than 5 ha

Source: Stormwater Management Guidelines, Alberta Environment, 1999.

Table 4: List of Indicator Species (Wildlife and Vegetation)

BIRDS: Endangered Species		
Piping plover - subspecies	*Charadrius melodus circumcinctus*	- **status: endangered, schedule 1 (Alberta's Red List); threatened by loss of habitat** due to human use of beaches and **disturbance of nesting sites** - **changes in water levels** due to recreational or building activities, dams and seasonal storms **also threaten nesting sites** - potentially in the Red Deer area; breeds in central Alberta - **nest just above the normal high-water level** on exposed sandy or gravelly beaches or gravel shores of shallow, saline lakes and on sandy shores of larger prairie lakes; nests are scratched in sand or gravel and are shallow - arrive on breeding grounds in late April or May; raise only one brood a year but will re-nest once or twice a season should the eggs get destroyed - feeds on insects and small aquatic invertebrates. - protected by **SARA and Migratory Birds Convention Act**
Yellow rail	*Coturnicops noveboracensis*	- **status: special concern, schedule 1; may be impacted by changes in water level; loss and degradation of wetlands** due to agricultural and human development is the **greatest threat throughout breeding range** - in the Red Deer area - **Shallow marshes,** and **wet meadows;** nesting rails found in marshes that are dominated by sedges, true grasses and rushes, where there is little or no standing water, and where the substrate remains saturated throughout the summer; uses drier habitat to build nests compared to other rails - females raise one brood, though will re-nest should the first one be unsuccessful - adults **eat invertebrates and seeds** - protected by **SARA and Migratory Birds Convention Act**
Trumpeter swan	*Cynus buccinator*	- **status: threatened (Alberta's Blue List) – considered endangered in the province** - seen at **Hazlett Lake in September of 1989**
Peregrine falcon	*Falco peregrinus anatum*	- **status: threatened (Alberta's Red List – species at risk)** - seen at **Hazlett Lake in September of 1992**
BIRDS		
Western Grebe	*Aechmophorus occidentalis*	- **status: sensitive; population on the decline** - breed on large inland lakes and wetlands; **floating nests** are constructed of plant material anchored to emergent vegetation - have six basic habitat requirements when breeding: 1. sufficiently long ice-free period to permit growth of emergent vegetation and allow time for all phases of nesting 2. protection of nests from wind **3. sufficient water depth at the nesting site for diving (min 25 cm)** **4. stable water levels while nesting** 5. access to open, weed-free (aquatic vegetation) water with sufficient fish populations **6. freedom from human disturbance** - seen **on Hazlett Lake in April of 1989**
American wigeon	*Anas americana*	- has a **diet that is higher in plant matter than any other dabbling duck;** feeds on aquatic plants, some insects and mollusks during breeding season - populations are considered stable but with **continued degradation of breeding habitat in agricultural areas is of concern** - habitat is **shallow freshwater wetlands** - breeds across Alaska and Canada; **nest type is a depression on the ground, lined with grasses and down and is located in tall grass or shrubs, often far from water**
Blue-winged teal	*Anas discors*	- habitat is **shallow ponds and seasonal or permanent wetlands** - **feeds on aquatic invertebrates, seeds and plants** - require a setback of a minimum 100 m
American bittern	*Botaurus lentiginosus*	- **status: sensitive; status is unknown at present but a decline is suspected** - uses **dense reed beds** - breeds in wetlands across Canada and US.
Black-crowned Night-heron	*Nycitcorax nycticorax*	- population is increasing but species is **on provincial Yellow List** as it **requires special management** - tends to **colonize relatively large bodies of water with dense emergent vegetation; nests in trees or dense emergent vegetation**
Black tern	*Chlidonias niger*	- **status: sensitive (Alberta's Yellow List); Wetland habitat vulnerable to alteration; species declining** across its North American range, likely a **result of habitat loss** on both breeding and wintering grounds**.** - **Seen on Hazlett lake in September of 1989**
American coot	*Fulica americana*	- **status: common** - summer range is from BC to the Atlantic coast - **nests are made from reeds, bulrush stems or cattails, makes floating mats** and are built up year after year - **seen on Hazlett Lake in September, 2006**
Sandhill crane	*Grus canadensis*	- **status: sensitive (Alberta's Yellow List); little is known of its population size; sensitive to human disturbance** and the pressure of resource extraction within its breeding range - seen at **Hazlett Lake in September of 1989**
White-winged scoter	*Melanitta fusca deglandi*	- most **common** scoter **but** it is not abundant anywhere in its range; **populations** may be **declining**; factors such as urban and recreational development of lakes are generally thought to negatively affect the quality of breeding habitat and breeding success - breeds on **large, permanent wetlands** and lakes; **nests on shrub covered islands**; nests are hollows in ground in dense cover away from water, lined with down and twigs - **uses large, permanent lakes** for **migratory staging grounds** - **mollusks** (especially clams and mussels), **crustaceans, and insects;** occasionally **aquatic plants and fish**
American white pelican	*Pelecanus erythrorhynchos*	- **status: sensitive;** population increasing but **number of active colonies decreasing,** leading to **concerns about disease, predation, and pesticide contamination.** Comprehensive colony protection essential; **Sensitive to human disturbance** - Drought elsewhere may have contributed to increase in Alberta. - Seen **on Hazlett lake in June of 1990**
American avocet	*Recurvirostra americana*	- summer range – western Great Plains – Saskatchewan and Alberta included; **population declined** in the 1960s and 1970s **due to loss of wetlands from water diversion for human use** - habitat is **shallow fresh and saltwater wetlands** - **feeds on aquatic invertebrates**, in shallow water, while wading or swimming - **nests are scraped in the ground and lines with grass or other vegetation, feathers, pebbles, etc;** nests in drier more open habitat with sparse vegetation

AMPHIBIANS: Endangered Species		
Northern leopard frog	*Rapa pipiens*	- **status: endangered/threatened; draining wetlands should be avoided** - has been observed south of Edmonton - **associated with clear water** that is relatively fresh to moderately saline; more sensitive to acidic conditions than other frog species - **breed in shallow and warm standing water associated with permanent and semi-permanent wetlands,** springs, dugouts, borrow pits, lakes, beaver ponds, and backwaters and oxbows of rivers - temporary ponds and shallow lakes that are unsuitable for fish and that contain water until late July or August are considered to be the most favourable spawning sites; most **breeding ponds contain a mix of open water and emergent vegetation** - **tadpoles are poorly adapted to cope with currents** – therefore they develop successfully only in slow reaches of streams or backwaters - summer feeding areas are located along margins of water bodies; overwinter in the water; **need well-oxygenated water** that does not freeze to the bottom
INSECTS		
Dragonfly		- require **permanent water;** need **high oxygen levels in water with low levels of nutrients and pollutants;** Sunny area that has some shelter from the wind - abundance of **submerged and emergent vegetation** for different stages of life - **large fluctuations in water levels should be avoided**
VASCULAR PLANTS		
Water lily/ pond lily spp	*Nymphaeceae sp*	- live in **slow-moving or still fresh wate**r of shallow lakes and ponds and slow streams; habitat is **fresh, nutrient-rich, unpolluted water; require depths of 0.5 to 3 m of water** in order **to ensure that root tubers do not freeze** during the winter; **water clarity is a limiting factor** in water depth - seasonal distribution May to October - muskrats and beavers feed on rhizomes and moose feed on leaves; lily pads provide shelter for invertebrates and fish; seeds eaten by waterfowl
Bebb's or Beaked Willow	*Salix bebbiana*	- common to wetlands - **tolerates drier locations** - found along Hazlett Lake
Sandbar Willow	*Salix exigua*	- drought resistant - **prefers wet areas and is the wettest of the willows** - found along Hazlett Lake
Hard-stem Bulrush	*Scirpus acutus*	- tolerant of some flooding - **inundation tolerance of up to 24 cm** - seeds and rhizomes are eaten by waterfowl and muskrats - found at Hazlett Lake

Sources: Bow Point Nursery Ltd.; Lahring, H. 2003. Water and Wetland Plants of the Prairie Provinces. Canadian Plains Research Centre. University of Regina.; Spirit of Alberta Wetland and Pond study – Checklist of wetlands birds in Alberta. 2006. 2Learn.ca Education Society.; Cornell Lab of Ornithology. 2003. All About Birds. www.**birds**.cornell.edu/**All**About**Birds**; Moir. G. 2006. Hazlett Lake Inventory – Draft. City of Red Deer parks;
McGillivray, W.B. and G.P. Semenchuk. 1998. Field Guide to Alberta Birds. Federation of Alberta Naturalists. Edmonton, Alberta.

Table 5: List of Birds Species Observed at Hazlett Lake

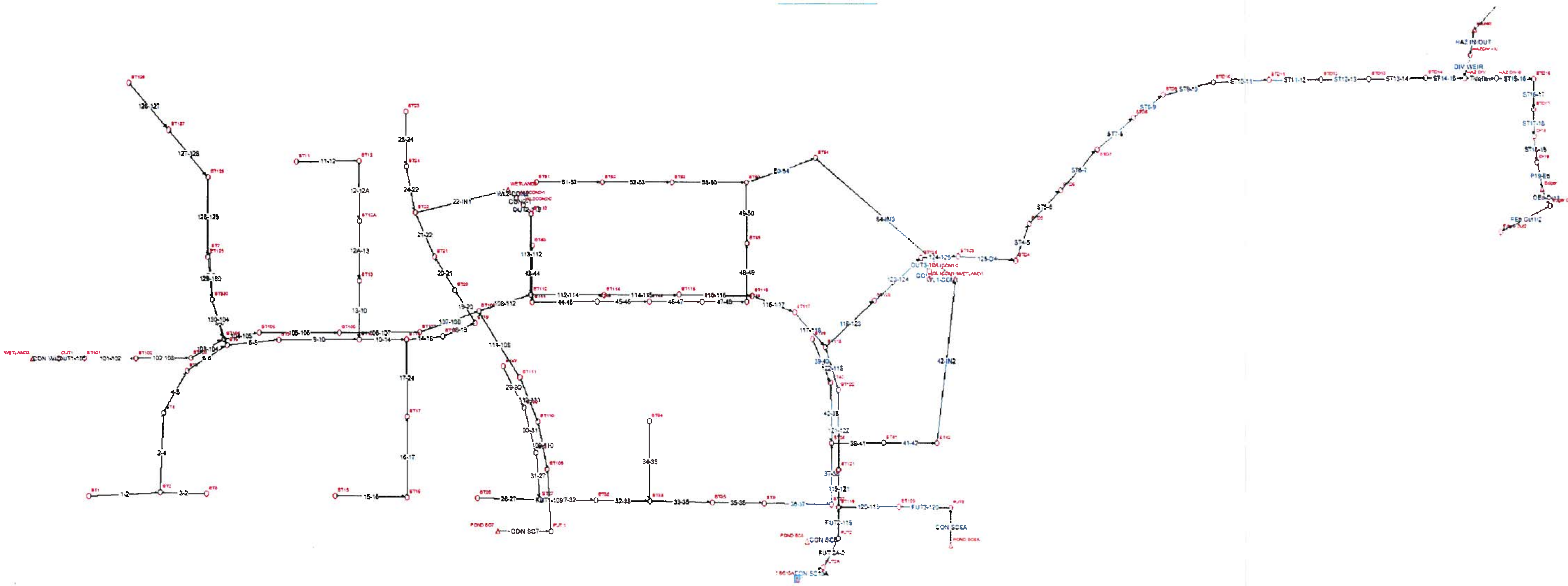
Date	Common Name	Scientific Name	Status	Date	Common Name	Scientific Name	Status	Date	Common Name	Scientific Name	Status
Apr/89	Common Loon	*Gaia immer*	C/SUM	May/90	Black-capped Chickadee	*Poecile atricapillus*	C/P	Jan/92	Northern Goshawk	*Accipiter gentilis*	UN/SUM
	Pied Billed Grebe	*Podilmbus podiceps*	C/SUM		Townsend's Solitaire	*Myadestes townsendi*	RH/SUM		Broad-winged Hawk	*Buteo platyperus*	UC/D/SUM
	Horned Grebe	*Podiceps auritus*	Y/SUM		Veery	*Catharus fuscescens*	C/SUM		Swainson's Hawk	*Buteo seainsoni*	C/D/RH/SUM
	Red-necked Grebe	*Podiceps grisegena*	D/SUM		Swainson's Thrush	*Catharus ustulatus*	C/SUM		Red Tailed Hawk	*Buteo jamaicensis*	C/SUM
	Eared Grebe	*Podiceps migricollis*	C/SUM		American Robin	*Turdus migratorius*	C/SUM		Rough-legged Hawk	*Buteo lagopus*	C/M/W
	Western Grebe	*Aechmorphorus occidentalis*	S/D/SUM		Gray Catbird	*Dumetella carolinensis*	C/RH/SUM		Golden Eagle	*Aquila chrysaetos*	Y/R/SUM
May/89	Double Crested Cormorant	*Phalacrocorax auritus*	C/SUM		Sprague's Pipit	*Anthus spraguei*	B/D/RH/SUM		American Kestrel	*Falco sparverius*	C/SUM
Sept/89	American Bittern	*Botaurus lentiginosus*	S/UN/D/SUM		Bohemian Waxwing	*Bombycilla garrulous*	C/SUM/W		Merlin	*Falco columberius*	C/SUM
	Great Blue Heron	*Ardea herodias*	ST/SUM		Cedar Waxwing	*Bombycilla cedrorum*	C/SUM	Sept 4/92	Peregrine Falcon	*Falco peregrinus*	RD/SR/RH/SUM
	Black Crowned Night Heron	*Nycticorax nycticorax*	Y/SUM		Northern Shrike	*Lanius excubitor*	M		Gyrfalcon	*Falco rusticolus*	UC/W
	Tundra Swan	*Cygnus columbianus*	M		European Starling	*Sturnus vulgaris*	C/SUM		Gray Partridge	*Perdix perdix*	ST/P
	Trumpeter Swan	*Cygnus buccinators*	E/B/SUM		Blue-headed Vireo	*Vireo solitarius*	C/SUM		Ring-necked Pheasant	*Phasianus colchicus*	Y/D/P
	Sandhill Crane	*Grus canadensis*	Y/UN/SUM		Warbling Vireo	*Vireo gilvus gilvus*	C/SUM		Ruffed Grouse	*Bonasa umbellus*	C/P
	Black-bellied Plover	*Pluvialis squatarola*	M		Philadelphia Vireo	*Vireo philadelphicus*	C/SUM		Sora	*Porzana carolina*	C/ST/SUM
	Semipalmated Plover	*Charadrius semipalmatus*	R/M		Red-eyed Vireo	*Vireo olivaceus*	C/SUM		American Coot	*Fulica americana*	C/SUM
	Killdeer	*Charadrius vociferous*	C/SUM		Tennessee Warbler	*Vermivora peregrine*	C/SUM	Jan 15/94	Red Breast Merganser	*Mergus serrator*	UN/UC/SUM
	American Avocet	*Recurvirostra americana*	C/D/RH/SUM		Orange-crowned Warbler	*Vermivora celata*	C/SUM		Ruddy Duck	*Oxyura jamaicensis*	C/SUM
	Greater Yellowlegs	*Tringa melanoleuca*	UC/SUM		Yellow Warbler	*Dendroica petechia*	C/SUM	1997	Rock Wren	*Salpinctes obsoletus*	RH/P
	Lesser Yellowlegs	*Tringa flavipes*	C/SUM		Yellow-rumped Warbler	*Dendrocia coronata*	C/SUM		House Wren	*Troglodytes aedon*	C/RH/SUM
	Willet	*Catoptrophorus semipalmatus*	Y/D/RH/SUM		Palm Warbler	*Dendroica palmarum*	C/SUM		Marsh Wren	*Cistothorus palustris*	C/SUM
	Spotted Sandpiper	*Actitis macularia*	C/SUM		Blackpoll Warbler	*Dendroica striata*	ST/SUM	Sept/98	Boreal Chickadee	*Poecile hudsonicus*	C/P
	Marbled Godwit	*Limosa fedoa*	C/RH/SUM		Black & White Warbler	*Mniotilta varia*	UC/Y/D/SUM		Red-breasted Nuthatch	*Sitta canadensis*	C/SUM
	Pectoral Sandpiper	*Calidris melanotos*	M		American Redstart	*Setophaga ruticulla*	C/SUM		White-breasted Nuthatch	*Sitta carolinensis*	UC/P/W
	Short-billed Dowitcher	*Limnodromus griseus*	UC/RH/SUM		Ovenbird	*Seiurus aurocapillus*	C/SUM	Dec/98	Golden Crowned Kinglet	*Regulus satrapa*	C/SUM
	Common Snipe	*Gallinago gallinago*	C/SUM		Northern Waterthrush	*Seiurus noveboracensis*	C/SUM		Ruby Crowned Kinglet	*Regulus calendula*	C/SUM
	Wilson's Phalarope	*Phalaropus tricolor*	C/SUM	June 1/90	American White Black Pelican	*Pelecanus erythrorhynchos*	S/D/SUM	May/02	Connecticut Warbler	*Oporornis agilis*	UN/SUM
	Franklin's Gull	*Larus pipixcan*	C/SUM	July/91	Mourning Dove	*Zenaida macroura*	ST/SUM		MacGillivry's Warbler	*Oporornis tolmiei*	RH/SUM
	Bonaparte's Gull	*Larus philadephia*	C/SUM		Great Horned Owl	*Bubo virginianus*	C/P		Common Yellowthroat	*Geothlypis trichas*	C/SUM
	Ring-billed Gull	*Larus delawarensis*	C/SUM		Short-eared Owl	*Asio fammeus*	B/P/UN/D		Wilson's Warbler	*Wilsonia pusilla*	RH/SUM
	California Gull	*Larus californicus*	ST/SUM		Common Nighthawk	*Chordeiles minor*	ST/SUM		Western Tanger	*Piranga ludoviciana*	C/SUM
	Common Tern	*Sterna hirundo*	C/SUM		Ruby-throated Hummingbird	*Archilochus colubris*	C/SUM		Rose-breasted Grosbeak	*Pheucticus ludovicianus*	C/SUM
	Black Tern	*Chilidonias niger*	D/Y/SUM	July 31/91	Osprey	*Pandion haliaetus*	UN/D		American Tree Sparrow	*Spizella arborea*	M
	Rock Dove	*Columba livia*	C/P		Bald Eagle	*Haliaeetus leucocephalus*	C/UC		Chipping Sparrow	*Spizella paaerina*	C/SUM
	Mountain Bluebird	*Dialia currucoides*	C/SUM		Northern Harrier	*Circus cyaneus*	SC/D		Clay Colored Sparrow	*Spizella pallida*	C/SUM
May/90	Yellow-bellied Sapsucker	*Sphyrapicus varius*	C/SUM		Sharp Shinned Hawk	*Accipiter striatus*	UN		Savannah Sparrow	*Passerculus sandwichensis*	C/SUM
	Downy Woodpecker	*Picoides pubescens*	C/ST/P		Cooper's Hawk	*Accipiter cooperii*	UN		Le Conte's Sparrow	*Ammodramus leconteii*	C/SUM
	Hairy Woodpecker	*Picoides villosus*	ST/P	Sept 15/91	Great White Fronted Goose	*Anser albifrons*	C/M		Song Sparrow	*Melospiza melodia*	C/UC/SUM
	Common/Northern Flicker	*Colaptes auratus*	C/SUM		Lesser Snow Goose	*Chen caerulescens*	C/M		Lincoln's Sparrow	*Melospiza lincolnii*	C/SUM
	Pileated Woodpecker	*Dryocopus pileatus*	ST/Y/P		Ross' s Goose	*Chen rossii*	C/M		White-throated Sparrow	*Zonotrichia albicollis*	C/SUM
	Western Wood-pewee	*Contopus sordidulus*	C/SUM		Canada Goose	*Branta canadensis*	C/SUM		White-crowned Sparrow	*Zonotrichia leucophrys*	RH/SUM
	Alder Flycatcher	*Empidonax alnorun*	C/SUM		Green – winged Teal	*Anas crecca*	ST/SUM		Dark-eyed Junco	*Junco hyemalis*	C/SUM
	Least Flycatcher	*Empidonax minimus*	C/SUM		Mallard	*Anas platyrhynchos*	C/SUM		Snow Bunting	*Plectrophenax nivalis*	M/W
	Eastern Phoebe	*Sayornis phoebe*	C/UC/SUM		Northern Pintail	*Anas acuta*	C/S/SUM		Red-winged Blackbird	*Agelaius phoeniceus*	C/SUM
	Say's Phoebe	*Sayornis saya*	C/RH/SUM		Cinnamon Teal	*Anas cyanoptera*	UC/RH/SUM		Western Meadowlark	*Sturnella neglecta*	C/RH/SUM
	Eastern Kingbird	*Tyrannus tyrannus*	C/SUM		Northern Shoveler	*Anas clypeata*	ST/SUM		Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	C/SUM
	Horned Lark	*Eremophila alpestris*	RH/SUM		Gadwall	*Anas strepera*	ST/SUM		Brewer's Blackbird	*Euphagus cyanocephalus*	C/RH/SUM
	Purple Martin	*Progne subis*	RH/SUM		American Wigeon	*Anas Americana*	ST/HD/SUM		Brown-headed Cowbird	*Molothrus ater*	C/SUM
	Tree Swallow	*Tachycineta bicolor*	C/SUM		Canvasback	*Aythya valisineria*	LC/SUM		Northern/Baltimore Oriole	*Icterus galbula*	C/SUM
	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	UC/RH/SUM		Redhead	*Aythya Americana*	LC/SUM		Pine Grosbeak	*Pinicola enucleator*	W/SUM
	Bank Swallow	*Riparia riparia*	C/SUM		Ring-necked Duck	*Aythya collaris*	ST/SUM		Purple Finch	*Carpodacus purpureus*	C/SUM
	Cliff Swallow	*Petrochelidon pyrrhonota*	C/SUM		Great Scaup	*Aythya marila*	UC/M		Common Redpoll	*Carduelis flammea*	W
	Barn Swallow	*Hirundo rustica*	C/SUM		Lesser Scaup	*Aythya affinis*	C/LC/SUM		Hoary Redpoll	*Carduelis hornemanni*	UC/W/R
	Blue Jay	*Cyanocitta cristata*	C/P		White Winged Scoter	*Melanitta fusca*	C/D/SUM		Pine Siskin	*Carduelis pinus*	C/W/P/SUM
	Black-billed Magpie	*Pica pica*	C/P		Common Goldeneye	*Bucephala clangula*	C/SUM		American Gold Finch	*Carduelis tristis*	C/SUM
	American Crow	*Corvus brachyrhynchos*	C/P		Barrow's Duck	*Bucephala islandica*	UC/RH/SUM		Evening Grosbeak	*Coccothraustes vespertinus*	C/P/W
	Common Raven	*Corvus corax*	C/P		Bufflehead	*Bucephala albeola*	ST/SUM		House Sparrow	*Passer domesticus*	C/P
					Hooded Merganser	*Lophodytes cucullatus*	UC/RH/SUM				
					Common Merganser	*Mergus merganser*	ST/SUM				

Source: Dorothy Hazlett, courtesy of G. Moir, City of Red Deer Parks Department, 2006; McGillivray and Semenchuck. The Federation of Alberta Naturalists Field Guide to Alberta Birds. * C = common; R = rare; T = threatened; E = endangered; S = sensitive; SR = species at risk; UN = unknown population; ST = stable population; UC = uncommon; LC = locally common; D = declining; Y = Alberta's Yellow List – species of concern; B = Alberta's Blue List – species at risk; RD = Alberta's Red List – species at risk; M = migrant; RH = restricted habitat; W = winter resident; P = permanent resident; SUM = summer resident; HD = habitat degradation. Yellow = Indicator Species; Blue = Species on the Alberta Blue list, Yellow list or Red list.

Table 6: Tolerance of vegetation found in or near wetlands

Common Name	Scientific Name	Native to Alberta	Tolerant flooding and drying cycles	Salinity Tolerance	Sodium Tolerance
Common Yarrow	*Achillea millelolium*	yes	Intolerant, very short term, < 2 weeks	Moderately sensitive	No data
Sweet Flag	*Acorus americanus*	yes	yes		
Slender wheat grass	*Agropyron trachycaulum*	yes		High tolerance	
Showy Milkweed	*Asclepias speciosa*		Intolerant, very short term, < 2 weeks	Moderately sensitive	No data
Slough Grass	*Beckmannia syzigachne*	yes	yes		
Saw Beak Sedge	*Carex stipata*		Tolerant of long term flooding	Moderately sensitive	No data
Red-osier Dogwood	*Cornus stolinifera*	yes	moderately tolerant of flooding but only up to 2 weeks	Sensitive	Extremely sensitive
Round Leaf Hawthorne	*Cratageus chrysocarpa*	yes		High tolerance	
Spike Rush	*Eleocharis erythropoda*	yes	yes		
Common Spikerush	*Elocharis palustris*		Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately sensitive	No data
Field Horsetail	*Equisetum arvense*	yes	Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately sensitive	No data
Swamp Horsetail	*Equisetum fluviatile*	yes	yes		
Green Ash	*Fraxinus pennsylvania*		Yes; Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately tolerant	No data
Wild Licorice	*Glycyrrhiza lepidota*	yes	Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately tolerant	Very tolerant
Knotted Rush	*Juncus nodosus*	yes	yes		
Creeping Juniper	*Juniperus horizontalis*	yeas		Moderately tolerant	
Field Mint	*Mentha arvensis*	yes	No data available	Sensitive-moderately sensitive	Extremely sensitive
Wild Bergamot	*Monarda fistulosa*	yes	No data available	Moderately sensitive	No data
Arrow-leaved Sweet Coltsfoot	*Oatasites sagitattus*	yes	yes		
Balsam Poplar	*Populus balsmifera*	yes		Moderately tolerant	
Plains Cottonwood	*Populus deltoides*		Yes; Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately sensitive	No data
Trembling Aspen	*Populus tremuloides*	yes	Tolerant of long term flooding up to 1 year but not of permanent flooding	sensitive	No data
Pondweed	*Potamogeton spp*	yes	yes		
Chokecherry	*Prunus virginiana*	yes	No; Intolerant, very short term, < 2 weeks	sensitive	Extremely sensitive
Douglas Fir	*Pseudotsuga menziesii*	yes		Low tolerance	
Skunkbush	*Rhus trixobata*		Moderately tolerant, short term, 2 weeks	Moderately tolerant	No data
Golden currant	*Ribes aureum*	yes	No data available	Moderately sensitive	Extremely sensitive
Prairie Rose	*Rosa arkansana*	yes	Moderately tolerant, short term, 2 weeks	Moderately sensitive	No data
Wild Red Raspberry	*Rubes ideaus*	yes	No data available	sensitive	Extremely sensitive
Arrow leaf	*Sagittaria latifolia*		Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately sensitive	No data
Bebb's Willow	*Salix bebbiana*	yes	More drought tolerant		
Pussy Willow	*Salix discolor*	yes	Moderately tolerant of inundation		
Sandbar Willow	*Salix interior*	yes	Yes; Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately sensitive	No data
Shining Willow	*Salix lucida*	yes	Tolerates some flooding		
Yellow Twig Willow	*Salix lutae*	yes	Moderately tolerant of inundation		
Blackbud Willow	*Salix petiolaris*	yes	Tolerates some flooding		
Hard-stem Bulrush	*Scirpus acutus*	yes	some		
Woolgrass	*Scirpus cyperinus*	yes	yes		
Small-fruited Bulrush	*Scirpus microcarpus*	yes	yes		
Bulrush	*Scirpus nevadensis*		Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately tolerant-tolerant	No data
Three-square Rush	*Scirpus pungens*	yes	yes		
Soft-stem Bulrush	*Scirpus validus*	yes	Some; inundation up to 1 ft; inundation can occur anywhere from 10 to 30 times a year; tolerant of long term inundation for a year or more but not tolerant of permanent inundation.		
Buffaloberry spp	*Shepherdia spp.*	yes		High tolerance	
Snowberry	*Symphoricarpos occidentalis*	yes	Tolerant of long term flooding up to 1 year but not of permanent flooding	Moderately sensitive	Extremely sensitive
Common Cattail	*Typha latifolia*	yes	Yes; tolerant of inundation up to a year but not tolerant of permanent inundation; max depth 12 to 18 inches; inundation can occur anywhere from 10 to 30 times a year	Moderately sensitive	No data
Stinging Nettle	*Urtica dioica*	yes	Intolerant, very short term, < 2 weeks	Moderately sensitive	No data

Sources: Bearberry Creek Water Gardens; Schueler, T.R. 1992. Design of Stormwater Wetland Systems; Warrence, N.J. et al. Salinity, Sodicity and Flooding Tolerance of Selected Plant Species of the Northern Cheyenne Reservation; Bow Point Nursery, 2006; Agriculture and Food, Alberta Government. Salt Tolerance of Plants, 2001.



Client:	Project: QUEENS BUSINESS PARK MASTER DRAINAGE PLAN				
Red Deer	Title: XPSWMM MODEL SCHEMATIC				
Westhoff Engineering Resources, Inc. Land & Water Resources Management Consultants	Date: 16/06/2008	Job No.: WER105-52	Cad File: 10552L00.dwg	Figure No.: XP-01	Rev. A

APPENDIX C
Hazlett Lake Management Plan
2006 Biophysical Assessment Summary

Westhoff
Engineering
Resources, Inc.

Land & Water Resources Management Consultants

May 18, 2007
WER 106-62 Hazlett Lake Management Plan

Ducks Unlimited Canada – Calgary Office
3520 – 114th Ave SE
Calgary, Alberta
T2Z 3V6

Attention: Mr. Jerry Brunen

Dear Jerry:

RE: Hazlett Lake Monitoring and Adaptive Management Plan

BACKGROUND AND PROPOSED PLAN

Hazlett Lake is a prairie pothole wetland that is located just north of the City of Red Deer limits. It is a large and unique wetland-lake system with a relatively small direct catchment area of about 268 ha in size. The total watershed area, however, is considerably larger as another 627 ha west of Highway 2 drains into Hazlett Lake via the existing swales and culverts at the Highway 2 / Highway 11A interchange. Prior to development of the Edgar Industrial Park subdivision to the south of Highway 11A, spillover flows from an additional 209 ha drained north into Hazlett Lake.

The area to the southwest of Hazlett Lake, to the west of Hwy 2, is slated for phased industrial development. The City of Red Deer contracted Al-Terra Engineering Ltd (Al-Terra) to design a trunk system that would service this area with sanitary and stormwater. The sanitary trunk would travel parallel to Hwy 11A (east) into a treatment centre near the Red Deer River. The stormwater trunk would also travel parallel to Hwy 11A and would have been discharged directly into the Red Deer River. The phased development does include the construction of on site detention ponds and constructed wetlands to aid in the treatment of the stormwater prior to its release into the River.

Upon further analysis of the design of the trunk system, it was found that the portion of the stormwater trunk that would travel along Hwy 11A would require excavation of up to 12 m in depth and would cost well over the budget that was allotted for the construction of this project. The City of Red Deer and Al-Terra began to look for other possibilities that would help to reduce the cost of construction.

The City of Red Deer and Al-Terra are now proposing to run a stormwater trunk system to an existing stormwater detention pond located south of Hwy 11A in the Edgar industrial area. They are proposing to use Hazlett Lake as an overflow facility should a storm event occur that maximizes the Edgar system, in which case the excess stormwater would be diverted north into Hazlett Lake. The diversion would continue until there is enough capacity again in the Edgar system to convey that water. In which case, the diverted water would then be drained from Hazlett Lake and transferred into the Edgar storm pond where it would continue on to the Red Deer River.

The incorporation of Hazlett Lake into this stormwater system may not occur during the first initial phases of development. The timing for bringing Hazlett Lake on line with the stormwater system will depend on the development to the southwest and how quickly that development exceeds the capacity of the Edgar storm pond. Only then would Hazlett Lake begin to be used for overflow.

CURRENT CONDITIONS

A preliminary assessment of the area was conducted by Westhoff Engineering Resources, Inc. (Westhoff) in 2005. This assessment found Hazlett Lake to be environmentally significant in that it shows moderate to little disturbance and it consists of predominantly native vegetation (refer to attached pictures). The lake has been classified as a Class V wetland according to the Stewart and Kantrud (1971) Wetland Classification Methodology.

Westhoff was subsequently retained by the City of Red Deer to compile existing information and undertake additional surveys of Hazlett Lake in order to develop adaptive monitoring and management strategies as part of a comprehensive lake management plan. In addition, a more detailed assessment of the hydrology of Hazlett Lake was carried out.

The area surrounding Hazlett Lake is currently dominated by agricultural land uses. However, north of the lake is a large mixed stand of trees dominated by Balsam poplar (*Populus balsamifera*) and Trembling aspen (*Populus tremuloides*) (Kershaw et al., 1998). Another stand is located to the southwest of the lake. The riparian area and wetland consists of low prairie, wet meadow and shallow marsh zones. Some of the non-native plant species found around the lake are: Curly dock (*Rumex crispus*), Canada thistle (*Cirsium arvense*), Smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*) and Perennial sow thistle (*Sonchus arvensis*) (Kershaw et al., 1998). Please see Table 1 for the vegetation inventory.

The deep marsh area is occupied by a species of yellow pond lily (*Nuphar spp*) and pondweed (*Potamogeton spp*). The lilies that inhabit Hazlett Lake are of importance as they indicate the lake has remained relatively stable in its water level or that the water levels have changed very gradually over time. Water lilies are reported to be sensitive to fluctuations in water level. They prefer slow moving or even still water. They also require fresh, nutrient-rich water as well as water of enough depth to ensure the root tubers do not freeze during the winter. The clarity of the water is a limiting factor for this lily species (Lahring, 1993; Biodiversity Plants website, date unknown; B.C. Adventure, 2006; MSU, 2004).

It was observed that species such as American Coots (*Fulica americana*), Canada Geese (*Branta canadensis*), Ring-billed Gulls (*Larus delawarensis*), as well as other migratory waterfowl, utilize the lake throughout the year and during their migration south (Alsop, 2002; Moir, 2006). Other bird species that were observed around the lake were Black-capped Chickadees (*Poecile atricapilla*), Dark-eyed Juncos (*Junco hyemalis*) and many different species of Sparrows, which use the willows and poplar and aspen stands as shelter and feeding areas (Wilson, 2007; Wilson, 2007; Alsop, 2002). Table 2 provides a comprehensive summary of bird species observed at Hazlett Lake. Some evidence of Deer (*Odocoileus spp*.) and Coyote (*Canus latrans*) were also noted (sightings of Mule Deer, scat, and tracks) (Sheldon, 1997).

PROPOSED STUDIES

After Westhoff initially conducted a preliminary investigation of Hazlett Lake and its surrounding area it became apparent that a more detailed environmental baseline study is needed in order to gain additional insight into this very unique and complex system and to work towards an adaptive management plan. Westhoff recommends and will be conducting a more detailed vegetation survey of the Hazlett Lake area to gain better understanding of what plant species inhabit the area. The vegetation survey will be conducted in mid-spring. It is also suggested that a rare plant survey be undertaken at around the same time to determine whether, if any, rare plants are located in this area and if they might be potentially impacted by this project. Westhoff will coordinate these efforts with a qualified rare plant specialist.

It is also recommended that a more detailed wildlife survey be conducted. This survey will entail a field assessment in mid-spring and another in late summer and will be completed by Nick Roe, P.Bio. and Westhoff. These two time periods will allow for an understanding of what animal and bird species utilize the Hazlett Lake area during the typical breeding season as well as during the beginning of the migratory season, especially for birds. Further investigation into the potential for fish to inhabit the lake should also be taken into consideration. This will be confirmed by others that are qualified fish biologists.

CLOSURE

Westhoff Engineering Resources, Inc. is in the process of developing a monitoring program and adaptive management plan for Hazlett Lake. The idea of the monitoring program is to study the responsive behaviour of the lake prior to, during and after the construction of the stormwater trunk system. The management plan will be altered or adapted as the over all scope of the project changes. The priority of this plan is to sustain Hazlett Lake and to mitigate any negative impacts that may result from the implementation of the lake into a stormwater system.

We would like to gather any input from you at this time to ensure that our proposed studies and work program captures the biophysical elements that Ducks Unlimited Canada (DUC) would like to see. In addition, any existing monitoring programs or management plans that DUC is currently working on would be of interest to our team and we would appreciate the opportunity to discuss these with you.

Please feel free to contact the undersigned should you have any questions.

Yours sincerely,

Westhoff Engineering Resources, Inc.

Katie Illian, B.Sc. (Env)
Junior Environmental Scientist

cc. Jodi Kohls, M.E.Des., CEPIT
Bert van Duin, M.Sc., P.Eng.
Dennis Westhoff, M.Eng., P.Eng.

REFERENCES

Alsop, F.J. 2002. Birds of Canada. Dorling Kindersley Handbooks. Doling Kindersley Limited. Toronto, Ontario.

B.C. Adventure. 2006. Yellow Water lily. Interactive Broadcasting Corporation. http://www.bcadventure.com/adventure/wilderness/wildflowers/yellow.htm

Biodiversity Plants. Unknown. The Water Lily Family (Nymphaeceae). http://www.naturegrid.org.uk/biodiversity/plants/fplily.html

Kershaw, L., A. MacKinnon, and J. Pojar. 1998. Plants of the Rocky Mountains. Lone Pine Field Guide. Lone Pine Publishing. Edmonton, Alberta.

Lahring, H. 2003. Water and Wetland Plants of the Prairie Provinces. Canadian Plains Research Centre. University of Regina.

Mississippi State University Extension Service. 2004. Yellow Water Lily: Description. http://msucares.com/wildfish/fisheries/farmpond/veg/yelllily.html

Moir. G. 2006. Hazlett Lake Inventory – Draft. City of Red Deer parks.

Sheldon, I. 1997. Animal Tracks of the Rockies. Lone Pine Publishing. Edmonton, Alberta.

Stewart, R.E. and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online.

Westhoff Engineering Resources, Inc. 2005. Ecological Assessment.

Wilson, B. 2007. Clay-coloured sparrow. Weaselhead: Talk about wildlife. http://weaselhead.org/profile/index.php?s=300

Wilson, B. 2007. Le Conte's sparrow. Weaselhead: Talk about wildlife. http://weaselhead.org/profile/index.php?s=309

PICTURES: September 8 & 24, 2006


Yellow pond lily species


Small-fruited bulrushes



Water fowl nests found in the south lobe area.


Migratory birds utilizing the lake's resources.

Inlet – Seasonal Stream


Reed grass, balsam poplar, and trembling aspen dominate this area. Some cattails are also present along with dead willows.

Northwest Lobe




Northeast Lobe

This area consists of numerous dead willows. This would indicate that the current water level is higher than in the past, causing the willows to be drowned out and pushed back in recent years.

Along the north shore is a good example of a large mixed tree stand consisting mostly of balsam polar trees. Their presence being close to the lake suggests that the water table is lower in this area and that the area is at a higher elevation.

South Lobe


Willows, dead and live, along with Reed canary grass are the most dominant species along this part of the shore line. Aspen and poplar trees are visible in the back ground.


View south towards Hwy 11A & industrial area.

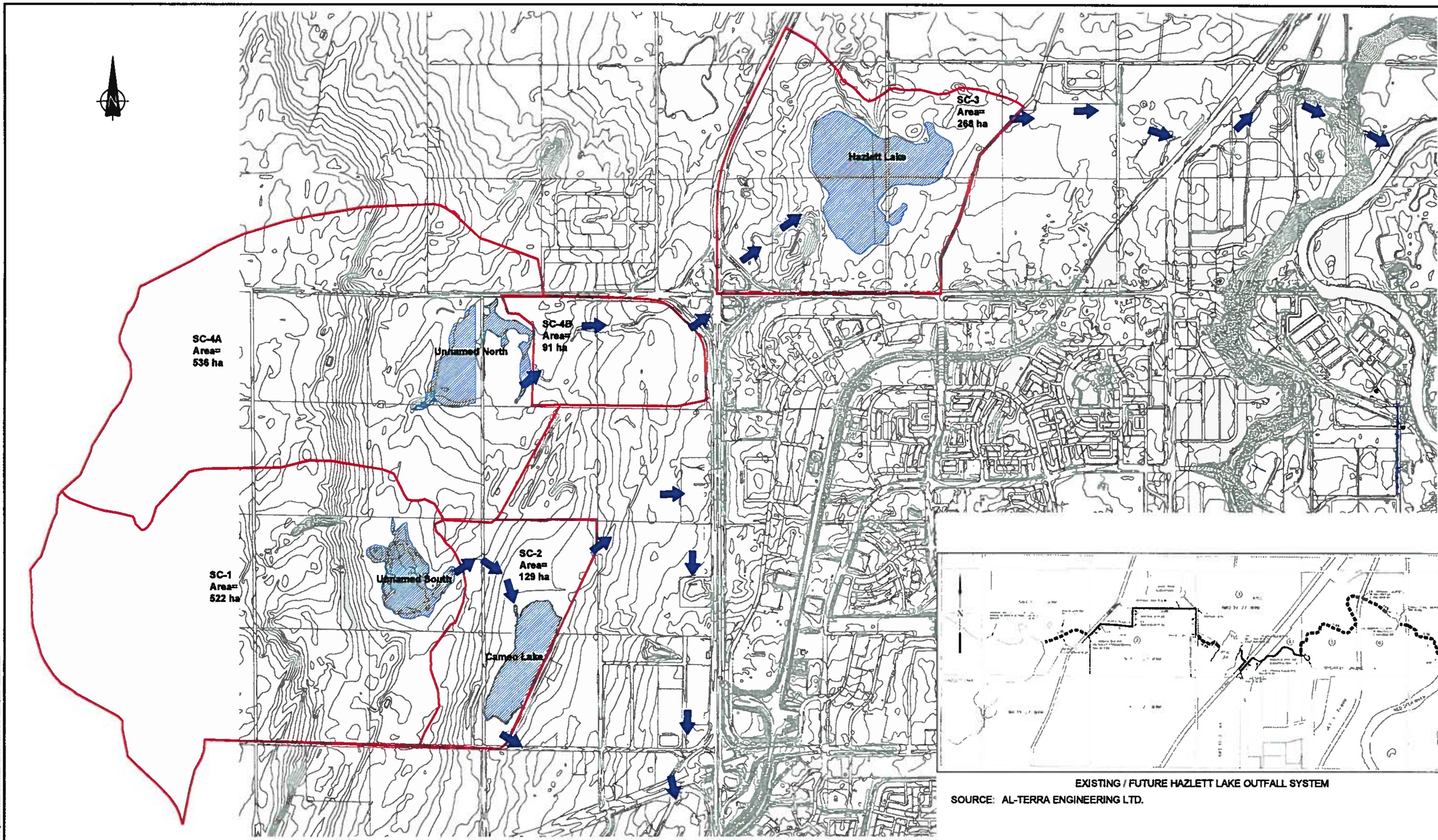
Table 1: Vegetation Inventory Lists

Treed Area Near House		Wetland Fringe		Northern Woodland		Wetland on East Side of Lake, Coinciding with Wetland Fringe Area	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**	**Common Name**	**Scientific Name**	**Common Name**	**Scientific Name**
Chokecherry	*Prunus virginiana*	Chokecherry	*Prunus virginiana*	Balsam poplar	*Populus balsamifera*	Willow sp	*Salix sp*
Aspen	*Populus tremuloides*	Balsam poplar	*Populus balsamifera*	Green ash	*Fraxinus pennsylvanica*	Smartweed sp	*Polygonum sp*
Balsam poplar	*Populus balsamifera*	Aspen	*Populus tremuloides*	Aspen	*Populus tremuloides*	Willowherb	*Epilobium sp*
Schubert		Willow sp	*Salix sp*	Willow sp	*Salix sp*	Fireweed	*Epilobium angustifolium*
Green ash	*Fraxinus pennsylvanica*	Saskatoon	*Amelanchier alnifolia*	Chokecherry	*Prunus virginiana*	Hedge nettle	*Stachys sp*
Lodgepole pine	*Pinus contorta*	Wild raspberry	*Rubus idaeus*	Pin cherry	*Prunus pensylvanica*	Dock sp	*Rumex sp*
Mountain ash	*Sorbus scopulina*	Buckbrush	*Symphoricarpos occidentalis*	Saskatoon	*Amelanchier alnifolia*	Mint	*Mentha arvensis*
Larch	*Larix occindentalis*	Pin cherry	*Prunus pensylvanica*	Dogwood sp	*Cornus sp*	Fringed loosestrife	*Lysimachia ciliata*
Crab apple		Wild rose	*Rosa sp*	Bunchberry	*Cornus Canadensis*	Shore buttercup	*Rancunculus sp*
White spruce	*Picea glauca*	Red osier dogwood	*Cornus sericea*	Snowberry	*Symphoricarpos albus*	Beggars tick	*Bidens cernua*
Willow sp	*Salix sp*	Black currant	*Ribes hudsonianum*	High bush cranberry	*Viburnum opulus ver americanum*	Marsh skullcap	*Scutellaria galericulata*
Colorado spruce	*Picea sp*	Gooseberry	*Ribes oxyacanthoides*	Twining honeysuckle	*Lonicera dioica*	Small bedstraw	*Galium sp*
Buckbrush	*Symphoricarpos occidentalis*	Currant	*Ribes sp*	White baneberry	*Actaea pachypoda*	**Stinkweed**	***Thlaspi arvense***
Saskatoon	*Amelanchier alnifolia*	Dewberry	*Rubus sieboldii*	Canada buffaloberry	*Shepherdia canadensis*	Plantian sp	
Red osier dogwood	*Cornus sericea*	Arrow-leaved coltsfoot	*Petasites frigidus var. sagittatus*	Dewberry	*Rubus sieboldii*	Rough cinquefoil	*Potentilla norvegica*
Late lilac	*Syringa villosa*	Wild peppermint/ bergamot	*Monarda fistulosa var. menthaefolia*	Wild raspberry	*Rubus idaeus*	Sedge sp	*Carex sp*
Purple sandcherry	*Prunus x cistena*	Wormseed mustard	*Erysimum cheiranthoides*	Buckbrush	*Symphoricarpos occidentalis*	Beaked sedge grass	*Carex utriculata*
Mugo pine	*Pinus mugo*	Marsh yellow cress	*Rorippa islandica*	Beaked hazelnut	*Corylus cornuta*	Marsh reed grass	*Calamagrostis Canadensis*
Nanking cherry	*Prunus tomentosa*	Solomon seal	*Polygonatum biflorum*	Cranberry		Cattail sp	*Typha sp*
Spiraea	*Spiraea sp*	Northern bedstraw	*Galium boreale*	Strawberry	*Fragaria sp*	Common reed grass	*Phragmites australis*
Horizontal juniper	*Juniperus horizontalis*	Wild sasparilla	*Aralia nudicaulis*	Wild mint	*Mentha arvensis*	Tickle grass	*Agrostis scabra*
Potentilla	*Potentilla sp*	Fireweed	*Epilobium angustifolium*	Meadowrue	*Thalictrum sp*	Stinging nettle	*Urtica dioica*
Mock orange	*Philadelphus lewisii*	Water lily	*Nuphar sp*	Cow parsnip	*Heracleum lanatum*	Hemlock sp	
Cotoneaster	*Cotoneaster horizontalis*	Columbine	*Aquilegia sp*	False Solomon seal	*Smilacina racemosa*	Spear leaf goosefoot	*Chenopodium sp*
Roses	*Rosa sp*	Cinquefoil sp	*Potentilla sp*	False loosestrife		Moss sp	
Goldenrod	*Solidago sp*	Cow parsnip	*Heracleum lanatum*	Sweet bedstraw	*Galium triflorum*	Yellow avens	*Geum aleppicum*
Quack grass	***Agropyron repens***	Yellow avens	*Geum aleppicum*	**Canary reed grass**	***Phalaris arundinacea***		
Canada thistle	***Cirsium arvense***	Lichen sp		Hosetail sp			
Perennials		Mushroom sp		Wood violet	*Viola sp*		
		Moss sp		Fairybells	*Disporum trachycarpum*		
		Plantain		Wintergreen	*Pyrola sp*		
		Dock sp	*Rumex sp*	Anemone sp	*Anemone sp*		
		Horsetail sp		Agrimony	*Agrimonia striata*		
		Canada thistle	***Cirsium arvense***	Wild lily of the valley	*Maianthemum canadense*		
		Stinging nettle	*Urtica dioica*	Wild sasparilla	*Aralia nudicaulis*		
		Goldenrod	*Solidago sp*	Aster sp	*Aster sp*		
		Hemp nettle	***Galeopsis tetrahit***	Giant hyssop	*Agastache foeniculum*		
		Wild oats	*Avena fatua*	Peavine sp	*Lathyrus sp*		
		Dandelion	***Taraxacum officinale***	Larkspur	*Delphinium sp*		
		Canada goldenrod	*Solidago canadensis*	Common yarrow	*Achillea millefolium*		
		Sedge sp	*Carex sp*	Harebells	*Campanula rotundifolia*		
		Canary reed grass	***Phalaris arundinacea***	Early blue violet	*Viola adunca*		
		Brome sp	*Bromus sp*	Showy aster	*Aster conspicuous*		
		Aster sp	*Aster sp*	Lungwort	*Boraginaceae sp*		
		Cattails	*Tyhpa sp*	**Canada thistle**	***Cirsium arvense***		
				Stinging nettle	*Urtica dioica*		
				Blue grass sp	*Poa sp*		
				Tall anemone	*Anemone sp*		
				Bee balm	*Monarda didyma*		
				Arrow-leaved coltsfoot	*Petasites frigidus var. sagittatus*		
				Hemlock sp	*Tsuga sp*		
				Sedge sp	*Carex sp*		
				Bullrush sp	*Scirpus sp*		
				Wild vetch	*Vicia Americana*		
				Palmate leafed coltsfoot	*Petasites frigidus*		
				Goldenrod sp	*Solidago sp*		
				Creamy peavine	*Lathyrus ochroleucus*		
				Cattail sp	*Typha sp*		
				Cup lichen			
				Lichen sp			
				Bracket lichen			
				Moss sp			
				Witches broom			
				Hawkweed sp	*Hieracium sp*	Source: G. Moir, Hazlett Lake Inventory, 2006.	

Table 2: List of Birds Species Observed at Hazlett Lake

Date	Common Name	Scientific Name	Status	Date	Common Name	Scientific Name	Status	Date	Common Name	Scientific Name	Status
Apr/89	Common Loon	*Gaia immer*	C/SUM	May/90	Black-capped Chickadee	*Poecile atricapillus*	C/P	Jan/92	Northern Goshawk	*Accipiter gentilis*	UN/SUM
	Pied Billed Grebe	*Podilmbus podiceps*	C/SUM		Townsend's Solitaire	*Myadestes townsendi*	RH/SUM		Broad-winged Hawk	*Buteo platyperus*	UC/D/SUM
	Horned Grebe	*Podiceps auritus*	Y/SUM		Veery	*Catharus fuscescens*	C/SUM		Swainson's Hawk	*Buteo seainsoni*	C/D/RH/SUM
	Red-necked Grebe	*Podiceps grisegena*	D/SUM		Swainson's Thrush	*Catharus ustulatus*	C/SUM		Red Tailed Hawk	*Buteo jamaicensis*	C/SUM
	Eared Grebe	*Podiceps migricollis*	C/SUM		American Robin	*Turdus migratorius*	C/SUM		Rough-legged Hawk	*Buteo lagopus*	C/M/W
	Western Grebe	*Aechmorphorus occidentalis*	S/D/SUM		Gray Catbird	*Dumetella carolinensis*	C/RH/SUM		Golden Eagle	*Aquila chrysaetos*	Y/R/SUM
May/89	Double Crested Cormorant	*Phalacrocorax auritus*	C/SUM		Sprague's Pipit	*Anthus spraguei*	B/D/RH/SUM		American Kestrel	*Falco sparverius*	C/SUM
Sept/89	American Bittern	*Botaurus lentiginosus*	S/UN/D/SUM		Bohemian Waxwing	*Bombycilla garrulous*	C/SUM/W		Merlin	*Falco columberius*	C/SUM
	Great Blue Heron	*Ardea herodias*	ST/SUM		Cedar Waxwing	*Bombycilla cedrorum*	C/SUM	Sept 4/92	Peregrine Falcon	*Falco peregrinus*	RD/SR/RH/SUM
	Black Crowned Night Heron	*Nycticorax nycticorax*	Y/SUM		Northern Shrike	*Lanius excubitor*	M		Gyrfalcon	*Falco rusticolus*	UC/W
	Tundra Swan	*Cygnus columbianus*	M		European Starling	*Sturnus vulgaris*	C/SUM		Gray Partridge	*Perdix perdix*	ST/P
	Trumpeter Swan	*Cygnus buccinators*	E/B/SUM		Blue-headed Vireo	*Vireo solitarius*	C/SUM		Ring-necked Pheasant	*Phasianus colchicus*	Y/D/P
	Sandhill Crane	*Grus canadensis*	Y/UN/SUM		Warbling Vireo	*Vireo gilvus gilvus*	C/SUM		Ruffed Grouse	*Bonasa umbellus*	C/P
	Black-bellied Plover	*Pluvialis squatarola*	M		Philadelphia Vireo	*Vireo philadelphicus*	C/SUM		Sora	*Porzana carolina*	C/ST/SUM
	Semipalmated Plover	*Charadrius semipalmatus*	R/M		Red-eyed Vireo	*Vireo olivaceus*	C/SUM		American Coot	*Fulica americana*	C/SUM
	Killdeer	*Charadrius vociferous*	C/SUM		Tennessee Warbler	*Vermivora peregrine*	C/SUM	Jan 15/94	Red Breast Merganser	*Mergus serrator*	UN/UC/SUM
	American Avocet	*Recurvirostra americana*	C/D/RH/SUM		Orange-crowned Warbler	*Vermivora celata*	C/SUM		Ruddy Duck	*Oxyura jamaicensis*	C/SUM
	Greater Yellowlegs	*Tringa melanoleuca*	UC/SUM		Yellow Warbler	*Dendroica petechia*	C/SUM	1997	Rock Wren	*Salpinctes obsoletus*	RH/P
	Lesser Yellowlegs	*Tringa flavipes*	C/SUM		Yellow-rumped Warbler	*Dendrocia coronata*	C/SUM		House Wren	*Troglodytes aedon*	C/RH/SUM
	Willet	*Catoptrophorus semipalmatus*	Y/D/RH/SUM		Palm Warbler	*Dendroica palmarum*	C/SUM		Marsh Wren	*Cistothorus palustris*	C/SUM
	Spotted Sandpiper	*Actitis macularia*	C/SUM		Blackpoll Warbler	*Dendroica striata*	ST/SUM	Sept/98	Boreal Chickadee	*Poecile hudsonicus*	C/P
	Marbled Godwit	*Limosa fedoa*	C/RH/SUM		Black & White Warbler	*Mniotilta varia*	UC/Y/D/SUM		Red-breasted Nuthatch	*Sitta canadensis*	C/SUM
	Pectoral Sandpiper	*Calidris melanotos*	M		American Redstart	*Setophaga ruticulla*	C/SUM		White-breasted Nuthatch	*Sitta carolinensis*	UC/P/W
	Short-billed Dowitcher	*Limnodromus griseus*	UC/RH/SUM		Ovenbird	*Seiurus aurocapillus*	C/SUM	Dec/98	Golden Crowned Kinglet	*Regulus satrapa*	C/SUM
	Common Snipe	*Gallinago gallinago*	C/SUM		Northern Waterthrush	*Seiurus noveboracensis*	C/SUM		Ruby Crowned Kinglet	*Regulus calendula*	C/SUM
	Wilson's Phalarope	*Phalaropus tricolor*	C/SUM	June 1/90	American White Black Pelican	*Pelecanus erythrorhynchos*	S/D/SUM	May/02	Connecticut Warbler	*Oporornis agilis*	UN/SUM
	Franklin's Gull	*Larus pipixcan*	C/SUM	July/91	Mourning Dove	*Zenaida macroura*	ST/SUM		MacGillivry's Warbler	*Oporornis tolmiei*	RH/SUM
	Bonaparte's Gull	*Larus philadephia*	C/SUM		Great Horned Owl	*Bubo virginianus*	C/P		Common Yellowthroat	*Geothlypis trichas*	C/SUM
	Ring-billed Gull	*Larus delawarensis*	C/SUM		Short-eared Owl	*Asio fammeus*	B/P/UN/D		Wilson's Warbler	*Wilsonia pusilla*	RH/SUM
	California Gull	*Larus californicus*	ST/SUM		Common Nighthawk	*Chordeiles minor*	ST/SUM		Western Tanger	*Piranga ludoviciana*	C/SUM
	Common Tern	*Sterna hirundo*	C/SUM		Ruby-throated Hummingbird	*Archilochus colubris*	C/SUM		Rose-breasted Grosbeak	*Pheucticus ludovicianus*	C/SUM
	Black Tern	*Chilidonias niger*	D/Y/SUM	July 31/91	Osprey	*Pandion haliaetus*	UN/D		American Tree Sparrow	*Spizella arborea*	M
	Rock Dove	*Columba livia*	C/P		Bald Eagle	*Haliaeetus leucocephalus*	C/UC		Chipping Sparrow	*Spizella paaerina*	C/SUM
	Mountain Bluebird	*Dialia currucoides*	C/SUM		Northern Harrier	*Circus cyaneus*	SC/D		Clay Colored Sparrow	*Spizella pallida*	C/SUM
May/90	Yellow-bellied Sapsucker	*Sphyrapicus varius*	C/SUM		Sharp Shinned Hawk	*Accipiter striatus*	UN		Savannah Sparrow	*Passerculus sandwichensis*	C/SUM
	Downy Woodpecker	*Picoides pubescens*	C/ST/P		Cooper's Hawk	*Accipiter cooperii*	UN		Le Conte's Sparrow	*Ammodramus leconteii*	C/SUM
	Hairy Woodpecker	*Picoides villosus*	ST/P	Sept 15/91	Great White Fronted Goose	*Anser albifrons*	C/M		Song Sparrow	*Melospiza melodia*	C/UC/SUM
	Common/Northern Flicker	*Colaptes auratus*	C/SUM		Lesser Snow Goose	*Chen caerulescens*	C/M		Lincoln's Sparrow	*Melospiza lincolnii*	C/SUM
	Pileated Woodpecker	*Dryocopus pileatus*	ST/Y/P		Ross' s Goose	*Chen rossii*	C/M		White-throated Sparrow	*Zonotrichia albicollis*	C/SUM
	Western Wood-pewee	*Contopus sordidulus*	C/SUM		Canada Goose	*Branta canadensis*	C/SUM		White-crowned Sparrow	*Zonotrichia leucophrys*	RH/SUM
	Alder Flycatcher	*Empidonax alnorun*	C/SUM		Green – winged Teal	*Anas crecca*	ST/SUM		Dark-eyed Junco	*Junco hyemalis*	C/SUM
	Least Flycatcher	*Empidonax minimus*	C/SUM		Mallard	*Anas platyrhynchos*	C/SUM		Snow Bunting	*Plectrophenax nivalis*	M/W
	Eastern phoebe	*Sayornis phoebe*	C/UC/SUM		Northern Pintail	*Anas acuta*	C/S/SUM		Red-winged Blackbird	*Agelaius phoeniceus*	C/SUM
	Say's Phoebe	*Sayornis saya*	C/RH/SUM		Cinnamon Teal	*Anas cyanoptera*	UC/RH/SUM		Western Meadowlark	*Sturnella neglecta*	C/RH/SUM
	Eastern Kingbird	*Tyrannus tyrannus*	C/SUM		Northern Shoveler	*Anas clypeata*	ST/SUM		Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	C/SUM
	Horned Lark	*Eremophila alpestris*	RH/SUM		Gadwall	*Anas strepera*	ST/SUM		Brewer's Blackbird	*Euphagus cyanocephalus*	C/RH/SUM
	Purple Martin	*Progne subis*	RH/SUM		American Wigeon	*Anas Americana*	ST/HD/SUM		Brown-headed Cowbird	*Molothrus ater*	C/SUM
	Tree Swallow	*Tachycineta bicolor*	C/SUM		Canvasback	*Aythya valisineria*	LC/SUM		Northern/Baltimore Oriole	*Icterus galbula*	C/SUM
	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	UC/RH/SUM		Redhead	*Aythya Americana*	LC/SUM		Pine Grosbeak	*Pinicola enucleator*	W/SUM
	Bank Swallow	*Riparia riparia*	C/SUM		Ring-necked Duck	*Aythya collaris*	ST/SUM		Purple Finch	*Carpodacus purpureus*	C/SUM
	Cliff Swallow	*Petrochelidon pyrrhonota*	C/SUM		Great Scaup	*Aythya marila*	UC/M		Common Redpoll	*Carduelis flammea*	W
	Barn Swallow	*Hirundo rustica*	C/SUM		Lesser Scaup	*Aythya affinis*	C/LC/SUM		Hoary Redpoll	*Carduelis hornemanni*	UC/W/R
	Blue Jay	*Cyanocitta cristata*	C/P		White Winged Scoter	*Melanitta fusca*	C/D/SUM		Pine Siskin	*Carduelis pinus*	C/W/P/SUM
	Black-billed Magpie	*Pica pica*	C/P		Common Goldeneye	*Bucephala clangula*	C/SUM		American Gold Finch	*Carduelis tristis*	C/SUM
	American Crow	*Corvus brachyrhynchos*	C/P		Barrow's Duck	*Bucephala islandica*	UC/RH/SUM		Evening Grosbeak	*Coccothraustes vespertinus*	C/P/W
	Common Raven	*Corvus corax*	C/P		Bufflehead	*Bucephala albeola*	ST/SUM		House Sparrow	*Passer domesticus*	C/P
					Hooded Merganser	*Lophodytes cucullatus*	UC/RH/SUM				
					Common Merganser	*Mergus merganser*	ST/SUM				

Source: Dorothy Hazlett, courtesy of G. Moir, City of Red Deer Parks Department, 2006; McGillivray and Semenchuck. The Federation of Alberta Naturalists Field Guide to Alberta Birds. * C = common; R = rare; T = threatened; E = endangered; S = sensitive; SR = species at risk; UN = unknown population; ST = stable population; UC = uncommon; LC = locally common; D = declining; Y = Alberta's Yellow List – species of concern; B = Alberta's Blue List – species at risk; RD = Alberta's Red List – species at risk; M = migrant; RH = restricted habitat; W = winter resident; P = permanent resident; SUM = summer resident; HD = habitat degradation. Yellow = Indicator Species; Blue = Species on the Alberta Blue list, Yellow list or Red list.



LEGEND:

SUBCATCHMENT BOUNDARY

FLOW LEAVING CATCHMENT AREA

1:25 000 — 0, 500, 1000 m

Client: Red Deer	Project: QUEENS BUSINESS PARK MASTER DRAINAGE PLAN
Westhoff Engineering Resources, Inc. Land & Water Resources Management Consultants	Title: HYDROLOGICAL ASSESSMENT PRE-DEVELOPMENT CATCHMENT DELINEATION

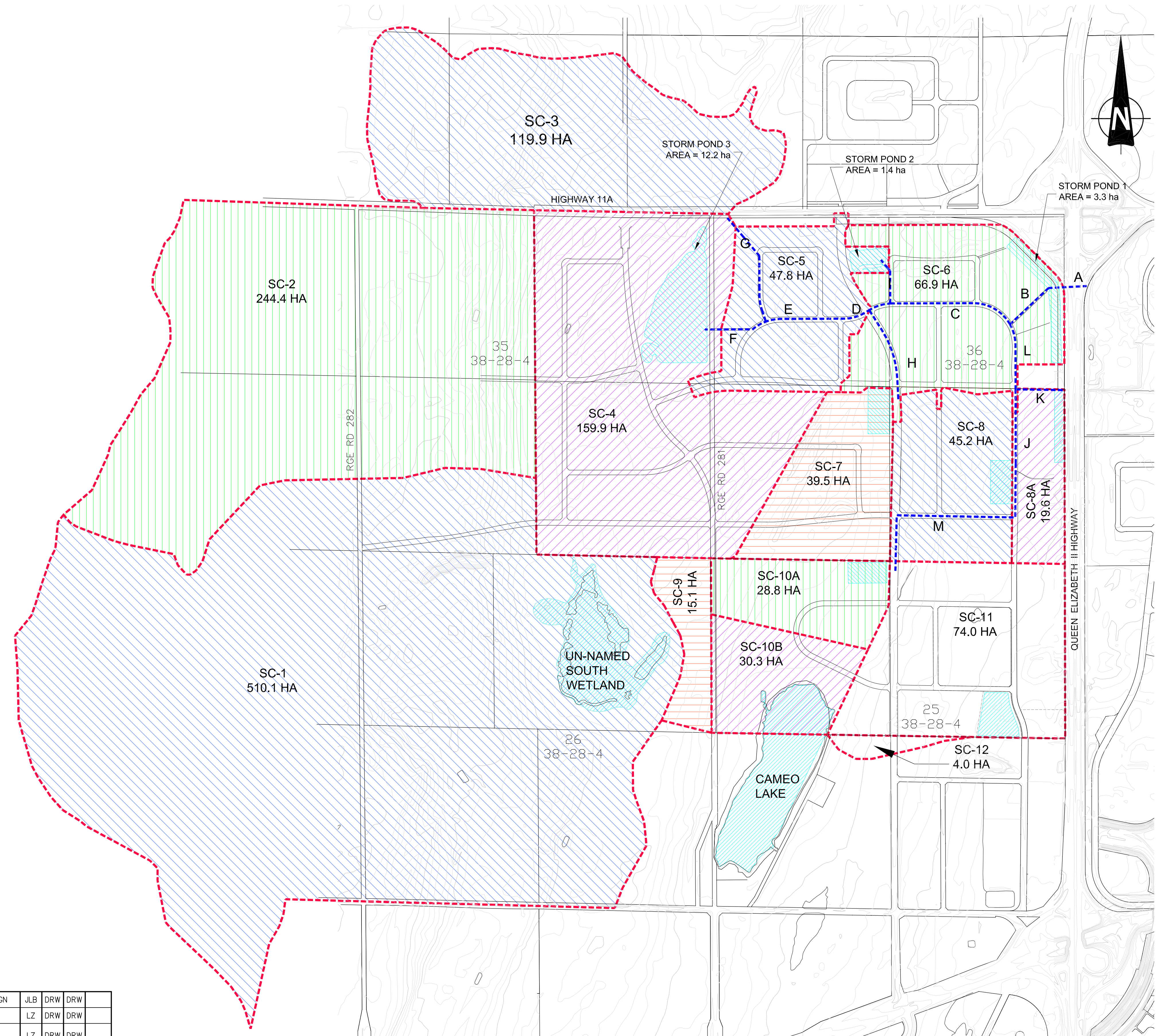
Date:	Job No.:	Cad File:	Figure No.:	Rev.
16/06/2008	WER105-52	10552L00.dwg	2	A

SUBCATCHMENT ID	AREA	UNIT-AREA RELEASE RATE	RELEASE RATE	SERVICED BY TRUNK	AREA SERVICED BY TRUNK	TRUNK CAPACITY REQUIRED	
	(ha)	(L/s/ha)	(L/s)		(ha)	(L/s)	
SC-1	510.1	1.39	709.0	NO	0.0	0.0	1.
SC-2	244.4	1.39	339.7	YES	244.4	0.0	2.
SC-3	119.9	1.39	166.7	YES	119.9	166.7	
SC-4	159.9	2.50	399.8	YES	159.9	399.8	
SC-5	47.8	9.02	431.2	YES	47.8	431.2	
SC-6	66.9	4.00	267.6	YES	66.9	267.6	
SC-7	39.5	4.00	158.0	YES	39.5	158.0	
SC-8	45.2	4.00	180.8	YES	45.2	180.8	
SC-8A	19.6	4.00	78.4	YES	19.6	78.4	
SC-9	15.1	1.39	21.0	NO	0.0	0.0	1.
SC-10A	28.8	4.00	115.2	YES	28.8	115.2	
SC-10B	28.8	4.00	115.2	NO	0.0	0.0	3.
SC-11	74.0	4.00	296.0	NO	0.0	0.0	3.
SC-12	4.0	1.34	5.4	NO	0.0	0.0	3.
TOTAL	1404.0				772.0	1797.6	

1. RUNOFF TO BE DIVERTED SOUTH INTO UN-NAMED SOUTH WETLAND.
2. FLOWS FROM CATCHMENT SC-2 WILL BE FLOW THROUGH FOR THE UPPER WETLAND (STORM POND 3) AND THE DOWNSTREAM TRUNK SYSTEM. PLEASE NOTE THAT AN XP-SWMM PRELIMINARY ANALYSIS INDICATES THAT UPSIZING OF THE TRUNK SYSTEM IS NOT NEEDED, GIVEN THE HYDROGRAPH LAG FROM THIS RURAL AREA.
3. RUNOFF FROM CATCHMENTS SC-11 AND SC-12 ARE EXCLUDED; CAMEO LAKE RELEASED LIMITE TO SUBACTHE SC-10A (I.E. 28.8 HA x 4.0 L/S/HA).
4. PRE-DEVELOPMENT FLOW CALCULATION:
   RED DEER RIVER AT RED DEER Q_{100} = 1540 m³/s
   EFFECTIVE DRAINAGE AREA = 11,100 km²
   UNIT-AREA-RUNOFF RATE = 1.39 L/s/ha

TRUNK SECTION	TRIBUTARY CATCHMENT AREAS	TOTAL AREA	TOTAL FLOW	LENGTH	SIZE	SLOPE	CAPACITY
		(ha)	(L/s)	(m)	Nominal mm	(%)	(L/s)
A	SC-2, SC-3, SC-4, SC-5, SC-6, SC-7, SC-8, SC-8A, SC-10A	772.0	1797.6	176	900	0.93	1821.3
B	SC-2, SC-3, SC-4, SC-5, SC-7, SC-8, SC-8A, SC-10A	705.1	1530.0	244	900	0.66	1534.3
C	SC-2, SC-3, SC-4, SC-5, SC-7	611.5	1155.6	588	900	0.39	1179.4
D	SC-2, SC-3, SC-4, SC-7	563.7	724.4	102	900	0.16	755.4
E	SC-2, SC-3, SC-4	524.2	566.4	486	675	0.43	575.0
F	SC-2, SC-4	404.3	399.8	289	525	0.80	401.3
G	SC-3	119.9	166.7	535	450	0.34	173.4
H	SC-7	39.5	158.0	441	450	0.30	162.9
I	SC-5	47.8	431.2	216	525	0.97	441.9
J	SC-8, SC-10A	74.0	296.0	342	675	0.15	343.0
K	SC-8A	19.6	78.4	217	375	0.24	89.6
L	SC-8, SC-8A, SC-10A	93.6	374.4	304	750	0.13	418.8
M	SC-10A	28.8	115.2	790	525	0.10	141.9

1. ELEVATIONS, LENGTH, AND SLOPES ARE PRELIMINARY.



LEGEND:

- CATCHMENT BOUNDARY
- PROPOSED STORM TRUNK
- STORM POND / EXISTING DEPRESSIONS
- CATCHMENT AREA

REV	DD-MM-YY	REVISION DESCRIPTION	DRN	DES	CHK	APPR
7	20-05-08	REVISED TO MATCH PHASE DESIGN	JLB	DRW	DRW	
6	07-05-07	REVISION TO TABLES	LZ	DRW	DRW	
5	23-04-07	REVISION TO TABLES AND SC-4/SC-5 AREAS	LZ	DRW	DRW	
4	05-02-07	REVISION TO TABLES	LZ	DRW	DRW	
3	21-11-06	ADD NEW POND AND CATCHMENT BOUNDARY	LZ	DRW	DRW	
2	09-11-06	REVISION TO TABLES	LZ	DRW	DRW	
1	09-03-06	ADDED TABLES	AZ	DRW	DRW	
0	06-03-06	ISSUED FOR CLIENT REVIEW	LZ	DRW	DRW	

Notes:

1. DIMENSIONS ARE IN MILLIMETRES, ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. ELEVATIONS, LENGTHS, SLOPES ARE PRELIMINARY.

1:10 000
0 100 200 300 400 m

ENGINEER'S SEAL:
PROFESSIONAL ENGINEER ALBERTA
DENNIS R. WESTHOFF

PERMIT:
PERMIT TO PRACTICE
WESTHOFF ENGINEERING RESOURCES INC.
Signature
Date
PERMIT NUMBER: P 6305
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

CONSULTANT:
Westhoff Engineering Resources, Inc.
Land & Water Resources Management Consultants
Suite 601, 1040 - 7th Avenue S. W., Calgary , Alberta, Canada, T2P 3G9
Phone: (403) 264-9366, Fax: (403) 264-8796, Email: werinc@westhoff.ab.ca

CLIENT:
THE CITY OF Red Deer

DESIGNED: D. WESTHOFF
DRAFTED: L. ZHAO
CHECKED: D. WESTHOFF
APPROVED: D. WESTHOFF
SCALE: 1:10,000

PROJECT: INDUSTRIAL LANDS RED DEER WEST

TITLE: CATCHMENT DELINEATION AND STORMWATER SERVICING

PROJECT No: WER105-73
CAD FILE: 10573J11
DATE: 06-03-06
DRAWING No: 001
SHEET No: 1 of 1