University of Western Ontario
Department of Geography
Geography 3341a Hydrology
2013 Fall Term

1. *Course Description and Prerequisites*

The study of water in the environment. Selected aspects of the terrestrial hydrological cycle, including: runoff generation, flooding and drought, snow and ice. Applied aspects will be considered in each topic covered. Prerequisites: Geog 2330a/b Geomorphology and Hydrology or Geog 2310a/b Weather and Climate or permission of instructor. (Geog 2210b Spatial Analysis (or equivalent) highly recommended.)

2. *Objectives*

a) To provide an overview of hydrological processes and the terrestrial water cycle from the water resource perspective, sufficient to the commissioning, oversight and interpretation of a hydrological consulting report.

b) To provide exposure to a range of general analytical techniques which are part of the tools of the trade of the environmental professional.

3. *Personnel*

Instructor: Dr.C.C. Smart, Room 1402 SSC Tel. 85007
E-mail: CSMART@UWO.CA
Office hours Tues. 10:00-12:00 (or by appt.)

Teaching Assistant: tba

4. Course Format

A two hour lecture period: Wednesday. 2:30-4:30 UC 59
A two hour lab period: Wednesday. 4:30-6:30 SSC1000

Two lecture sessions will run each week with a short break between. Lab exercises will be posted on line, introduced and explained during lab sessions. The lectures provide most “raw material” for the course, and final marks depend entirely on exercises, tests and examinations. Attendance at class and lab sessions is critical in passing the course.

Exercises will consist of laboratory problems devised to demonstrate fundamental aspects of measurement, data processing and analysis for hydrological problems. You will normally be allowed two weeks to tackle the assignment and raise questions in scheduled classes and labs. Use assigned laboratory hours to work on exercises. You are encouraged to work in small groups, but unless stated otherwise your assignment should be explicitly written up independently. Deadlines will be enforced.

5. Marking Scheme

Exercises (five @8%).......................................	40%
Fall mid-term test, 1h (Provisionally 2:30pm. 30/10/13)	20%
Final Exam (2h in December).............................	40%

Tests are usually short answer and calculation format. The final examinations will also incorporate a "pre-announced" essay topic of strictly limited length, typically 200 words. Brief in-class tests ("pop" tests) worth 2% each may be introduced as an incentive to maintaining the level of revision. Key concepts from previous lectures will be assessed. The mid-term and exercise weighting will be reduced to accommodate such tests. Basic calculators are permitted, no electronic communications are permitted.

6. *Texts*

Background information can be found in texts used in earlier Geography courses.. The “texts” for the course are expensive, so I have not ordered them. They are available in the Taylor Library

George M. Hornberger, Jeffrey P. Raffensperger, Patricia L. Wiberg 1998*Elements of Physical Hydrology* Taylor GB661.2.E44 1998

Dingman, S.L., 1993. *Physical Hydrology*. Prentice Hall Taylor GB661.2.D56 2008

Ward, R.C., and Robinson, M. 2004. *Principles of hydrology* McGraw Hill. Weldon GB661.2.W35 2000

Some copies of Dingman may be available second hand (possibly listed under Earth Sciences). This and Hornberger are excellent, but rather expensive books that covers material to a far more advanced level than required for the course. As a purchase, it would be best suited to those wishing to have a superior reference source at their disposal for future studies or work. Ward and Robinson is less technical, but rather long winded. Web retailers list books at very variable prices. More basic texts can be found in the library by perusing the stacks and selecting something appropriate to particular needs. Online resources are increasingly available and will be posted as suitable.

7. Course Outline (Note that the full curriculum may not be covered in this course. Examinations adjusted accordingly.)

1. Terms of reference: dimensions, precision etc.
2. Water: an anomalous compound. Measurement of hydrological fluxes
   Lab 1. Current metering and the discharge rating curve
   Lab 2. Dilution gauging
3. The hydrological cycle: reservoirs and fluxes (In-class exercise)
4. Hydroclimatology: Precipitation, interception and evaporation. (Lab 3. Thiessen polygons)
5. Soil water and ground water.(see Geog 3342a/b for more advanced groundwater course)
6. Surface water runoff (Lab 4. Hydrological modelling, Lab 5. Time series analysis

{7. Limnology}
{8. Snow and Ice}.

The course material is cumulative, i.e. you are expected to keep up with the material week by week. Discuss problems with your peers, read the text and make use of the open question forum at the beginning of each lecture. If you do not keep up with the material, you may find subsequent lectures difficult. Revision should be weekly, not exclusively the night before an examination.

Schedule

3341a Lab and test schedule (provisional timing depending on weather)		
11/09/13	Exercise 1 Stream Gauging and instrumentation	
18/09/13	weather permitting Field work 2:30pm Medway Creek Gauging Station 43° 0'49.16"N, 81°16'49.35"W Wellington Drive @ Windermere Rd. return to SSC1000 ~4:30 Exercise 1	
25/09/113	Exercise 2 Dilution gauging & water quality	Ex1 due
02/10/13	No lecture: Lab with TA	Field Camp Week
09/10/13	Exercise 3 Rainfall GIS	Ex2 due 07/10/11
16/10/13		
23/10/13		Ex3 due 21/10/11
30/10/13	Mid term 2:30 UCC59 1 hour	
06/11/13	Exercise 4 Hydrologic modelling	
13/11/13		
20/11/13	Exercise 5 Time series analysis	Ex4 due
27/11/13		
04/12/13	Last Class	Ex5 due 25/11/11
8-19/12/13	Final Examinations	2 hours

In the early fall, field work will take place as noted. Meet at Medway Creek Gauging Station (100 m west of Western Road on Windemere Road 18 September at 2:30pm unless otherwise indicated. 25 September rain date. Field work will complement associated exercises, but because of uncertainties with the weather is not essential to their completion.

Geography 2210 (or equivalent) level of statistical analysis and Excel is assumed

Spreadsheets provide exceptionally useful general management and analysis tools, relevant not only in hydrology, but in many areas of employment. Accordingly, the exercises are generally framed in an Excel format, and the labs are held in SSC1000. *Rudimentary Windows and Excel skills are assumed, although a quick tutorial may be arranged.* You must have a SDAL student account.

Exercises are written to back up material from lectures and reading and to provide training in use of the course material. Exercise marks are awarded to encourage completion of the exercise, NOT as a rigorous form of evaluation. Therefore, in most exercises it should be possible to gain rather high marks. Tests and examinations are the primary means of evaluation, and may therefore appear to be much more demanding. The end result might be an overall average mark for the course in the mid B range, while the average lab. mark may be in the mid A range.

Expectations

You are expected to develop knowledge of the component processes of the land surface hydrological cycle, their measurement, implementation in a water balance and their analysis using graphical and statistical tools. In addition, you are expected to understand how humans interact with and influence the hydrological cycle. Capacity to operate, implement and report on spreadsheet based data analysis is also expected.

Prerequisite Checking - the student's responsibility

One of Geography 2310A/B, 2320A/B or 2330A/B, (or equivalent) or at least 3rd year standing in an Environmental Science or Earth Sciences program. Or permission of Instructor

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Exercises and Examinations, Medical and Crisis Absences

Exercises are due at the start of the class on the date noted. They are to be submitted electronically to the Teaching Assistant. Late penalties apply up to the point of return of the marked exercise (typically one week later).

Students unable to attend scheduled classes should indicate this in advance if possible and be prepared to provide supporting evidence. Absentees are expected to attempt to make up for missed materials and curriculum, by arranging for notes to be shared for example. They may consult the instructor/TA for help in comprehending such materials In the event of not being able to complete assignments, students are required to notify the instructor/TA and to attempt to complete such work if possible to ensure the learning experience is gained. With approval exercises can be marked up to the point of return. After this point, exercises will not be marked, and the marks assessed based on those submissions received.

Absence from examinations requires documentation under established terms of reference. The midterm test may be waived and course mark balance adjusted, but students should be prepared to write a make-up final examination at a time determined by the department.

For UWO Policy on Accommodation for Medical Illness and a downloadable SMC see:

http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf

Downloadable Student Medical Certificate (SMC): https://studentservices.uwo.ca under the Medical Documentation heading

Students seeking academic accommodation on medical grounds for any missed tests, exams, participation components and/or assignments worth 10% or more of their final grade must apply to the Academic Counselling office of their home Faculty and provide documentation. Academic accommodation cannot be granted by the instructor or department.

Statement on Academic Offences

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

Mental Health

If you or someone you know is experiencing distress, there are several resources here at Western to assist you. Please visit the site below for more information on mental health resources: http://www.uwo.ca/uwocom/mentalhealth/.

Western's commitment to accessibility

The University of Western Ontario is committed to achieving barrier free accessibility for persons studying, visiting and working at Western.

Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Support Services

Registrarial Services: http://www3.registrar.uwo.ca/index.cfm

Student Development Services: http://www.sdc.uwo.ca/

Geography 3341a/b 3342a/b

Exercise and Examination Guide

Systeme Internationale (S.I.) units will be used in class, exercises and examinations in this course. Where questions require calculations, only a *part of the mark* is awarded for the correct answer. *It must be clear that you have developed the answer in a logical way*. In general, a **calculation** requires the following:

1. An algebraic statement of the calculation to be performed, with a brief explanation of the approach to be used.
2. Identification of the symbols in 1 (and possibly the values which will be assigned to these variables using standard units).
3. Rearrangement or other algebraic operation (including a check of dimensional homogeneity), including explanation.
4. Substitution of values with standardised units into the equation
5. The correct answer given to the same precision (number of figures) as the least precise of the known values (usually 2-3 figures), with appropriate units.
6. Several separate stages may be necessary to reach an answer, in which case follow 1-4 for each step with appropriate documentation, and maintain full precision through all calculations, round the final answer.
7. Do not provide detailed "working." *Repetitive calculations should be tabulated.*

Example: What is the mass of a rock with potential energy of 500J when perched 50.0 m above datum?

The basic equation for potential energy is

$$E_p = m\ g\ h$$

where E_p is potential energy in J
m is mass in Kg
g is acceleration due to gravity (9.81 m s^{-2})
h is elevation above datum in m

Rearranging the equation : $m = E_p/(g\ h)$

[Check of dimensional homogeneity: $Kg = \dfrac{Kg\ m^2\ s^{-2}}{m\ s^{-2}\ m} = Kg$ - OK.]

Substituting $m = 500 / (9.81 \times 50)$

Mass of rock = 1.02 Kg

Written answers should be readable and grammatically correct. Typewritten reports are preferred, but not obligatory. There are no marks for length, and concise, well though-out answers should be your objective. The underlying organisation and purpose of an essay should be worked out before writing and should be clear to the reader.

Short answer questions do not require sentence structure, but should be readable, clear and not contain irrelevant information. Use relevant figures and graphs either alone or as a part of written answers (providing they are referred to in the text). Maps should have a scale and orientation (e.g. a "north arrow").

Graphs should have a title, labelled axes and a key to multiple plots. You are encouraged to use computer aids such as spreadsheets in exercises. However, the results should be presented in readable order.

You are encouraged to use library resources at your own discretion. Make certain to adequately reference any bibliographic sources used or cited.

Unit Conversion

Errors in calculations often arise from using inconsistent units or incorrect conversions. Converting units can be by rote, but this is prone to mistakes. Instead, look at the *dimensions* in a quantity or equation and add a conversion needed to generate the units required. Thus, rainfall in mm/a is needed in m/a. So m/mm is the conversion factor needed. mm/a x m/mm = m/a. 1 m is 1000mm, giving a conversion factor of 1/1000 m/mm. Remember that squared or cubed units require the conversion factor to be scaled accordingly. Thus a catchment area in km^2 is converted to m^2 using m^2/km^2. There are 1000 x 1000 $=10^6$ m^2/km^2.

Always inspect the conversion result to make sure that it is working reasonably and hasn't been accidentally inverted..

GEOGRAPHY 3341a/b, 3342a/b
BASIC QUANTITIES AND UNITS

Multipliers: e.g. applied to g,m,s etc.

Tera..	T.. 10^{12}	e.g. Tg	Milli..	m..	10^{-3} e.g. mg
Giga..	G.. 10^{9}	e.g. Gg	Micro..	:(μ)	10^{-6} e.g. :g
Mega..	M.. 10^{6}	e.g. Mg	Nano..	n..	10^{-9} e.g. ng
Kilo..	K.. 10^{3}	e.g. Kg	Pico..	p..	10^{-12} e.g. pg

Conversions:

Length	10^6mm =10^3m =1km	
Area	10^6m^2 = 1 km^2	
Volume	10^9m^3 =1 km^3	1000 L= 1 m^3
Time	3.15x10^7s = 365 d = 1 a	
Time	8.64x10^4s = 24 h =1 d	
Time	3600s = 60 min = 1 h	

1. **Fundamental units**:

Quantity	*Symbol*	*Units*
Mass:	M	kg
Length:	L	m
Time:	T	s (not metricated
Temperature:	T(θ)	K or °C where K= °C + 273.2

2. **Geometric Units** (length) e.g.

Quantity	*Symbol*	*Units*
Wavelength:	λ(Lambda)	m, :nm)
Linear Frequency:	f	m^{-1}
Spatial Frequency:		m^{-2}
Area:	A	m^2 (Hectare,1Ha=100x100m=10,000 m^2**; 1km^2 = 10^6m^2** = 10^{12}mm^2)
Volume:	V	m^3 (**1km^3=10^9m^3**=10^{18}mm^3=10^{12}L; 1m^3= 1000 L = 10^6cm^3=10^9mm^3)

3. **Kinematic Units** (length and time) e.g.

Quantity	*Symbol*	*Units*	*Definition*
Velocity:	u	m s^{-1}	length/time
Acceleration:	a	m s^{-2}	velocity/time
Diffusivity:	D	m^{2}s^{-1}	volume/length x time
Volumetric Discharge:	Q	m^{3}s^{-1}	volume/time
Kinematic Viscosity:	ν(nu)	m^{2}s^{-1}	dynamic Visc./Density

4. **Dynamic Units** (mass and length with time) e.g.

Quantity[Symbol]	*Units*	*Practical Units*	*Derivation*
Density[ρ(rho)]:	kg m^{-3},		mass/volume
Force:	kg m s^{-2},	Newtons (N)	mass x acceleration
Weight:	kg m s^{-2},	N	mass x 9.81 m s^{-2}
Weight Dens.[γ(gamma)]:	kg m^{-2}s^{-2},	N m^{-3}	weight/volume
Stress:[τ(tau),σ(sigma)]:	kg m^{-1}s^{-2},	Pascals (Pa)	Force/Area
Pressure[ψ(psi)]:	kg m^{-1}s^{-2},	Pa	Force/Area
Energy, work:	kg m^2 s^{-2},	Joules (J)	Force x Length
Power:	kg m^2 s^{-3},	Watts (W)	Energy/Time
Energy Flux Density:	kg s^{-3},	W m^{-2}	Power/Area
Momentum[M]	kg m s^{-1},		Mass x Velocity
Dynamic Visc.[μ(mu)]:	kg m^{-1}s^{-1},	Pa.s	
Surface Tension[T]:	kg s^{-2}, N m^{-1}		Force/Length

5) **Dimensionless Quantities** e.g.

Quantity	*Symbol*	*Dimensions*	*Definition*
Porosity:	P	L^3/L^3	volume of voids/total volume of sample
Sinuosity:	S	L/L	length of channel/linear distance
Reynolds Number:	N_R	$L\ LT^{-1}\ ML^{-3}/ML^{-1}T^{-1}$	Depth u ρ/μ
Froude Number:	N_F	$LT^{-1} / (L\ L\ T^{-2})^{0.5}$:	u / (Depth x g)$^{0.5}$

Some (possibly) Useful Values: (sources: 1. Handbook of Chemistry and Physics
2. Oke, Boundary Layer Climates
3. Richards, Rivers)

Substance	*Temp.*	*Density*	*Dynamic Viscosity*	*Specific Heatx10^{-3}*	*Thermal Conduct.*	*Surface Tensionx10^{2}*
	EC	*kg m^{3}*	*kg m^{-1}s^{-1}*	*J kg^{-1}K^{-1}*	*W m^{-1}k^{-1}*	*N m^{-2}*
Ice	<0	~910	large	2.09		2.24
Water	0	999.84	0.001787	4.22	0.56	7.56
Water	5	999.97	0.001519	4.20		7.49
Water	10	999.70	0.001307	4.19	0.57	7.42
Water	15	999.10	0.001139	4.19		7.35
Water	20	998.21	0.001002	4.18		7.28
Water	25	997.05	0.0008904	4.18		7.20
Water	30	995.65	0.0007975	4.18		7.15
Air	-5	0.00132				
Air	0	0.00129				
Air	5	0.00127				
Air	10	0.00125	1.72×10^{-6}	1.01	0.025	
Air	15	0.00123		0.857		
Air	20	0.00120				
Air	25	0.00118				
Air	30	0.00116				
Moving Air	10				~125	
Snow(fresh)	<0	100		2.09	0.08	
Snow(old)	<0	480		2.09	0.42	
"Rock"		~2700		0.7-0.90	~2.0	
Quartz		2660		0.80	8.80	
Quartzite		2600		0.8	5.9	
Granite		2700		0.80	2.0	
Sandy Soil(dry)		1600		0.80	0.3	
Clay Soil (dry)		1600		0.89	0.25	
Peat (dry)		300		1.92	0.06	
Sandy Soil(wet)		2000		1.48	2.2	
Clay Soil (wet)		2000		1.55	1.58	
Peat (wet)		1100		3.65	0.50	

Approx. Density of Water at temperature T (°C); $\Delta_w(T) = 1000 - (0.03\ ((T^2/4) - 2T + 4)$ {useful for lake stability assessment}

Latent Heats for water
L_x Fusion 0.333 MJ kg^{-1}
L_v Vapourisation 2.51 MJ kg^{-1}
L_s Sublimation 2.83 MJ kg^{-1}

Time:
1 min = 60 s
1 h = 3,600 s = 60 min
1 day = 86,400 s = 1,440 min = 24 h
1 year = 31,536,000 s . 3.15×10^7 s = 525,600 min = 8,760 h = 365 d

g, Acceleration due to earth's gravitational field 9.81 m s^{-2}
π(pi), Circumference of a circle÷diameter = 3.14159
perimeter of a circle = $2 \pi r$
area of a circle = πr^2
area of a sphere = $4 \pi r^2$
volume of a sphere = $4 \pi r^3/3$
e, the base of natural logarithms = 2.71828