Elements

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THE NEWSLETTER OF THE CANADIAN GEOPHYSICAL UNION

IN THIS ISSUE

LE BULLETIN DE L'UNION GÉOPHYSIQUE CANADIENNE

CMOS/CGU Joint Congress

The joint CMOS/CGU Congress will be held on May 31 to June 4, 2010 in Ottawa, Ontario. This will be the 44th Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS) and the 36th Annual Scientific Meeting of the Canadian Geophysical Union (CGU). This will be the third occasion for a joint Congress between the two societies. The Congress theme for this year will be "Our Earth, Our Air, Our Water: Our Future". See: http://cmos.ca/congress2010/indexe.html

The Congress will feature:

- Plenary presentations by leading researchers.
- Science sessions that highlight top Canadian and international research contributions spanning the meteorological, oceanographic, geophysical, climatic and hydrologic sciences, as well as the policy implications of research in these fields.
- An evening lecture of general-interest, open to the public.
- A banquet, a hosted lunch, awards of CMOS and CGU prizes, and the Annual General Meetings of both societies.

Congrès conjoint SCMO/UGC

Le Congrès conjoint SCMO/UGC aura lieu du 31 mai au 4 juin 2010 à Ottawa, en Ontario. Il s'agira du 44^{e} Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO) et de la 36^{e} Rencontre scientifique annuelle de l'Union géophysique canadienne (UGC). Il s'agira de la troisième participation de ces deux sociétés à un congrès conjoint. Cette année, le thème du congrès sera : « La Terre, l'air et l'eau : Notre avenir ». Visitez: http://cmos.ca/congress2010/indexf.html

Le congrès comprendra:

- Des conférences plénières tenues par des scientifiques à la fine pointe de la recherche.
- Des sessions scientifiques accentuant les plus importantes découvertes de la recherche canadienne et internationale dans les domaines du climat, de la météorologie, de l'océanographie, de la géophysique et de l'hydrologie, ainsi que les implications politiques de la recherche avancée dans ces domaines.
- Une présentation en soirée d'intérêt général et ouverte au public.
- Un banquet et un dîner, la remise des prix de la SCMO et de l'UGC, et l'assemblée générale annuelle des deux sociétés.

Announcement and Call for Papers:
CMOS/CGU Joint Congress

Dear colleagues,

The joint CMOS/CGU Congress will be held on May 31 to June 4, 2010 in Ottawa, Ontario at the Crowne Plaza. This will be the 44th Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS) and the 36th Annual Scientific Meeting of the Canadian Geophysical Union (CGU). This will be the third occasion for a joint Congress between the two societies. The Congress theme for this year will be "Our Earth, Our Air, Our Water: Our Future". See: http://cmos.ca/congress2010/indexe.html

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- An evening lecture of general-interest, open to the public.
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Please submit abstracts electronically to the link found on the Congress website (http://cmos.ca/congress2010/abstractse.html) **after January 7, 2010 and before the deadline of February 17, 2010**. You will be asked to submit your abstract to one of several planned sessions that are listed on the website and to specify your preference for either an oral or a poster presentation. An abstract fee of $50 will be charged at the time of submission. Your abstract will be evaluated by the Scientific Program Committee and you will be notified of acceptance by **2 March 2010**. Details for your oral or poster presentation will be provided by **17 March 2010**.

CMOS and CGU student members are welcomed and encouraged to apply for a Student Travel Bursary when submitting an abstract; the application form may be found at: http://cmos.ca/congress2010/studentse.html The deadline for submission is **February 26, 2010**.

If you are an exhibitor, an educator, a member of the media, or anyone else with an interest in the meeting, please visit the Congress website

(http://www.cmos.ca/congress2010) and contact the Chair of the Local Arrangements Committee for further information.

Sincerely,

Dick Stoddart (dick.stoddart@sympatico.ca)

Rod Blais (blais@ucalgary.ca)

Co-Chairs of the Scientific Program Committee for the Ottawa 2010 Congress

Annonce et appel des soumissions de résumés :
Congrès conjoint SCMO/UGC

Chers collègues :

Le Congrès conjoint SCMO/UGC aura lieu du 31 mai au 4 juin 2010 à Ottawa, en Ontario, au Crowne Plaza. Il s'agira du 44[e] Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO) et de la 36[e] Rencontre scientifique annuelle de l'Union géophysique canadienne (UGC). Il s'agira de la troisième participation de ces deux sociétés à un congrès conjoint. Cette année, le thème du congrès sera : « La Terre, l'air et l'eau : Notre avenir ». Visitez: http://cmos.ca/congress2010/indexf.html

Le congrès comprendra:

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- Des sessions scientifiques accentuant les contributions ultimes de la recherche canadienne et internationale dans les domaines du climat, de la météorologie, de l'océanographie, de la géophysique et de l'hydrologie, ainsi que les implications politiques de la recherche avancée dans ces domaines.
- Une présentation d'intérêt général dans la soirée ouverte au public.
- Un banquet, un déjeuner inclus, la remise des prix de la SCMO et de l'UGC, et l'assemblée générale annuelle des deux sociétés.

Veuillez soumettre vos résumés électroniquement en utilisant le lien sur le site du congrès (http://cmos.ca/congress2010/abstractsf.html) entre le **7 janvier et le 17 février 2010**. Vous devrez soumettre votre résumé sous une des nombreuses sessions affichées sur le site et spécifier votre préférence quant à une présentation orale ou une présentation affichée. Des frais de $50 seronts retenus au moment de la soumission. Votre soumission sera évaluée par le comité du programme scientifique du congrès qui vous avisera de son acceptation le **2 mars 2010**. Les détails pour votre présentation orale ou affichée vous seront communiqués le **17 mars 2010**.

Les étudiants, membres de la SCMO et de l'UGC, sont les bienvenus et ils sont encouragés à soumettre une demande de bourse étudiante d'aide au voyage lors de la soumission de leur résumé; le formulaire d'application se trouve à : http://cmos.ca/congress2010/studentsf.html La date limite pour les soumissions est le **26 février 2010.**

Si vous êtes un exposant, un éducateur, un membre des médias, ou quelqu'un avec un intérêt particulier pour le congrès, veuillez visiter le site Web du congrès (http://www.cmos.ca/congress2010) ou contactez le président du Comité des arrangements locaux pour obtenir plus d'information.

Cordialement,

Dick Stoddart (dick.stoddart@sympatico.ca)

Rod Blais (blais@ucalgary.ca)

Coprésidents du Comité du programme scientifique pour le Congrès de 2010 à Ottawa

J. Tuzo Wilson Medal – Call for Nominations

The Executive of the CGU solicits nominations for the J. Tuzo Wilson Medal – 2010. The Union makes this award annually to recognize outstanding contributions to Canadian geophysics. Factors taken into account in the selection process include excellence in scientific and/or technological research, instrument development, industrial applications and/or teaching.

If you would like to nominate a candidate, please contact Dr. Hugh Geiger, Chair of the CGU Awards Committee, Talisman Energy, Calgary AB (Email: HGEIGER@talisman-energy.com). At a minimum, the nomination should be supported by letters of recommendation from colleagues, a brief biographical sketch and a Curriculum Vitae. Nominations should be submitted by February 28, 2010. Additional details concerning the nomination process can be obtained from the Chair of the CGU Awards Committee.

L'exécutif de l'UGC vous invite à suggérer des candidats pour la médaille J. Tuzo Wilson – 2010. L'Union décerne la médaille chaque année "en reconnaissance d'une contribution remarquable à la géophysique canadienne". En choisissant parmi les candidats, on considére les accomplissements en recherches scientifique ou technologiques, aux développements d'instruments, aux applications industrielles et/ou à l'enseignement.

Si vous désirez suggérer un candidat pour cette médaille, s.v.p. contacter Dr. Hugh Geiger, Président du Comité des Prix d'Excellence, Talisman Energy (Email: HGEIGER@talisman-energy.com). Les nominations doivent être supportées de lettres de recommandation de colléques, d'un bref sommaire biographique et d'un Curriculum Vitae. Les nominations doivent être soumises avant le 28 février, 2010. Des détails additionnels concernant le processus de nomination peuvent être obtenus en communiquant avec le Président du Comité des Prix d'Excellence de l'UGC.

Past Wilson Medallists

1978	J. Tuzo Wilson
1979	Roy O. Lindseth
1980	Larry W. Morley
1981	George D. Garland
1982	Jack A. Jacobs
1983	D. Ian Gough
1984	Ted Irving
1985	Harold O. Seigel
1986	Michael Rochester
1987	David Strangway
1988	Ernie Kanasewich
1989	Leonard S. Collett
1990	Gordon F. West
1991	Thomas Krogh
1992	R. Don Russell
1993	Alan E. Beck
1994	Michael J. Berry
1995	Charlotte Keen
1996	Petr Vaníček
1997	Chris Beaumont
1998	Ron M. Clowes
1999	David Dunlop
2000	Don Gray
2001	Roy Hyndman
2002	Doug Smylie
2003	Garry K.C. Clarke
2004	W.R. (Dick) Peltier
2005	Ted Evans
2006	Alan Jones
2007	Herb Dragert
2008	Ming-ko (Hok) Woo
2009	Garth van der Kamp

CGU Young Scientist Award – Call for Nominations

The Executive of the CGU solicits nominations for the CGU Young Scientist Award – 2010. The CGU Young Scientist Awards recognize outstanding research contributions by young scientists who are members of the CGU. Both the quality and impact of research are considered. To be eligible for the award, the recipient must be within 10 years of obtaining their first Ph.D. or equivalent degree. The awards are made by the CGU Executive on the recommendations of a special committee struck for this purpose. The selection committee seeks formal written nominations from the membership, plus letters of support and a current curriculum vitae. Nominations for the CGU Young Scientist Awards may be submitted by CGU members at any time.

If you would like to nominate a candidate, please contact Dr. Hugh Geiger, Chair of the CGU Awards Committee, Talisman Energy, Calgary AB (Email: HGEIGER@talisman-energy.com). The nomination should be supported by three letters of recommendation from colleagues. Nominations should be submitted by February 28, 2010. Additional details concerning the nomination process can be obtained from the Chair of the CGU Awards Committee.

L'exécutif de l'UGC vous invite à suggérer des candidats pour le prix pour Jeune Scientifique de l'UGC – 2010. Les Prix pour Jeunes Scientifiques de l'UGC reconnaissent les contributions exceptionnelles de jeunes scientifiques qui sont membres de l'UGC. La qualité et l'impact de la recherche sont considérés. Pour être éligible pour le prix, le scientifique doit avoir obtenu son premier Ph.D. ou degré équivalent au cours des dix dernières années. Les prix sont accordés par l'Exécutif de l'UGC sur recommendations d'un comité spécial à cette fin. Le comité de sélection sollicite des nominations formelles par écrit des membres de l'UGC, accompagnées de lettres d'appui et d'un curriculum vitae à jour. Des nominations pour les Prix pour Jeunes Scientifiques de l'UGC peuvent être soumis en tout temps par les membres de l'UGC.

Si vous désirez suggérer un candidat pour cette médaille, s.v.p. contacter Dr. Hugh Geiger, Président du Comité des Prix d'Excellence, Talisman Energy, Calgary AB (Email: HGEIGER@talisman-energy.com). Les nominations doivent être supportées de trois lettres de recommandation de colléques. Les nominations doivent être soumises avant le 28 février, 2010. Des détails additionnels concernant le processus de nomination peuvent être obtenus en communiquant avec le Président du Comité des Prix d'Excellence de l'UGC.

Past Winners

2005 Shawn J. Marshall, J. Michael Waddington
2006 No winner
2007 No winner
2008 Brian Branfireun, Scott Lamoureux
2009 Gwenn Flowers, Stephane Mazzotti

CGU Meritorious Service Award – Call for Nominations

The Executive of the CGU solicits nominations for the CGU Meritorious Service Award – 2010. The CGU Meritorious Service Award recognizes extraordinary and unselfish contributions to the operation and management of the Canadian Geophysical Union by a member of the CGU. All members of the CGU are eligible for this award, although the award is not normally given to someone who has received another major award (e.g. the J. Tuzo Wilson Medal). Nominations for the CGU Meritorious Service Award may be submitted by CGU members at any time. The award is made by the CGU Executive based on recommendations from the CGU Awards Committee, and is based on lifetime contributions to CGU activities.

If you would like to nominate a candidate, please contact Dr. Hugh Geiger, Chair of the CGU Awards Committee, Talisman Energy, Calgary AB (Email: HGEIGER@talisman-energy.com). The nomination should be supported by three letters of recommendation from colleagues. Nominations should be submitted by February 28, 2010. Additional details concerning the nomination process can be obtained from the Chair of the CGU Awards Committee.

L'exécutif de l'UGC vous invite à suggérer des candidats pour le Prix pour Service Méritoire de l'UGC – 2010. Le Prix pour Service Méritoire de l'UGC reconnait les contributions extraordinaires et désintéressées à l'opération et à l'administration de l'Union Géophysique Canadienne par un membre de l'UGC. Tous les membres de l'UGC sont éligibles pour ce prix, sauf que normalement, ce prix n'est pas donné à quelqu'un qui a recu un autre prix important tel que la Médaille Tuzo Wilson. Des nominations pour le Prix pour Service Méritoire de l'UGC peuvent être soumises en tout temps par les membres de l'UGC. Le Prix est accordé par l'Exécutif de l'UGC sur recommendations du Comité des Prix de l'UGC, pour l'ensemble des contributions d'un membre aux activités de l'UGC.

Si vous désirez suggérer un candidat pour cette médaille, s.v.p. contacter Dr. Hugh Geiger, Président du Comité des Prix d'Excellence, Talisman Energy, Calgary AB (Email: HGEIGER@talisman-energy.com). Les nominations doivent être supportées de trois lettres de recommandation de colléques. Les nominations doivent être soumises avant le 28 février, 2010. Des détails additionnels concernant le processus de nomination peuvent être obtenus en communiquant avec le Président du Comité des Prix d'Excellence de l'UGC.

Past Winners

2004 Ron Kurtz
2005 Ted Glenn
2006 J.A. Rod Blais
2007 Ed Krebes
2008 Patrick Wu
2009 Gary Jarvis

CGU-UGC ARCHIVAL CD FOR 2009

An ISO disk image of the 2009 Archival CD will be available shortly from our CGU website for downloading along with some instructions. The ISO image can be used directly with virtual CD mounting with or without CD burning using open source and commercial software. For any further information, please feel free to contact the undersigned at any time.

■ Rod Blais

GEODESY SECTION NEWS

Prepared by Marcelo Santos

Ottawa 2010 Joint Meeting CGU-CMOS

Likewise the Meeting in St. John's, the Ottawa Meeting is going to be a Joint Meeting with the Canadian Meteorological and Oceanographical Society (CMOS). Please check the geodesy-related sessions to take place as they will be advertised soon. Other activities planned to take place during the Joint Meeting are the Geoid Workshop and the Annual General Meeting.

Student Paper Competition:

Students are encouraged to participate. Please, check the normal deadline for CGU abstracts. Final deadline for the extended abstracts will be 14 May 2010, two weeks before the meeting.

Perspectives on Modern Geodesy Research

This is the title of the Special Issue of the Canadian Journal of Earth Sciences dedicated to papers presented at geodesy sessions of the 2008 CGU Meeting. This is issue is the Volume 46, Number 8, issued in August 2009. Link to this issue can be found at:
http://pubs.nrc-cnrc.gc.ca/rp-ps/inDetail.jsp?jcode=cjes&lang=eng&vol=46&is=8

We are planning to have another special issue based on papers presented at the 2010 Joint Meeting. Please, check the Geodesy Section website for more information.

Membership

Please, do not forget to check "Geodesy Section" whenever renewing your CGU membership.

CGU 2009 Best Student Paper Awards

Abstracts follow for the D.M. Gray Award for Best Student Paper in Hydrology (C.J Oswald) and for the Campbell Scientific Award for Best Student Poster in Hydrology (S.J. Ketcheson):

Hydrologic connectivity and runoff response in the METAALICUS catchment

Claire J. Oswald* and Brian A. Branfireun
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3359 Mississauga Rd. N., Mississauga, Ontario, L5L 1C6, Canada. *claire.oswald@utoronto.ca

ABSTRACT

Hydrological processes exert a major control on the timing and magnitude of the boreal upland response to changes in mercury loading. Our overarching goal is to understand how changes in water storage and hydrologic connectivity in the catchment control water, dissolved organic carbon, and mercury runoff to the lake. In this study, we examine the nature of the runoff responses measured in the METAALICUS (Mercury Experiment to Assess Atmospheric Loading in Canada and the United States) experimental upland catchment located at the Experimental Lakes Area in north-western Ontario. Inter-year comparisons of rainfall and stream discharge response show that there is substantial variability from wet to drier conditions. Hydrograph separations of 58 storm events indicate a threshold of 6 mm of rainfall required to generate a runoff response at the catchment outlet. Seasonal variations in runoff response indicate a 'wet' season in spring/early summer and a 'dry' season in late summer/autumn. A comparison of runoff responses to 'wet' and 'dry' season storm events indicates that antecedent soil moisture and water table elevation in large, soil-filled bedrock depressions exert a primary and predictable control on runoff generation by regulating subwatershed hydrologic connectivity. The *fill-and-spill* hydrologic behavior of this catchment suggests that the timing and magnitude of mercury export will be influenced by not only the size of the runoff event, but also by the extent of hydrologic connectivity between different landscape units within the catchment.

INTRODUCTION

The response of fish methylmercury concentrations to changes in mercury deposition remains difficult to establish due to uncertainty about the hydrologic processes that control the magnitude and timing of mercury release from upland soils and the export of upland mercury to the lake (Munthe et al., 2007). Previous studies (e.g. Bushey et al., 2008; Branfireun et al., 1996) have measured large fluxes of mercury coincident with large runoff events, such as snowmelt and storms that generate quickflow, however, process explanations of these hydrological controls remains sparse, especially in the boreal Shield region of Canada. Hydrological studies carried out across the boreal Shield have examined the relative roles of surface and bedrock topography, spatially heterogeneous soil depths, event timing and magnitude, and antecedent wetness conditions on runoff generation (Allan and Roulet, 1994; Branfireun and Roulet, 1998; Buttle et al., 2004; Spence and Woo, 2006). The present study is a logical extension of this work and aims to apply previous conceptual findings in a framework that is scalable. Central to this framework is the ability to quantitatively demonstrate how spatial variations in topography and soil depth can have a dramatic influence on storage deficits and excesses, hydrologic connectivity between unique landscape elements, and ultimately discharge to lakes.

The goal of this study is to develop a process explanation for the hydrologic response observed in the METAALICUS experimental catchment. The specific objectives are to: (1) evaluate the nature of the hydrologic response in the catchment under wet to drier conditions; (2) examine differences in hydrologic connectivity for two storm events that are similar in magnitude but occur under different states of wetness in the catchment. We hypothesize that the hydrologic response of the catchment will exhibit threshold behaviour and that the state of water storage in topographically-constrained landscape units will control hydrologic connectivity and discharge dynamics. Thus, we examined seasonal patterns of runoff response for 58 storm events spanning 6 years to address objective (1), and analyzed one year's worth of spatially intensive discharge, water table and soil moisture data to address objective (2).

STUDY SITE

The study was conducted in the 7.75 ha catchment (UP1) of the Lake 658 (L658) METAALICUS experimental watershed, located in the Experimental Lakes Area (ELA) in north-western Ontario (49˚ 40' N, 93˚ 43' W). The climate of the study area is boreal cold temperate. Mean annual air temperature is 2.7 ˚C and mean annual precipitation is 662 mm, 78% of which is rain (Canadian Climate Normals, 1971-2000). UP1 is drained by a short, ephemeral stream into L658, with high flows during spring snowmelt, and early summer and fall rain storms. UP1 is south-facing and the morphology of the basin is a complex array of flat areas underlain by bedrock depressions and steep bedrock cliffs on the western side, and more subdued, continuous slope on the east side (Fig. 1). The mean slope is 12 ˚ and the difference in elevation from the outflow datum to the watershed divide is 63 m. UP1 is underlain by unfractured, granitic bedrock, which is exposed over approximately 16 % of the catchment. In the remaining areas, soils range in depth from 5 to 250 cm with an average soil depth of 57 cm. The soils are humic regosols and sombric brunisols, are texturally classified as silt loams, and are likely of a glaciolacustrine origin (Allan and Roulet 1994). The mineral horizon is made up of a sandy till and this is overlain by an organic layer in various stages of decomposition. UP1 contains significant coverage of wet depressions, which are located on large bedrock shelves that cascade down the west side of the catchment. In these areas, the organic horizon is relatively thick and *Sphagnum* spp. dominate the forest floor. The dominant tree species are black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), and paper birch (*Betula papyrifera*). Lichens, mosses, and juniper grow on and from shallow fractures in the bedrock outcrops.

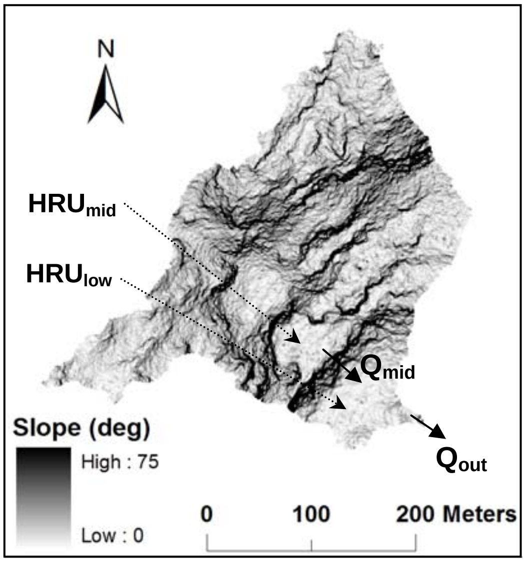

Figure 1: Surface topography of the UP1 study catchment expressed as slope. Instrumentation and areas of interest are marked.

METHODS

The ground return from a LIDAR (light detection and ranging) survey flown in 2006 was used to generate a sub-metre resolution digital elevation model (DEM) of the L658 watershed. ESRI ArcMap and SAGA GIS software were used to estimate the locations of flow convergence based on the DEM. Manual measurements of shallow soil moisture and visual observations were used to verify the existence of these subsurface flowpaths and points of surface flow convergence over bedrock sills. 200 manual measurements of depth-to-bedrock were used to create a model of the soil thickness and bedrock topography in the catchment. Hydrologic response units (HRUs) were defined using the DEM, estimated flowpaths, and the soil thickness model. The two HRUs of interest in this study are labeled in Fig. 1.

Open precipitation and throughfall were measured with tipping bucket rain gauges in HRU_{low} by the United States Geological Survey (USGS) since 2001 and at a meteorological tower in HRU_{mid} since July 2007. Outlet discharge (Q_{out}) from the UP1 catchment to L658 has been monitored from mid-April to late-October since 2001 by the USGS using a flume equipped with a bubble water level recorder. Since July 2007, midslope discharge (Q_{mid}) from HRU_{mid} to HRU_{low} has been monitored during the same seasons using a 60˚ V notch weir-box equipped with a pressure transducer. Short diversion walls were built to encourage the already existing convergence of surface flow over an exposed bedrock sill. In June 2007, 26 screened, PVC wells were installed to refusal in key HRUs. 1.5 m-long capacitance water-level recorders were installed in 18 of the wells during the periods of flow monitoring. All 18 recording sites also had continuous measurements of shallow (7.5 to 12.5 cm below surface) soil volumetric water content.

The 2001-2008 (excluding 2003 and 2007) hydrographs were separated into quickflow (QF) and baseflow components using a modified constant discharge method. 58 storm events were identified during this time period.

RESULTS

In this study we focus on quickflow generation because it is associated with the periods of greatest discharge and mercury fluxes to the lake. Fig. 2a shows quickflow depths and runoff coefficients for all storms measured between 1 April and 31 October in UP1 during the 2001-2008 period (excluding 2003 and 2007; n = 58). Storm precipitation has to exceed a threshold depth of 6 mm in order to

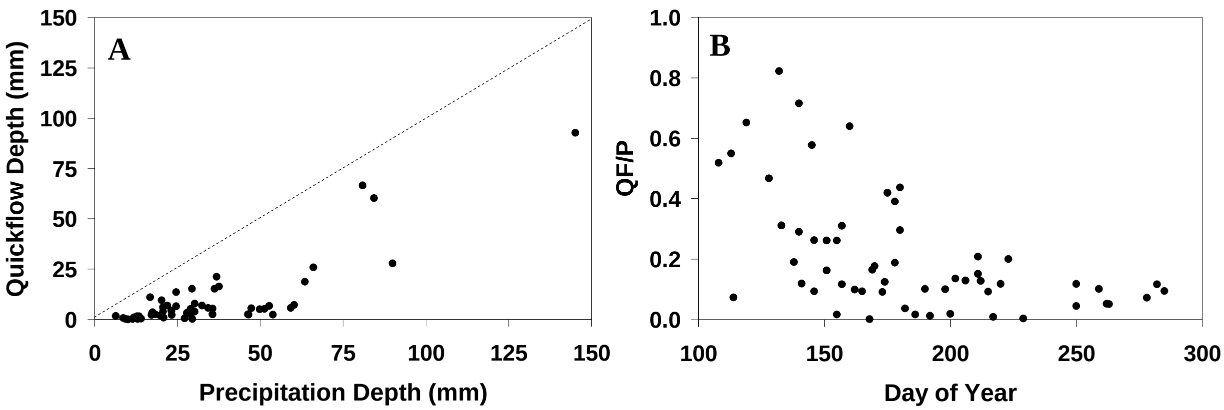

Figure 2: a) The threshold relationship between storm precipitation and quickflow and b) the seasonal trend of runoff coefficients.

generate quickflow from the catchment. Quickflow tends to increase linearly after this threshold; however there is significant scatter in this relationship ($r^2 = 0.62$) (Fig. 2a). Fig. 2b shows a large range in QF/P values in the spring and a distinct drop to less than 0.2 after 30 June (DOY 181). 33% of the QF/P values are < 0.1, 31% are between 0.1 and 0.2, and 36% are > 0.2. Only 12% of QF/P are > 0.5.

In 2008, 550mm of rain fell between Apr 16 and Oct 29, making it a wet year relative to the 1971-2000 mean during the same period, which was 66 mm less. Flow from HRU_{mid} to HRU_{low} (Q_{mid}) is continuous throughout the spring and early summer, however in mid-August it stops (Fig. 3). HRU_{low} continues to drain (Q_{out}) and possibly receives subsurface flow from the east side of the catchment until early September when it too ceases to flow. Q_{mid} and Q_{out} resume in mid-October, however baseflow is less than in the spring and flow is only sustained for 10 days.

The late-June and mid-October storm events indicated by arrows in Fig. 3 are used to illustrate how changes in hydrologic connectivity between HRU_{mid} and HRU_{low} affect the runoff response of the catchment. Table 1 summarizes the characteristics of these two storms. The precipitation input of both storms is close to 60 mm, however the QF/P is 0.205 larger in June. The water table depth and shallow volumetric water content the day before the June storm are 18 cm and 27 % higher, respectively. The hydrographs in Fig. 3 also indicate that during the October storm, HRU_{mid} only drains for 5 days, while HRU_{low} drains for 11 days and responds to a subsequent small storm event.

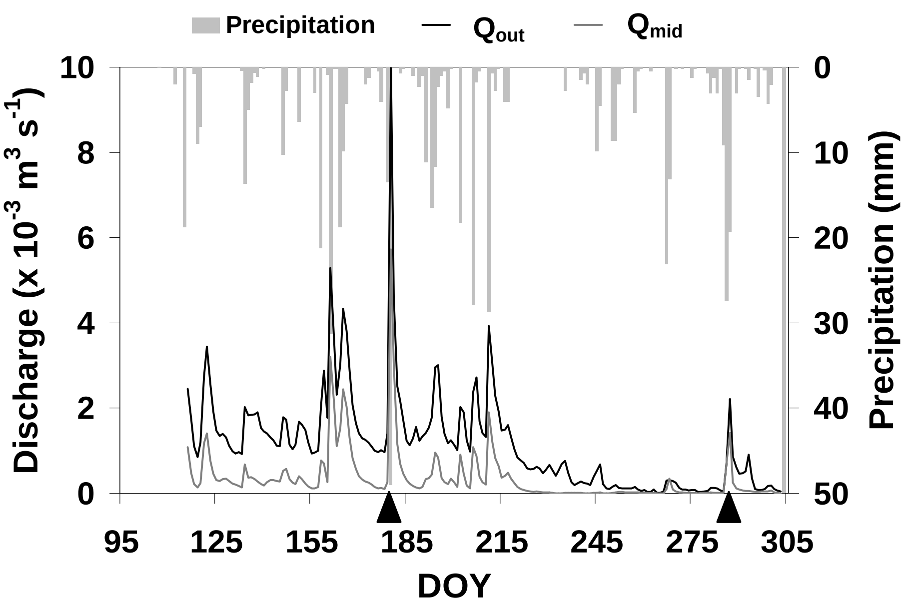

Figure 3: Rainfall, outlet and midslope discharge in 2008. Arrows indicate storm events starting on DOY 179 (27 June) and DOY 285 (11 October).

In order to understand the nature of hydrologic connectivity between HRU_{mid} and HRU_{low}, the water table records from sites within each HRU were examined (the well sites closest to the flow gauges are shown in Fig. 4). At the Q_{mid} site there is relatively no discharge until the water-table in HRU_{mid} rises to approximately 1.7 m above the bedrock surface (Fig. 4a). The same pattern is seen for HRU_{low} and Q_{out} (Fig. 4b). In HRU_{low}, the water table must rise to approximately 1.65 m above the bedrock, near the ground surface (same elevation as downslope bedrock sill) before discharge increases significantly. Scatter below the sill heights likely reflects flow derived from precipitation inputs on the area between the sill and the site of flow measurement.

*Table 1: Characteristics of the late-June and mid-October storms. *On the day prior to the start of the runoff event.*

Event Starting On DOY (Date)	P (mm)	QF/P	WT Depth Above Bedrock in HRU_{mid} (m) *	WT Depth Above Bedrock in HRU_{low} (m) *	Shallow Volumetric Water Content (%) *
179 (27 June)	62.5	0.30	1.77	1.67	53
285 (11 October)	59.2	0.095	1.63	1.49	26

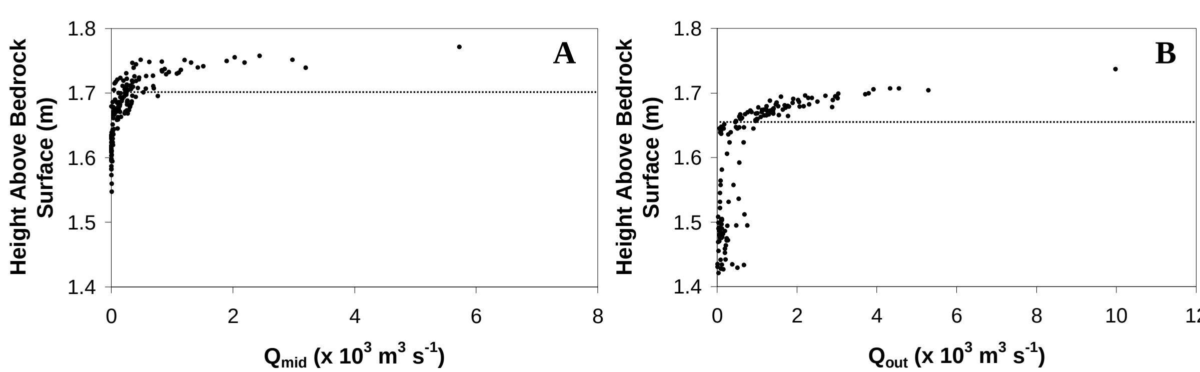

Figure 4: Relationship between water-table height and discharge for a) HRU_{mid} and b) HRU_{low} (dashed lines indicate the elevation of bedrock sills along the downslope edge of each HRU).

DISCUSSION AND CONCLUSIONS

The QF/P analysis of 6 years worth of historical data indicates that a threshold rainfall amount of 6mm is required for runoff to occur. Previous studies on the Canadian Shield have also found a threshold runoff response of similar magnitude (Branfireun et al., 1998; Buttle et al., 2004). The scatter in Fig. 2a likely reflects the role of antecedent wetness conditions and the state of water storage in the catchment. 33% of the QF/P ratios were less than 0.1, which is the approximate fraction of the catchment occupied by HRU_{low}. QF/P ratios greater than 0.1 suggest hydrologic connectivity from HRUs that are higher in the catchment. Events where more than half of the catchment is contributing are limited to the spring season when inputs from snowmelt and precipitation dominate evaporative losses and a state of storage excess exists. In 2008, baseflow, water table height, and shallow soil moisture were all greater than in the fall. The runoff response of two similarly-sized events, one beginning on 27 June and the second on 11 October, reflect these differences in antecedent wetness and storage state. During the 'wet' spring/early summer season, the height of the water table in HRU_{mid} is higher than the bedrock sill and storage excess is transferred to HRU_{low}. The 'wet' conditions in HRU_{low} combined with inputs from upslope generate a greater runoff response than the 'dry' season storm in mid-October. This storm begins with the water table in HRU_{mid} below the elevation of the sill, however over the course of the storm the water table rises enough to generate Q_{mid} for 5 days. After Q_{mid} stops, Q_{out} continues as HRU_{low} drains and possibly receives some input from the continuously sloping HRU on the eastern side of the catchment.

The results of this study indicate that drainage of large, soil-filled bedrock depressions is limited to times when the water table rises above the elevation of the downslope sill. These types of HRUs act like a bucket that *fills-and-spills*, such that a *storage deficit* exists when the water table is lower than the sill and when the water table is higher than the sill the *storage excess* translates into flow to the next HRU. This process explanation is similar to the findings of Spence and Woo (2006) and Allan and Roulet (1994). Although this process of runoff generation and hydrologic connectivity is not the only one operating in UP1, it's influence on discharge to the lake is evident when comparing storm events occurring during 'wet' and 'dry' seasons.

The progression of this work will involve quantifying the relationship between the amount of water stored in different HRUs during 'wet' and 'dry' periods, and the topography and soil characteristics of the unit. The UP1 catchment is fairly typical of the Canadian Shield landscape in the region and thus provides an opportunity to scale these results such that they are applicable in other catchments. Ultimately, these findings will be combined with information on the behaviour of mercury in boreal soils in order to predict the timing and magnitude of mercury export to aquatic ecosystems.

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Ecohydrological Processes in Cutover Peatlands: The impact of peatland restoration on the site hydrology and water balance of an abandoned block-cut bog in Québec

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1. Introduction

Sphagnum mosses, the dominant peat-forming plant in Canadian peatlands, generally do not regenerate spontaneously in cutover peatlands because of restricted water transfers between the developing moss diaspores and the structurally altered peat matrix. Artificial drainage networks established during the peat extraction process reduce average pore-diameters by means of increased compression, oxidation and shrinkage, consequently decreasing soil-water pressures and limiting water availability to plants, especially non-vascular *Sphagnum* mosses. Seasonal peat volume changes, have a direct effect on the hydraulic parameters and relationships between porosity (n), Specific yield (S_y), saturated hydraulic conductivity (K_{sat}) and water storage capacity (Schlotzhauer and Price, 1999). An alteration of these parameters caused by volume change has profound consequences regarding the availability of water for non-vascular *Sphagnum* mosses, as they directly influence the movement of water through the peat and dictate the hydrological characteristics of the peatland, however their response following water table reestablishment is poorly understood (Holden, 2005). Altered water dynamics and distribution within a bog following rewetting has direct implications for the components of the water balance, inevitably changing the distribution and magnitude of water losses from the site. However, full water balance studies of managed (rewet) cutover bogs are rare. To effectively improve peatland restoration strategies, there is a need to understand the impact of site rewetting on the system hydrology, to facilitate a timely return to a functioning ecohydrological state. Therefore, the specific objectives of this study are to (i) compare the full water balance of an abandoned block-cut bog prior to and following rewetting; (ii) understand the hydrological consequences caused by peatland restoration (rewetting) and (iii) address the implications for *Sphagnum* moss recolonization.

2. Methods and Approach

The study site is an abandoned block-cut bog in Cacouna, Québec, Canada (47°53' N, 69°27' W). Peat harvesting was conducted using the traditional block-cut extraction technique, resulting in a cutover landscape of alternating baulks, 2–4 m wide and raised approximately 0.5-1.0 m above adjacent, lower-lying trenches of 10–12 m width. These baulk-trench combinations occur in parallel, with typical lengths of 180 m. The primary drainage network within the Cacouna bog (previously fully functional) was blocked in October of 2006 through the construction of twenty seven peat dams. The water balance of the Cacouna bog (removed from surface and ground water inputs) is estimated as

$$P = ET + R \pm \Delta S + \varepsilon$$

where P is precipitation, ET is evapotranspiration, R is runoff, ΔS is change in soil storage and ε is the residual term (Van Seters and Price, 2001). Rewetting the site involves blocking the drainage ditches (affecting R), altering site water distribution (affecting ET) and increasing site water storage capacity (affecting ΔS and ET). To quantify the altered distribution and magnitude of water losses from a site following rewetting, each component of the water balance was evaluated from 19 May to 16 August in three consecutive years (2005 – 2007), prior to and following rewetting. Furthermore, transects of wells, piezometers and surface level monitors were installed throughout the site to facilitate monitoring of water table and surface level fluctuations and K_{sat} throughout the three year study period.

3. Results and Discussion

The hydraulic conductivity of peat dams and raised baulk structures was variable, with estimates ranging from 10^{-2} to 10^{-5} cm s^{-1}. This was sufficiently low to detain spring snowmelt and summer precipitation waters on-site, raising the average site water table level from approximately -44 and -39 cm (with reference to the cutover peat surface) during the 2005 and 2006 study periods, respectively, to -10 cm in the 2007 study period. Topographical variability within the study site, in combination with the location of the constructed peat dams, had a profound influence on the magnitude of the water table rise at any given location within the site. The rewetting had a disproportionately large impact on the lowest-lying areas in the site, nearest to the location of a peat dam, as compared to the topographically higher locations, furthest from the peat dams. For example, the water table level rose by 112 cm at a well situated in the lower end of a trench, 7 m upslope from a peat dam, while a well situated 153 m upslope in the same trench exhibited a rise in water table level of only 26 cm. In the 2007 study period, standing water covered 37% of the Cacouna bog, with an average depth of 24 cm, occupying some trenches along their entire length, and others not at all.

Each of the components used in the water balance estimation (with the exception of P, given its discrete nature) were influenced by the site management approach (rewetting) implemented at the Cacouna Bog (Table 1). ET was the dominant water loss from the site each year, with ET rates increasing by 25% following rewetting in 2007 (3.6 mm day^{-1}), compared to pre-restoration ET rates of 2.7 mm day^{-1} during both the 2005 and 2006 study periods. R losses were the largest in 2006, due mainly to the occurrence of one large (60 mm) precipitation event and an active primary drainage network. An average runoff efficiency (percent precipitation produced as stream discharge) of 10% was observed following drainage ditch blocking (2007), reduced from 23% during the 05/06 study periods. A notable difference between the daily flow duration curves of 2005/2006 and 2007 illustrates the impact of blocking the drainage network on the site flow regime (Fig. 1). For the largest discharge rates, similar curves are observed; however following blockage, the flow duration curve shifts to the left and exhibits a much steeper slope. This indicates a reduction in daily discharge rates in all but extreme conditions.

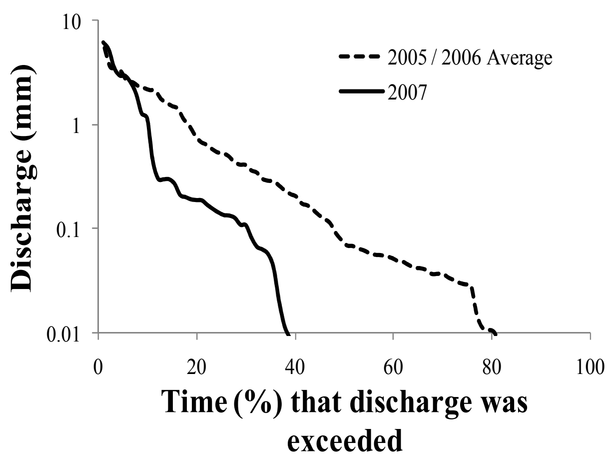

Fig. 1. *Flow duration curves at the Cacouna bog.*

This is likely a factor of an increased yet finite storage capacity following rewetting. The discharge regime remains somewhat unresponsive to precipitation, as these water inputs are retained within the site until the site storage capacity has been reached (i.e. the system can no longer hold water), at which time the system becomes more responsive to precipitation inputs, producing large discharge rates and shortened time lags. Even though more than 100 mm of precipitation occurred in 2007 as compared to 2005, R was similar due to the reduced runoff efficiency following blockage of the drainage network. The high compressibility of peat soils, owing to typically high water contents, necessitates the inclusion of the effects of water table changes on aquifer compression and moisture content changes in the unsaturated zone in seasonal estimates of ΔS.

Year	PPT	ET	R	Δ S	Residual	% Error
2005	199.6	245.6	24.7	-85.8	-15.1	7.6
2006	222.2	243.4	73.1	-70.8	23.5	10.6
2007	327.4	327.6	31.5	-26.3	5.4	1.7

Table 1. *Water balance components within the Cacouna bog for 19 May - 16 August, 2005 – 2007. All values in mm.*

At the Cacouna bog, total storage change was greatly reduced following rewetting, due to the increase in availability of water on site restricting seasonal water table drawdown, consequently constraining the amount of water lost from storage due to pore drainage. The water table declined by 258, 215 and 113 mm during the 2005 – 2007 study periods, respectively. The specific yield values for the substrate were estimated as 0.22, 0.18 and 0.14 (2005 – 2007), generating water losses due to the drainage of soil pores of approximately 58, 38 and 16 mm over each study period, respectively. The increased pressure caused by the higher water table subsequently reduced the effective stress and restricted the amount of surface subsidence following rewetting. Consequently, water lost from storage due to the expulsion of water from pores during compression of the aquifer (peat) was limited, reducing these specific storage losses following rewetting to 10 mm in 2007, from 28 and 33 mm in 2005 and 2006, respectively.

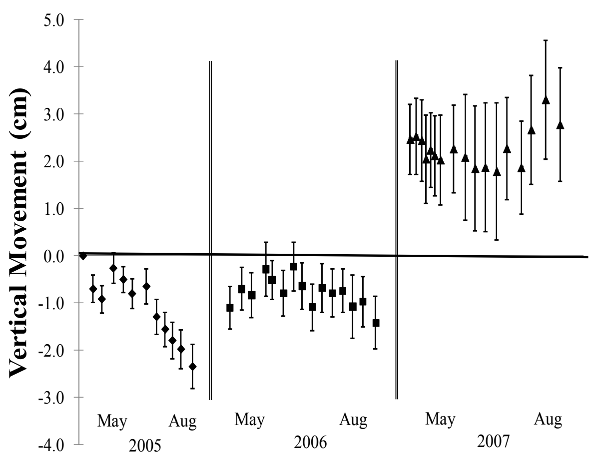

Fig. 2. *Surface level fluctuations (relative to the first measurement in 2005) over the 3 study periods. Error bars represent the standard error of the mean.*

Site-averaged surface subsidence, relative to the first measurement of each respective study period, was found to be 2.0, 0.6 and +0.2 (i.e. rebound) cm in 2005, 2006 and 2007, respectively. The surface level rebounded by an average of 3.2 cm following rewetting (relative to the 2005/2006 average level) (Fig. 2). Presumably due to the rebounding peat surface level as a consequence of the site rewetting, the mean K_{sat} increased by an order of magnitude in 2007, both throughout the entire site (55.1 ha) and within a typical trench (~0.2 ha). This might increase subsurface site drainage, however the presence of peat dams will reduce the impact of the higher K_{sat}, as the subsurface flow will be intercepted by the blocked drainage network, providing no outlet for discharge, retaining the water on-site.

4. Conclusions

The rewetting of the Cacouna bog caused the water table to rise and lower-lying areas to flood, altering the distribution of water and consequently impacting the site hydrology and components of the water balance. A rebounding surface and associated volume change following rewetting results in an alteration of the hydraulic properties and water storage capacity of residual peat soil, causing substantial implications for the system ecohydrology. These parameters control the water movement and hydrological characteristics within the peatland, and thus influence the availability of water for *Sphagnum* mosses.

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Challenge

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Nature of Work

The *Lead Hydrologist* leads a multi-disciplinary team of scientists to carry out hydrological research and analysis throughout British Columbia and Pacific North America. The incumbent reports to the Director/PCIC and works closely with the Senior Scientist, senior staff in Regional Climate Impacts, Climate Model Diagnostics, and Climate Analysis. The incumbent also collaborates with members of the Consortium; sponsors of projects, such as BC Hydro and the Provincial government; and with other hydrology professionals, the Water & Climate Impacts Research Center (W-CIRC) at the University of Victoria and with the River Forecast Centre (RFC) within the BC Ministry of Environment.

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- Supports the Director/PCIC to sustain and develop the consortium, collaborates with Consortium Members, and works as a member of PCIC senior leadership and administration staff.
- Develops, supervises and manages project staff
- Designs and executes hydrological model experiments and intercomparison studies.
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- An equivalent combination of education and experience may be considered (eg, MSc degree, plus 10 years).
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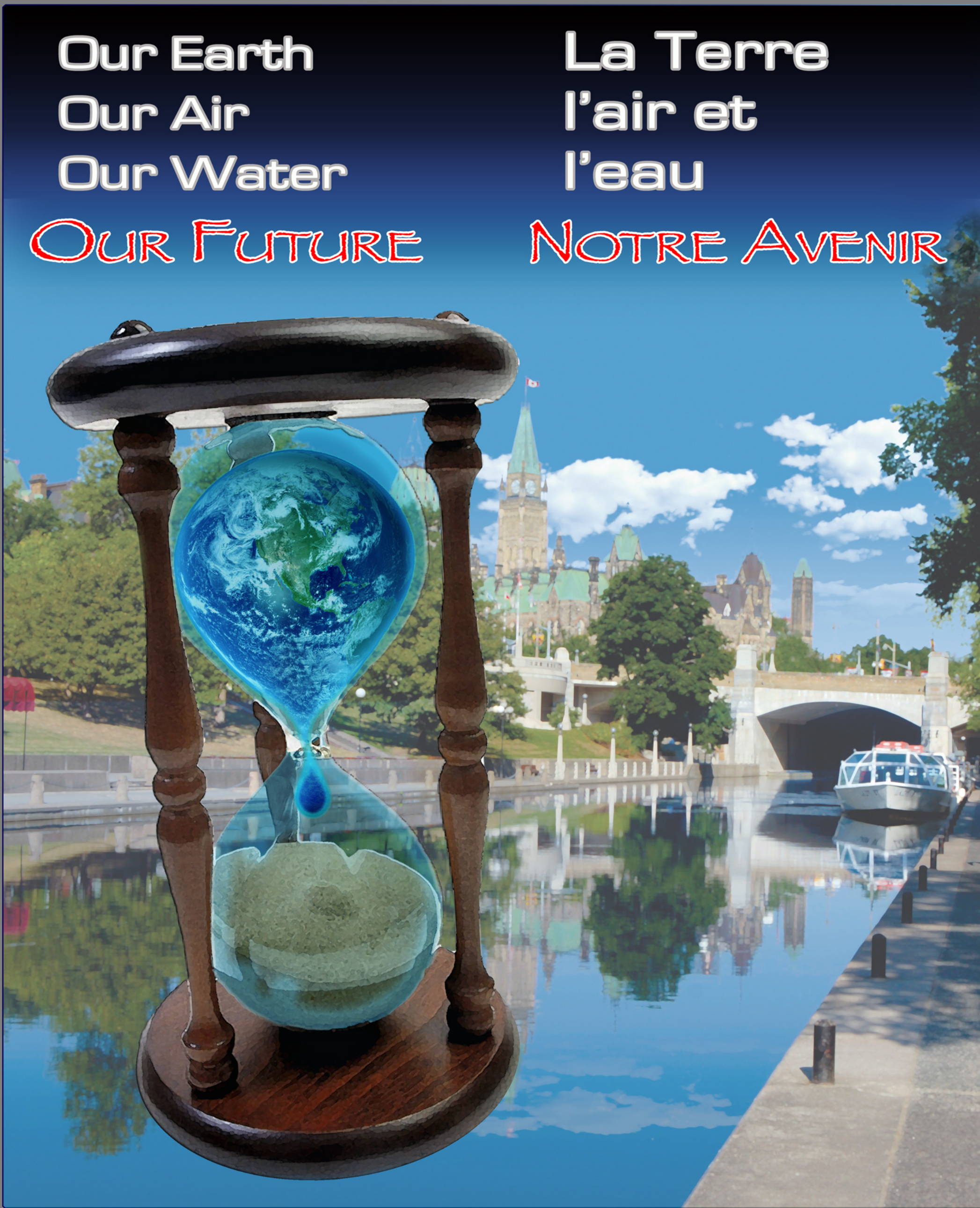

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