



UNIVERSITY OF TORONTO

Proposal for a

Ph.D. in Environmental Science

In

the Department of Physical & Environmental Sciences
University of Toronto Scarborough

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1 Executive Summary

Canada and the world currently face a number of significant and serious environmental challenges: thawing of vast areas of permafrost in the north, shrinking of the surface area of Arctic pack ice, changing water levels in rivers and lakes, the active retreat of many glaciers, risk associated with rising deforestation, and the remediation of abandoned mine and industrial sites. Unfortunately, our ability to find solutions to these challenges is increasingly constrained by a severe shortage of suitably qualified scientists who are trained in Environmental Science at the graduate level.

This proposal is for a new tri-campus graduate program to be housed in the Department of Physical & Environmental Sciences at the University of Toronto Scarborough (UTSC) leading to a degree of Ph.D. in Environmental Science.¹ This program will build directly on the Department's undergraduate program in Environmental Science and Master's level programs. The Department's extremely successful Master of Environmental Science Program (M.Env.Sc.) was established in 2005 and currently has enrolments of 54 full-time and 20 part-time students². A significant number of these students now wish to pursue doctoral research in a truly interdisciplinary mode, and it is appropriate that the University of Toronto provide these, and other like-minded students, from across Canada and abroad, the opportunity to further their education at a higher level.

The University of Toronto is recognized internationally for its disciplinary graduate programs focusing on scientific environmental issues. In particular, Environmental Chemistry in the graduate Department of Chemistry, the Environmental Engineering Collaborative graduate program, Environmental Geosciences in the graduate Department of Geology, Physical Geography and Natural Systems in the graduate Departments of Geography, and the Faculty of Forestry have all offered high quality Ph.D. programs in their disciplines for many years. In all likelihood, chemistry graduates wishing to pursue research in environmental interactions at the molecular level are expected to register in the graduate Department of Chemistry. Similarly, those students wishing to research the engineering needs and solutions to environmental problems (generally engineering graduates) will pursue their degrees through the Faculty of Applied Science and Engineering. Students focusing on environmental geosciences, including biogeochemistry, contaminant hydrogeology, oceanography and global climate change can still choose a Ph.D. program in Geology. Further, students pursuing graduate studies in forestry, forest-sciences and forest ecosystems are likely to enter the Faculty of Forestry. The proposed program will appeal to those students wishing to carry out research into environmental issues that involve an interdisciplinary approach, yet at a fundamental scientific level. Such students may have done an undergraduate degree in a subject area (e.g. Environmental Science) that may be deemed to have insufficient chemistry, engineering, geology or forestry content to be considered for admission to these other disciplines. Yet such students are well-suited to the interdisciplinary nature of the proposed program.

The main requirement for this Ph.D. will be the execution of an original piece of laboratory or field research in Environmental Science carried out under faculty supervision and presented in thesis form. To ensure students are aware of emerging issues not only in their own research field but also in closely allied fields, and to ensure the interdisciplinary nature of the program in Environmental Science, there will be a mandatory advanced seminar on environmental research. The program also requires a minimum of 1.5 full-course equivalent courses from an approved course list in the graduate program, bringing the full course load to 2.0 FCE.

The initial enrolment in the proposed Ph.D. is expected to be between 5 and 10 students, with numbers continuing to increase as the program develops, as new faculty are brought on stream and as existing faculty focus their graduate supervision on students in the new doctoral program. A stable annual enrolment of between 20 and 25 students will be attained within the first 7 years.

¹ The Department of Physical & Environmental Sciences at UTSC will assume graduate responsibilities, the first department to do so at UTSC.

² Once the graduate Chair of the Department of Physical & Environmental Sciences has been established, the Master of Environmental Science will be moved from the Centre for Environment to the Department of Physical & Environmental Sciences so as to align its administrative and operational homes.

2 Academic

2.1 Description and rationale for the proposal

2.1.1 Description of proposed program

This proposal is for a new tri-campus graduate program housed in the Department of Physical & Environmental Sciences (DPES) at UTSC leading to a degree of Ph.D. in Environmental Science. The Department will assume graduate responsibilities and a graduate Chair will be appointed. The expected start date is September 2010. This program will build directly on the Department's undergraduate program in Environmental Science and Master's level programs. The Department's extremely successful Master of Environmental Science Program (M.Env.Sc.) was established in 2005 and currently has enrolments of 54 full-time and 20 part-time students.³ A significant number of these students now wish to pursue doctoral research in a truly interdisciplinary mode, and it is appropriate that the University of Toronto provide these, and other like-minded students, from across Canada and abroad, the opportunity to further their education at a higher level.

The objective of the proposed Ph.D. program in Environmental Science is to prepare students for careers in teaching and research within universities and colleges, and also in government laboratories or private organizations where fundamental research on the environment is carried out. Graduates from this program will be expected to have acquired autonomy in conducting research, and in the preparation of scholarly publications. The Ph.D. program is designed to provide both a broad knowledge of current environmental research issues, especially those that exist at the interface between traditional disciplines, and specific training in the most appropriate research methodologies to tackle these scientific problems in the environment.

UTSC is ideally situated with respect to such a program as expertise in both research and training already exists in Environmental Science, and we have nationally and internationally recognized research facilities to which students have access. The addition of core faculty from other departments at UTSC, from other departments within the tri-campus system, as well as from the ranks of government scientists, will provide a program that will be unique. Ph.D. course work and research training may be carried out anywhere within the tri-campus system, although the core seminar course, ENV2200H, and the bulk of the other course offerings will be held at UTSC, and all students will have access to office space at UTSC. The main requirement for the Ph.D. is the execution of an original piece of laboratory or field research in Environmental Science carried out under faculty supervision and presented in thesis form. The program requires successful completion of a thesis proposal, a departmental thesis defense and a final thesis defense carried out under the auspices of the School of Graduate Studies involving examination by an appropriate at-arms-length examiner.

To ensure students are aware of emerging issues not only in their own research field but in closely allied fields, and to ensure the interdisciplinary nature of the program in Environmental Science, there will be a mandatory advanced seminar on environmental research. The program also requires a minimum of 1.5 full-course equivalent (FCE) courses from an approved course list in the graduate program, bringing the full course load to 2.0 FCE. The courses are required to provide the requisite background for the student's research. Courses selected have to be approved by the departmental Program Director.

The areas of study that provide the primary focus for graduate training and research in the new program have emerged in part from the current M.Env.Sc. graduate program in the general field of "Biophysical Interactions in Aquatic and Terrestrial Systems" and are listed below:

- Contaminant flux through surface and subsurface environments and biogeochemical cycles
- Urban geosciences

³ Once the graduate Chair of the Department of Physical & Environmental Sciences has been established, the Master of Environmental Science will be administratively transferred from the Centre for Environment to the Department of Physical & Environmental Sciences so as to align its administrative and operational homes.

- Remediation/restoration of degraded environmental systems
- The Great Lakes ecosystem
- Climate change and the environment
- Environmental science and transitional economies

Students admitted to the program will be required to have a strong background in the basic sciences (biology, chemistry, mathematics, physics), and a desire to do research at the interfaces between these disciplines. Students will be admitted with a completed M.Sc., M.Env.Sc., MA.Sc., etc., or, for exceptional students, they will be accepted as direct entry students with a B.Sc., BA.Sc., B.Eng., etc.

2.1.2 Rationale for proposal

Over the next several decades, the environment and its complexity will receive increasing attention locally, provincially, nationally and internationally. Many environmental problems are fundamental and cannot be solved using existing knowledge and methodologies. Furthermore, solutions to these problems may not necessarily be found within a single discipline; in fact, it is increasingly the norm that solutions are found at the interface between more traditional disciplines and interdisciplinary work. UTSC has been at the forefront of training students to work at this interface between disciplines ever since the formation of the undergraduate environmental science group in the early 1990s.

Canada took billions of years to form, hundreds of years to explore and decades to map, but within the last decade or so it has experienced the dramatic impacts of global change. These represent a major research frontier requiring a new generation of highly trained researchers using new and emerging technologies. Vast areas of permafrost are thawing across northern Canada, the surface area of Arctic pack ice has shrunk, water levels have changed in rivers and lakes, and many glaciers are in active retreat. At the same time timber, mineral and oil resources have been in increasing demand internationally requiring new approaches to environmentally-sustainable methods of extraction. Canada's resource based industries (particularly mineral and oil sands extraction) have expanded rapidly to meet world demand, and urban and industrial development has smothered entire watersheds under a built landscape. The remediation of abandoned mine and industrial sites is a major national priority. Effective management of Canadian forests remains crucial for minimizing forest ecosystem degradation while maintaining supply levels. Development in the far north has also accelerated with the search for new resources and for geopolitical reasons. The management of Canada's watersheds and lakes, and water resources in general, is a key priority.

Unfortunately, there are large gaps in our knowledge of the effects of environmental change, which has reduced our ability to manage their impacts and create effective policy. Our understanding of many natural processes is still incomplete, because we have had scant opportunity to study them over appropriate timeframes, and much of our existing knowledge has limited application to emerging issues. Filling these scientific gaps is necessary in order to create credible report cards on the state of our environment.

Canada's ability to meet these environmental challenges is constrained by a severe shortage of suitably qualified scientists trained at the graduate level in Environmental Science. The environmental sector is one of the world's fastest-growing industries - generating well over 120,000 new jobs in Canada in 2005, but ECO Canada's Environmental Labour Market (ELM) research in 2004⁴ concluded that employers are facing a growing shortfall in the numbers of skilled people in this field – a shortage that is increasingly exacerbated by the retirements of the "Baby Boom" generation. Industry and government are experiencing increasing difficulties hiring people who are appropriately trained in the application of a wide variety of environmental sciences to manage and remediate environmental problems, and there is an increased demand for suitably qualified instructors in colleges and universities. Our ability to cope with the environmental challenges of the future is dependent upon expanding the breadth of existing science teaching and particularly research programs in universities and government and private sector laboratories. This increasing demand for science-based environmental research cannot be met through

⁴ *Environmental Labour Market Report (2004)*. Canadian Council for Human Resources in the Environment Industry. Retrieved from: <http://www.eco.ca/Portal/productList.aspx>

existing *Environmental Studies* programs because, although there is a wide range of environmental programs across Canada, only programs in *Environmental Science* that are firmly rooted in the physical, chemical, biological and earth sciences can satisfy this demand. Furthermore, the environmental challenges we face need the contribution of individuals trained at the doctoral level, and at present there are relatively few dedicated doctoral programs in Environmental Science.

The UTSC proposal to establish a Ph.D. in Environmental Science supports the Federal Government's program aimed at environmental sustainability and the economic development that can flow from environmental research. In November 2006, the federal government released *Advantage Canada*⁵, an economic plan to make Canada a world leader for current and future generations. *Advantage Canada* is based on the premise that Canada already has tremendous strengths — including the drive and ingenuity of our people, the relative strength of our fiscal position, and our strong research base. It also recognizes that Canada can do more to turn environmental research into innovations that provide solutions to environmental challenges and improve our economic competitiveness. This can only stem from research into the fundamental issues.

The science and technology (S&T) strategy — *Mobilizing Science and Technology to Canada's Advantage* — is the government's plan to achieve these goals. It sets out a comprehensive, multi-year science and technology agenda. The S&T initiatives announced in the Budget Plan 2007 demonstrate the government's commitment to take early action to implement this agenda. For Canadians to continue to enjoy a high quality of life and standard of living, productivity and competitiveness must be improved through innovation. At the same time, economic activity must be sustainable over the long term. Clean air, land, and water are fundamental priorities. To succeed in an increasingly competitive global arena, Canadians must be at the leading edge of important developments that generate environmental benefits.

An aging population, combined with opportunities for Canadians to work anywhere in the world, challenge us to put in place the right conditions to attract, retain, and develop the talent and ingenuity that Canada needs. We believe that the Ph.D. program at UTSC will generate more interest among young people in pursuing advanced environmental careers, thereby encouraging a circle of talent generation and mobilization.

Canada's federal government strategy focuses on research in areas that are in the national interest from a social and economic perspective. Special emphasis is given to:

- environmental science and technologies;
- natural resources and energy; and
- health and related life sciences and technologies.

Clearly all three are interrelated; the resource industry is a major user of environmental science research and technology, similarly the overall health of the environment is a strong determinant of human health, especially as our cities grow. The government is planning new investments in R&D ensuring that higher-education institutions have the leading-edge research equipment and facilities required to compete with the best in the world, and supporting domestic and international research and networks in areas of strategic importance to Canada. The objective is to increase the impact of federal investments, to leverage university and private sector strengths, to create better learning opportunities for students, and to foster research excellence.

Fundamental to all of the above is a steady supply of well-qualified practitioners of environmental science at the advanced graduate level. It is essential that we meet the environmental challenges of change by training a new generation of environmental scientists with advanced skills. Given the national strategic needs clearly identified by the Federal Government, we note significantly, that, at present, there are relatively very few dedicated graduate programs offering a Ph.D. in Environmental Science as a 'stand alone' degree. There are clearly opportunities for environmental research, but these are often linked through several departments. By far the largest numbers of environmental programs are in Environmental Studies, Geography and Natural Resources and these are often heavily biased towards the social

5 Visit: <http://dsp-psd.pwgsc.gc.ca/Collection/F2-105-2006-3E.pdf>

sciences (see Appendix Ia). There are also a significant number (11) of environmental engineering programs (see Appendix Ib). However, the number of science-based Ph.D. degree programs in the environment is small (two in Environmental Biology – Appendix Ic; 1 in Environmental Health – Appendix Id; three in Environmental Chemistry and Toxicology – Appendix Ie; and four in Environmental Science - Appendix If). The proposed program differs from those listed in Appendix If in two fundamental ways. First, the program has a core faculty based in one department, whereas programs at McGill and Memorial are cobbled together with researchers within a faculty but belonging to different departments. The department-centric nature of this program, while not excluding the important participation from others, will provide a greater sense of coherency for students in the program and the development of a dynamic cohort. Second, other programs are smaller niche programs such as Trent (Watersheds) and RMC (Remediation) whereas the full range of Environmental Science is covered by the proposed program. The relatively large course load compared to other PhD programs in Environmental Science ensures that our students are provided a thorough foundation in the emerging discipline of Environmental Science, rather than a narrow aspect of it.

There is a clear need for a Ph.D. in Environmental Science to be offered at the University of Toronto, the most research intensive university in Canada.

2.2 Pedagogical and other academic issues, including expected benefits of the proposed program

There is a great deal of energy, enthusiasm and intellectual commitment within the Department of Physical & Environmental Sciences and across the three campuses to develop a Ph.D. in Environmental Science. Members of the core faculty at UTSC are trained in a range of traditional disciplines (e.g. biology, chemistry, ecology, engineering, geography, geology, and physics) and have been brought together within a single department at UTSC, the Department of Physical & Environmental Sciences. The synergies that produced this unique proposal resulted from the interactions among faculty within one department and the realization that many significant environmental science problems could not be resolved within a single traditional discipline. The M.Env.Sc. program, which currently resides in the Centre for Environment but operates on the UTSC Campus, was started specifically to take advantage of these synergies and a Ph.D. program is a logical progression in graduate education in environmental science at the University of Toronto.

We will follow a holistic approach to both teaching and research by integrating the physical, chemical and biological sciences with the geosciences in the study of natural and human environments. We believe this is a truly modern philosophy designed to meet worldwide concern with environmental quality.

Our aim is to train researchers in environmental science at the doctoral level, where students can develop theoretical and practical skills, and can be exposed to the very latest research technologies. Training will be achieved primarily through direct interaction between faculty and student, although each student will also undertake course work as part of his/her program and one core course will be mandatory for all students. Each student entering the program will already have mutually agreed upon a supervisor for his/her research; this research will result in a thesis, which will be a required element for graduation. The primary supervisor will direct the research program, but final responsibility for the student's progress will rest with a core advisory committee (supervisor plus at least two other faculty members with expertise in the research area) that will ensure the interdisciplinary nature of the Ph.D. program. However, the student's primary supervisor will chair the core advisory committee, which will meet at least annually to oversee the student's progress.

2.3 Projected student demand

There is a clear need for highly qualified environmental scientists working as faculty in universities and colleges and universities, and also as researchers in government laboratories or private organizations

where fundamental research on the environment is carried out. The Ph.D. program builds upon the extremely successful and popular Master of Environmental Science Program, which has been in existence since January 2006. A significant number of these students now wish to pursue doctoral research in a truly interdisciplinary mode. It is therefore appropriate that the University of Toronto provide such an opportunity for these students and other like-minded students from across Canada and abroad to further their education at a higher level.

The M.Env.Sc. program has generated a large body of students from all regions of Canada, as well as a significant number of international students. The Ph.D. program will garner Master's students from the same market base, but will also provide a higher level of research training for the best M.Env.Sc. students graduating from UTSC.

Students enrolled in the M.Env.Sc. program have two options: 1, the internship option, which is normally chosen by those who seek employment immediately following graduation; or 2, the research option, which is most appropriate for students intending to continue into a Ph.D. Those who have chosen to pursue the research option, although the minority, have proven to be excellent research students, capable of doctoral-level work. Of the approximately 68 students who have already graduated from the program we are aware of at least seven students who have gone on to doctoral programs at the University of Toronto. These include three in Geography, and one each in Ecology & Evolutionary Biology, Geology, Civil Engineering and Chemical Engineering. Of these, three were awarded external scholarships from either NSERC or OGS. We expect a small but steady stream of our own students to continue to go on to do doctoral work in the proposed Ph.D. program. We also anticipate that some successful Masters students from the graduate Departments of Chemistry, Chemical Engineering, Ecology & Evolutionary Biology, Forestry, Geography and Geology may find our program of interest. We also fully anticipate that students from other universities will find the Ph.D. program attractive and will choose to apply for admission to it.

The expected doctoral enrolment in the first year (2010-11) is a total of 5 students. This rather modest number will ensure that only the very best students are admitted; it must also be remembered that all the core faculty currently have both masters and doctoral students through their cross-appointments to other units. However, as more faculty are hired, and as the core faculty accept more students in the Environmental Science program, the number of Ph.D. enrolments will increase. The projected enrolment at the end of the initial spin-up phase is an annual intake of 10 students for a steady state enrollment of 40 students in the funded cohort. It is clearly important to assess the number and quality of graduating students and their careers, before further expansion is considered.

Table 1 illustrates the projected intake of students and the overall enrollments in the proposed Ph.D. program and the continuing M.Env.Sc. program at UTSC.

Table 1: Projected Intake and Enrolments

PROJECTED INTAKE AND ENROLMENTS										
Masters (M) And Doctoral (D) Programs										
	FULL-TIME				PART-TIME				TOTAL ENROLMENT	
	Intake		Enrolments		Intake		Enrolments		M	D
	M	D	M	D	M	D	M	D		
2009-10	50		50		5	0		0	55	
2010-11	50	5	50	5	5	0	5	0	55	5
2011-12	50	6	50	11	5	0	5	0	55	11
2012-13	50	7	50	18	5	0	5	0	55	18
2013-14	50	8	50	26	5	0	5	0	55	26
2014-15	50	9	50	30	5	0	5	0	55	30
2015-16	50	10	50	34	5	0	5	0	55	34

2.4 Impact on the Department's and Division's program of study, including impact on other divisions

The proposed Ph.D. in Environmental Science has the full support of the Department of Physical & Environmental Sciences, and the program is one of the key initiatives put forth by the Department in its academic plan.

The University of Toronto is recognized internationally for its disciplinary undergraduate and graduate programs focusing on scientific environmental issues. In particular, Environmental Chemistry in the graduate Department of Chemistry, the Environmental Engineering Collaborative graduate program, Environmental Geosciences in the graduate Department of Geology, Physical Geography and Natural Systems in the graduate Departments of Geography, and the Faculty of Forestry have offered high quality Ph.D. programs in their disciplines for many years. In all likelihood, chemistry graduates wishing to pursue research in environmental interactions at the molecular level are expected to register in the graduate Department of Chemistry. Similarly, those students wishing to research the engineering needs and solutions to environmental problems (generally engineering graduates) will pursue their degrees through an engineering graduate department. Students focusing on environmental geosciences, including biogeochemistry, contaminant hydrogeology, oceanography and global climate change can still choose a Ph.D. program in Geology. Further, students pursuing graduate studies in forestry, forest-sciences and forest ecosystems are likely to enter the Faculty of Forestry. The program proposed in this document will appeal to those students wishing to carry out research into environmental issues that involve an interdisciplinary approach, yet at a fundamental scientific level. Such students may have done an undergraduate degree in a subject area (e.g. Environmental Science) that may be deemed to have insufficient chemistry, engineering, geology or forestry content to be considered for admission to these other disciplines. Yet such students are well-suited to the interdisciplinary nature of the proposed program.

The Centre for Environment has been a major player in promoting cross-disciplinary collaborative programs particularly at the Masters' degree level; indeed, the M.Env.Sc. program operating on the UTSC campus currently reports through the Centre. However, while a number of collaborative graduate programs already exist through the centre, there is no Ph.D. program committed explicitly to the training of graduates at the interface among disciplines.

The University of Toronto, including UTSC, has an impressive international reputation for research and training of highly qualified personnel in all the basic sciences. The introduction of a Ph.D. degree in Environmental Science at UTSC as a distinct and separate graduate program will enhance the profile both of UTSC and the University as a whole, and accords well with the tri-campus responsibilities of UTSC.

2.5 Evidence of consultation with other affected divisions

The decision to establish a Ph.D. program in Environmental Science in the Department of Physical & Environmental Sciences (DPES) developed as a natural response to the noteworthy success of the M.Env.Sc. program on the Scarborough campus. Extensive discussions were undertaken within the Department and at UTSC in a series of formal meetings from 2007 to 2009. Subsequent to this a detailed proposal for a Ph.D. in Environmental Science was prepared. This document evolved over several meetings of a large subset of faculty members within DPES and was widely circulated to interested individuals. These discussions produced a final document that was then forwarded to the Dean by the Chair of DPES. Coincident with all these discussions, the Director of the Centre for Environment was consulted and had been fully supportive of the curriculum and of the need to provide a doctoral program in Environmental Science to University of Toronto students.

Further discussions were held at the University decanal level and the proposal was considered in detail by the School of Graduate Studies. UTSC has established a new academic administrative position – of Vice-Dean, Graduate Education and Program Development – with the aim of establishing a formal office for focusing graduate training carried out at UTSC. Approval for the development of a full proposal was given

at a meeting between the Vice-Dean, Graduate Education and Program Development at UTSC and the Dean and Vice-Dean Programs of the School of Graduate Studies. The Vice-Dean, Graduate Education and Program Development had discussions with the respective Deans or Chairs of all the relevant Faculties and Departments concerned with the environment at the University (the Faculty of Applied Science and Engineering – in particular the Departments of Chemical Engineering and Applied Chemistry and Civil Engineering; the Faculty of Arts and Science – in particular the Departments of Chemistry, Ecology and Evolutionary Biology, Geography, Geology; and the Faculty of Forestry). Members of many of these faculties/departments are part of the core faculty supporting this proposal.

In addition, extensive discussions with faculty in other departments at UTSC involved in environmental research, and with other faculty at the St. George and Mississauga campuses, were initiated in 2008 and have continued to the present. The proposal was widely circulated to all interested faculty, with an invitation for involvement; substantive comments were made and the document has evolved into the present proposal. A similar process was also followed for those research colleagues working in other local universities and in government research laboratories. Discussions with current graduate students and especially the graduating M.Env.Sc. students at UTSC have shown them to be fully supportive of this initiative.

2.6 Appropriateness of the name and designation of the new program

The new graduate program will be a Doctor of Philosophy (Ph.D.) in Environmental Science. The program is designed to build directly on the existing undergraduate program in Environmental Science and the Master of Environmental Science degree (M.Env.Sc.), which currently resides in the Centre for the Environment, but operates on the UTSC campus. The Ph.D. designation signifies the depth of understanding that will be gained by students in this program and the expectation that graduates will become the leaders in this field both in Canada and around the world.

2.7 Program description and requirements, course titles/numbers, and faculty members

2.7.1 Program description and requirements

Admission Requirements

- Students are accepted under the general regulations.
- Normally, the degree program is completed in four years.
- Students may be accepted into the Ph.D. program through one of three routes:
 1. Following completion of the M.Env.Sc., M.Sc. degree in environmental sciences or a related discipline or M.A.Sc. degree in environmental engineering or a related discipline, or equivalent from a recognized university with a minimum of B+ average in all work completed in the master's program;
 2. By requesting transfer from a suitable master's program (see above): students may reclassify from the master's program after 12 months of full-time study;
 3. In the case of exceptional students, by direct entry, that is, after completing an honours B.Sc. degree in a bachelor's program in a related discipline with a minimum U of T average of A- or equivalent.

Program requirements

Degree Requirements

The degree requirements consist of successful completion of: coursework, a thesis proposal, and a thesis.

The degree program has been designed so that it can be completed within four years for students who have completed a related master's degree.

- Students transferring from the master's program are expected to complete the Ph.D. program within five years from the start of enrolment in the M.Sc. program.
- Direct-entry students from a bachelor's program are expected to complete the Ph.D. program within five years.

Thesis proposal and thesis requirement:

- Students are required to prepare and defend a thesis as per the regulations of the School of Graduate Studies (see <http://www.sgs.utoronto.ca/current/thesis/index.asp>).
- All Ph.D. program requirements must be completed within six years from first enrolment.

Course requirements

1. To ensure students are aware of research in their own research field and in closely allied fields, and also to ensure the interdisciplinary nature of the program in Environmental Science, course ENV 2200 H *Advanced Seminar on Environmental Research* is mandatory.
2. Each student must also successfully complete a minimum of 1.5 full-course equivalent (FCE) courses from an approved course list in the graduate program, bringing the full course load to 2.0 FCE. The courses are required to provide background relevant to the student's research. Courses selected have to be approved by the Program Director.
3. During admission, students' preparedness will be assessed, and where it is deemed insufficient, students will be required to take additional courses. It is expected that graduates of the M.Env.Sc. research stream, or other graduate programs listed in page 11 above, normally will have sufficient background at the time of admission.

Research Proposal

Program students are required to submit a detailed Research (Thesis) Proposal to their supervisory committee. The committee will advise the student on the acceptability of the proposal and will decide on any further steps to be taken in shaping the thesis research project. The Research Proposal should be presented at the beginning of the first term in Year II.

Thesis requirements

The candidate shall present a thesis embodying the results of original investigation, conducted by the candidate, on the approved topic from the field of specialization. The thesis shall constitute a significant contribution to the knowledge of the field and must be based on research conducted while registered for the Ph.D. program.

A thesis should have a coherent topic with an introduction presenting the general theme of the research and a conclusion summarizing and integrating the major findings. Nonetheless, it may contain a collection of three or more papers where the candidate is the primary author. The collection of papers may be expanded or supplemented by unpublished material, scholarly notes, and necessary appendices.

The SGS Calendar sets out criteria for "good academic standing" and "satisfactory academic progress". The Program Director will apply these criteria in the evaluation of a student's progress.

Progress through the Ph.D. Program for students admitted with a master's degree:

- Year I: Complete course work
- Year II: Complete and defend thesis proposal/Start thesis research
- Year III: Research and thesis writing
- Year IV: Thesis writing and defense

Progress reports

Review meetings must be held in May of each year in the Ph.D. student's program. The Review Committees (normally the Supervisory Committee) must consist of at least three faculty from the graduate Department. The Ph.D. student must be present at the meetings. For the Review Meetings in Years II, III, and IV, the Ph.D. student must submit a Progress Report of between two to five pages. The Progress Reports can be accompanied by materials such as draft questionnaires, initial tabulations and analysis results, or draft thesis chapters. (For further details see the SGS Calendar).

Thesis evaluation procedures

Students will participate in two thesis defenses. For the Departmental Thesis Defense, the examination committee will consist of at least four faculty members (normally including the members of the Supervisory Committee). One or more members can be from outside the Department. The committee will notify the Program Director that the thesis is ready to be forwarded to SGS for the final oral examination (FOE).

Language requirements

There will be no language requirements for the Ph.D. program other than those specified by the candidate's Ph.D. Committee. The Committee may require proficiency in a language other than English in cases where the thesis research is in a country where English is not the mother tongue.

2.7.2 Course titles/numbers⁶**ENV1102H Analytical Chemistry for Geoscientists**

This course will familiarize students with a working knowledge of analytical chemistry and modern instrumentation and the common laboratory method used in the analysis of contaminants and ions in environmental media. Students will be introduced to a number of instruments and techniques and the method used to analyze soils, air and water.

ENV1103H Air and Water Quality Sampling and Monitoring

This course will focus on the measurement of atmospheric contaminant fluxes, including dry and wet atmospheric deposition rates and gas fluxes (e.g. NO_x, CO₂) to and from the surface. It will also consider the sampling of chemical storages and fluxes in the aqueous phase in soil, snow and snowmelt, stream flow and groundwater. Problems of sampling including spatial and temporal variability and process (pathway) uncertainty will be examined.

ENV1104H Methods for the Detection of Pathogens

This course is focused on biological contaminants in the environment such as *E. coli*, *Giardia*, *Cryptosporidium* in public water supplies. Population pressure combined with a changing climate is increasing the range of *Vibrio cholerae* world wide, and the expansion of viruses such as West Nile. The ability to control these serious problems depends on our ability to detect these pathogens and to track their movements. This course will introduce students to the biology of the life history of these organisms, and will educate them in the state of the methods of high sensitivity detection.

ENV1105H Soil Contamination Chemistry

This course will present fundamental chemical concepts and reactions that occur in soils with emphasis on contaminant behavior. The basics of soil chemistry will be introduced and the processes that relate to: quantities, attenuation, sequestration, and movement of ions, heavy metals, and organic molecules in terrestrial environments will be addressed in detail. Students will become familiar with geochemical computer models and these models will be used to predict the behavior of ions in soil. Soil chemical characteristics, which can be used to predict the fate of contaminants in terrestrial environments, will also be presented.

ENV1106H Geology and Geophysics of the Shallow Subsurface

This course provides an overview of the principal geophysical techniques; emphasis will be placed on their use in understanding site conditions in glaciated terrains such as in Canada. Contaminants move through

⁶ Many of the courses listed below are also offered in the M.Env.Sc. program. The teaching capacity of these courses is sufficient to accommodate any students from the Ph.D. in Environmental Science wishing to enroll in them. We anticipate that on average it would mean an increase in enrolment of approximately 1-2 students per course. At present these courses range in enrolment from about 10 to 30. We anticipate new faculty and other planned hires will increase the number of graduate courses offered.

The M.Env.Sc. courses listed for the Ph.D. program are academic courses offered by our core faculty. Regularly doctoral stream students from the graduate Departments of Chemistry, Ecology & Evolutionary Biology, Geography have taken these courses for credit in its graduate programs.

subsurface and surface environments along pathways controlled by geologic conditions and by surface processes. Identifying these complex pathways is fundamental to environmental assessments of contaminated sites and their remediation and in turn, is reliant on a good understanding of the local sedimentology and stratigraphy. In places, this can be gained by direct sampling or drilling but in most cases requires the application of geophysical techniques such as radar, on-land and marine seismic and down-hole logging.

ENV1107H Remediation Methods

This course will examine the principal methods currently in use for remediating contaminated soils and waters. Emphasis will be placed on reviewing the advantages and limitations and site-specific applicability of remediation techniques and technologies.

ENV1109H Advanced Techniques in Geographic Information Systems

This course covers an advanced set of techniques and applications of GIS, including a substantial practical component. Technical issues (including data format and conversion, geo-referencing, spatial indexing and terrain analysis), application/spatial modeling (including watershed analysis, land use classification, soil erosion modeling, etc) as well as visualization and incorporation of spatial data and analysis into decision support systems will be examined. Underlying programming techniques will be reviewed and extended on a student-project basis.

ENV1110H Sediment and Contaminant Transport in Aquatic Systems

This course examines contaminant transport in water bodies such as rivers and the Great Lakes using numerical modeling and other techniques. Physical methods for determining mass circulation in response to wind and water temperatures at different times of the year will be examined; case studies will be reviewed.

ENV1111H Freshwater Ecology and Biomonitoring

Freshwater environments support diverse communities of plants and animals that are controlled by both biotic and abiotic factors. Organisms respond to changes in the habitat through detectable shifts in population abundances and the loss/gain of species. Monitoring such biological changes in freshwater communities is an established protocol for assessing the condition of rivers, lakes and ponds subject to human influence. This new course will have a large practical component in which students will have the opportunity to learn the skills necessary to evaluate the condition of aquatic environments variously affected by urbanization.

ENV1112H Boundary Layer Climates and Contaminant Fate

This course examines the dynamics and radiation physics of the atmospheric planetary boundary layers. Topics include the formation of a planetary boundary layer, vertical stability, temperature inversions, diurnal and seasonal variations and impacts of local and regional scale circulation. With this foundation the dispersion of airborne pollutants will be studied. The course will conclude with modeling of airborne pollutants and case studies.

ENV1113H Groundwater Hydrochemistry and Contaminant Transport

This course focuses on groundwater contamination and the various methods used to investigate, assess and evaluate the movement and behavior of contaminants in the subsurface. Emphasis will be on urban groundwater issues with case study examples taken from North America, Europe, central Asia and Africa.

ENV1117H Climate Change Impact Assessment

The study and consideration of climate change is of increasing significance to society. This course will review the evidence for climate change over the past 150 years using both direct measurements and proxy data. Projection of future climate change will also be considered by modeling. Students will complete a major case study and research paper.

ENV1118H Fundamentals of Ecological Modelling

This course provides an introduction to the rapidly growing field of ecological and environmental modelling. Students will become familiar with most of the basic equations used to represent ecological

processes. The course will also provide a comprehensive overview of the population and dynamic biogeochemical models; prey-predator, resource competition and eutrophication models will be used as illustrations. Emphasis will be placed on the rational model development, objective model evaluation and validation, extraction of the optimal complexity from complicated/intertwined ecological processes, explicit acknowledgment of the uncertainty in ecological forecasting and its implications for environmental management.

ENV1119H Quantitative Environmental Analysis

This course provides an introduction to the field of ecological statistics. Students will become familiar with several methods of statistical analysis of categorical and multivariate environmental data. The course will provide a comprehensive presentation of the methods: analysis of variance, regression analysis, structural equation modeling, ordination (principal component & factor analysis) and classification (cluster & discriminant analysis) methods, and basic concepts of Bayesian analysis. Emphasis will be placed on how these methods can be used to identify significant cause-effect relationships, detect spatiotemporal trends, and assist environment management by elucidating ecological patterns (e.g., classification of aquatic ecosystems based on their trophic status, assessment of climate variability signature on ecological time series, landscape analysis). The course will consist of 2 hr-lectures/tutorials where the students will be introduced to the basic concepts of the statistical methods and 2-hr lab exercises where the students will have the opportunity to get hands-on experience in statistical analysis of environmental data.

ENV1120H The Dynamics of Contaminant Dispersal in Fluids

This course will introduce the mechanisms of contaminant transport in lakes and the coastal ocean. The emphasis will be on a practical understanding of different dispersion regimes from point and distributed pollution sources. Students will learn to use the basic equations that model these processes and understand how these equations are used in water quality models. Students will also be introduced to field measurement techniques and learn to compare field data with model data. Among the subjects to be discussed are the dispersion of pollutants in lakes, rivers and the coastal zone, mixing in stratified estuaries and the dynamics of the seasonal thermocline.

ENV1121H Modelling the Fate of Organic Chemicals in the Environment

This course will give an introduction to quantitative approaches to describing the behaviour of organic chemicals in the environment. Building upon a quantitative treatment of equilibrium partitioning and kinetically controlled transfer processes of organic compounds between gaseous, liquid and solid phases of environmental significance, it will be shown how to build, use, and evaluate simulation models of organic chemical fate in the environment. The course will provide hands on experience with a variety of such models.

ENV1122H Global Environmental Security and Sustainable Development

The major objectives of ENV 1122H are to: 1) discuss major environmental challenges the planet earth is now facing and 2) examine how human interventions are deteriorating global environment and that affecting sustainable development; 3) analyse major environmental initiatives which include: the Stockholm Conference on Human Development, The Brundtland Commission Report, the Rio Earth Summit, the Johannesburg World Summit on Sustainable development, Montreal Protocol on Ozone Depletion, Kyoto Protocol and other global conventions, protocols and processes and their usefulness; 4) discuss extensive north-south cooperation in facilitating global environmental security and sustainable development.

ENV1126H (new) Environmental Tracers

This course focuses on the use of various isotope and chemical tracers for furthering our understanding of complex environmental problems, ranging from the characterization of freshwater resources to contaminant transport in aquatic systems. Particular focus will be placed on how chemical and isotope tracer studies can be coupled with physical measurements to understand complex problems in hydrology, biogeochemistry, and contaminant transport. This course will cover fundamentals of environmental tracer chemistry through to recent case studies, advanced models and applications.

ENV2200H (new) Advanced Seminar in Environmental Science

This course is designed to introduce doctoral students to the major issues in research in environmental science. It will also expose students to the diverse fields of research expertise within the core faculty of the Ph.D. program in Environmental Science. Students will be expected to contribute one seminar paper in their own field of interest. The class will meet weekly throughout the fall and winter and will act as a focus group for the Ph.D. program. The course is restricted to those students enrolled in the PhD in Environmental Science program.

ENV2201H (new) Advanced Readings in Environmental Science

Students may follow a structured independent readings course in any sub-discipline of Environmental Science. A faculty member will supervise the student and a short description of the objectives, scope and procedures for evaluation for the course must be approved by both the faculty member and Program Director. Students need the approval of the Program Director of the Ph.D. in Environmental Science to register in this course.

The 1000 series courses listed above are currently available for credit in the M.Env.Sc. program. The purely professional courses taught by specialists from outside the core faculty in Program II of the M.Env.Sc. program are not included in this list and will not be eligible for credit towards the Ph.D. degree.

There are also a number of Ph.D. level courses taught by core faculty both within the department and outside the Department of Physical & Environmental Sciences that can be considered for the Ph.D. degree. For example:

EEB1700H	Seminar on Recent Advances in Plant Sciences
ENV1001H	Environmental Decision Making
ENV1002H	Environmental Policy
ENV1004H	Urban Sustainability and Ecological Technology
ENV1703H	Water Resources Management
ENV4002H	Environment and Health of Vulnerable Populations
GGR1203H	Coastal Hydrodynamics, Sediment Mechanics and Morphodynamics
GGR1214H	Global Ecology and Biogeochemical Cycles
GLG1450H	Contaminant Fate and Transport in Subsurface Environments
GLG2303H	Earth System Evolution
GLG2704H	Isotope Geochemistry
JGE1212H	Fate of Contaminants in the Environment

Students may apply to take one of these half courses as part of their 1.5 FCE credits for the degree; however, all courses for PhD degree credit must be approved by the Program Director.

Note: EEB stands for Ecology and Evolutionary Biology; ENV for Centre for Environment; GGR stands for Geography; and GLG stand for Geology.

2.7.3 Faculty members

Table 2 below, lists the 43 core faculty members (and their major fields of study) that are to be involved in the supervision of students and/or teaching of graduate courses in the proposed Ph.D. program in Environmental Science. Included are both faculty whose primary appointment is in the Department of Physical & Environmental Sciences (DPES), and faculty from the other two campuses within the Toronto system (St. George & UTM). This proposed Ph.D. program is therefore a fully “tri-campus” program, but with a home base at UTSC. Drawing on the wealth of professional expertise in the field of environmental science, a number of individuals will be appointed as Adjunct Faculty members. Table 2 lists their qualifications, existing cross-appointments to other graduate departments and institutions and gender.

There are a total of 17 Full Professors, 7 Associate Professors, 9 Assistant Professors, 9 Adjunct Faculty members who are Research Scientists, and 1 Professor Emeritus associated with the program. It is also worth noting that the core faculty includes four Tier 1 Canada Research Chairs (Dr. J. Chen, Chair of

Remote Sensing of Terrestrial Ecosystems; Dr. D. Holdway, Chair of *Aquatic Toxicology*; Dr. H. Kronzucker, Chair of *Metabolic Bioengineering of Crop Plants*; and Dr. B. Sherwood Lollar, Chair of *Isotopes of the Earth and Environment*).

Furthermore, many core faculty are either holders of endowed chairs, directors of important laboratory facilities, holders of important research administrative positions at the University, or holders of positions with important scientific organizations both nationally and internationally (Dr. B. Branfireun, Dr. D. Cormack, Dr. M. Diamond, Dr. J. Donaldson, Dr. G. Evans, Dr. W. Gough, Dr. A. Miall, Dr. B. Sherwood Lollar, Dr. A. Simpson). The core faculty also hold important scientific editorial positions in international scientific journals dealing with the environment. This is an impressive list of individual researchers, who have published extensively in international refereed journals, and who have significant experience in graduate training and research

The Environmental Science faculty in the Department of Physical & Environmental Sciences at UTSC is in a strong position to lead this proposed Ph.D. program at the University of Toronto, as this group already offers both undergraduate and masters programs in Environmental Science. Further, DPES faculty already support undergraduate and graduate teaching and research in the focus areas of the Ph.D. program, namely: contaminant flux through surface and subsurface environments and biogeochemical cycles; urban geoscience; remediation and restoration of degraded environmental systems; Great Lakes ecosystems; climate change and the environment; and environmental science in transitional economies. It should be noted that UTSC has had a long-standing educational interest in “transitional economies”, with a well-established undergraduate program in *International Development Studies*. A doctoral degree focusing, in part, on the environment and development is therefore a natural fit. At UTSC there is expertise in such diverse areas as geochemistry, biochemistry, hydrology, hydrogeology, aquatic ecology, atmospheric physics and chemistry, climatology, surface processes including atmospheric and lacustrine processes, sedimentology, soil science, stratigraphy, geophysics, geomorphology, etc. These fields are all essential building blocks for advanced graduate training in a truly interdisciplinary practise of environmental science. The foci of the graduate program will be strengthened by the addition of like-minded faculty from other campuses within the University of Toronto system, as well as researchers from other universities and government research laboratories.

The core faculty listed in Table 2 below has coalesced over several years, through shared research interests, joint research programs, shared research facilities and co-supervision of students within existing disciplinary programs. For example, Dr. F. Wania has collaborated extensively over several years with Dr. D. Muir, Environment Canada, Dr. T. Harner, Meteorological Service of Canada and Dr. T. Bidleman, Environment Canada. More recently Dr. M. Wells has collaborated with Dr. S. Bailey (DFO) and Dr. G. Arhonditsis has collaborated with Dr. R. Yerubandi (Environment Canada). Dr. W. Gough hosts a node of the Adaptations and Impacts Group of Environment Canada in his UTSC based Climate Lab providing an intellectual home for two Environment Canada scientists (Dr. M. Mirza, Dr. A. Fenech). Dr. M. Diamond has collaborated for many years with Dr. C. Marvin, L. Jantunen, S. Gagupatty, M. Aarts and others in Environment Canada, with Dr. P. Helm at the Ontario Ministry of the Environment, and with Dr. A. Wheeler at Health Canada. Such joint research is especially important for the graduate students who are involved with large government laboratories as part of their graduate training at UTSC. The opportunities for future careers in government research are clearly enhanced through this continued contact with government scientists at the graduate level.

The core faculty at UTSC are closely linked to other important research centres both within the university (e.g. the Centre for Global Change – Dr. J. Abbatt, Dr. M. Diamond, Dr. J. Donaldson, Dr. W. Gough, Dr. F. Wania, Dr. M. Wells, etc.), locally at other universities (e.g. Watershed Ecosystem Program at Trent – Dr. F. Wania, etc.) and nationally (e.g., CRESTech at Waterloo; e.g. Dr. K. Howard, Dr. R. Fulthorpe, etc.). In addition, DPES faculty work closely with government research agencies such as the Federal Department of the Environment (e.g. Dr. G. Arhonditsis, Dr. W. Gough, Dr. F. Wania, etc.), the Federal Department of Fisheries and Oceans (e.g. Dr. M. Wells, etc.), the Ontario Ministry of Natural Resources, the Ontario Ministry of the Environment (e.g. Dr. M. Diamond), and area municipalities (e.g. Dr. N. Eyles; Dr. W. Gough, Dr. K. Howard). The adjunct appointments that have already occurred (e.g. Dr. A. Fenech, Dr. M. Mirza, Dr. D. Muir) and those that are proposed (Dr. S. Bailey, Dr. T. Bidleman, Dr. I. Droppo, Dr. T.

Harner, Dr. D. Muir, Dr. H. Hung and Dr. R. Yerubandi) have all emerged as part of past joint research with faculty in DPES.

TABLE 2: Core faculty members

Core Faculty Members by Field									
Faculty Name & Rank	M/F	Home Unit ¹	Supervisory Privileges ²	Fields					
				1 ³	2	3	4	5	6
Category 3⁴									
Arhonditsis, G Assistant Professor	M	DPES - UTSC	Full	x		x	x	x	
Cormack, D Full Professor & Chair, Department of Physical & Environmental Sciences	M	DPES - UTSC	Full	x					
Dittrich, M Assistant Professor	F	DPES - UTSC	Full	x	x		x	x	
Donaldson, J Full Professor & Associate Chair, Graduate Studies (Chemistry)	M	DPES - UTSC	Full	x				x	
Eyles, N Full Professor	M	DPES - UTSC	Full	x	x	x	x	x	
Fulthorpe, R Associate Professor	F	DPES - UTSC	Full	x		x	x	x	
Gough, W Associate Professor	M	DPES - UTSC	Full		x	x	x	x	
Howard, K Full Professor & Vice-President, International Association of Hydrogeologists	M	DPES - UTSC	Full	x	x	x	x	x	x
Isaac, ME Assistant Professor	F	DPES - UTSC	Associate	x	x	x		x	x
Kerman, K Assistant Professor	M	DPES - UTSC	Full	x		x			
Mitchell, C Assistant Professor	M	DPES - UTSC	Full	x	x				
Simpson, A Associate Professor & Director, Environmental NMR Centre (UTSC)	M	DPES - UTSC	Full	x					
Simpson, M Associate Professor & Associate Director, Environmental NMR Centre at UTSC	F	DPES - UTSC	Full	x	x			x	
Wania, F Full Professor	M	DPES - UTSC	Full	x		x		x	x

Wells, ME Assistant Professor	M	DPES - UTSC	Full	x			x			
Core Faculty Members by Field										
				Fields						
Faculty Name & Rank	M/F	Home Unit ¹	Supervisory Privileges ²	1³	2	3	4	5	6	
Category 3 ⁴										
Abbatt, JPD Full Professor & Associate Director, Centre for Global Change Science	M	Chemistry	Full	x		x			x	
Berquist, B Assistant Professor	F	Geology	Full	x						
Boonstra, R Full Professor	M	Biological Sciences - UTSC	Full			x	x	x		
Branfireun, B Associate Professor & Director, UTM Programs in Environment	M	Geography - UTM	Full	x	x					
Chen, JM Full Professor, Tier 1 Canada Research Chair	M	Geography	Full	x	x	x			x	
Cowling, S Associate Professor	F	Geography	Full	x	x				x	
Diamond, M Full Professor	F	Geography	Full	x	x	x	x			
Edwards, E Full Professor	F	Chemical Engineering & Applied Chemistry	Full	x		x				
Evans, G Full Professor & Director, Southern Ontario Centre for Atmospheric Aerosol Research	M	Chemical Engineering & Applied Chemistry	Full	x		x			x	
Ferris, G Full Professor	M	Geology	Full	x	x	x				
He, Y Assistant Professor	F	Geography - UTM	Associate		x				x	x
Kronzucker, H Full Professor Tier 1 Canada Research Chair	M	Biological Sciences - UTSC	Full							x
Miall, A Full Professor & President, Academy of Science, Royal Society of Canada	M	Geology	Full		x				x	x

Sherwood-Lollar, B Full Professor & Director, Isotope Laboratory Tier 1 Canada Research Chair	F	Geology	Full	x	x				x	
Williams, D Full Professor & Board of Directors, Toronto Zoo	M	Biological Sciences – UTSC	Full		x	x	x	x		
Category 3⁴										
Wortmann, U Associate Professor	M	Geology	Full	x						
Core Faculty Members by Field										
				Fields						
Faculty Name & Rank	M/F	Home Unit¹	Supervisory Privileges²	1³	2	3	4	5	6	
Category 5										
Bailey, S Research Scientist Adjunct Professor	F	Department of Fisheries & Oceans	Associate			x	x			
Bidleman, TF Senior Research Scientist Adjunct Professor	M	Environment Canada, Centre for Atmospheric Research Experiments (CARE)	Associate	x		x		x		
Droppo, IG Research Scientist Adjunct Professor	M	Environment Canada	Associate	x	x		x			
Fenech, A Research Scientist Adjunct Professor	M	Environment Canada	Associate						x	
Greenwood, B Professor Emeritus	M	DPES - UTSC	Full	x	x		x			
Harner, T Senior Research Scientist Adjunct Professor	M	Environment Canada	Associate	x					x	
Holdway, D Full Professor, Tier 1 Canada Research Chair	M	Faculty of Science at UOIT	Associate	x		x				
Hung, H Research Scientist, Adjunct Professor	F	Environment Canada	Associate	x						
Kirkwood, A Assistant Professor	F	Faculty of Science, UOIT	Associate	x		x	x			
Mirza, M Research Scientist, Adjunct Professor	M	Environment Canada	Associate						x	x
Muir, D Senior Research Scientist & Section Chief: Priority Substances Exposure Adjunct Professor	M	Environment Canada	Associate	x		x	x	x	x	x
Yerubandi, RR Research Scientist Adjunct Professor	M	Environment Canada	Associate	x	x		x			

Notes:

1. *The budget unit paying the salary of the faculty member. The Department of Physical & Environmental Sciences is the department in which the budgetary appointment for the first 15 faculty resides. Consistent with the University policy, all U of T graduate faculty have appointments in tri-campus graduate departments.*
2. *Full supervisory privileges allow student supervision or co-supervision up to the Ph.D. level. Associate supervisory privileges allow supervision or co-supervision up to the MSc level.*
3. *The field numbers refer to: 1. Contaminant flux; 2. Urban geoscience; 3. Remediation and restoration of degraded environmental systems; 4. The Great Lakes ecosystem; 5. Climate change and the environment; 6. Environmental science and transitional economies.*
4. *Category 3: these are tenured or tenure-track core faculty members who are involved in teaching and/or supervision in other graduate program(s) in addition to being a core member of the graduate program under review.*
5. *Category 5: other core faculty: this category includes emeritus professors with supervisory privileges and persons appointed from government laboratories as adjunct professors.*

2.8 Libraries

The University of Toronto Scarborough is just one part of a vast network of libraries within the University of Toronto Library System, to which the Ph.D. students will have automatic access. There are over 40 separate, but inter-linked, libraries and resource centres within the University of Toronto network, which is ranked fourth overall in total holdings for North American libraries. The UTSC Library has provided excellent support for an undergraduate program in Environmental Science for over 15 years, and for the M.Env.Sc. program since 2005. The existing library network, which provides the necessary support for a very large number of other Ph.D. programs at the University of Toronto, will continue to provide the necessary facilities to support the proposed Ph.D. degree in Environmental Science. Nevertheless, it is clear that some resources will need to be allocated to enable the purchase of research monographs and new e-journals as they emerge in the rapidly expanding environmental science field.

The report of the Head Librarian is included in Appendix 2.

3 Students

3.1 Student affairs and services

The Ph.D. students in Environmental Science will have access to all the services of the University of Toronto Scarborough as well as the University of Toronto, and will have dedicated workspace with the Department of Physical & Environmental Sciences. The students will also have access to the visiting fellows in environmental science, helping them to establish connections in the Canadian environmental science community, and the international academic community interested in environmental science.

3.2 Student conduct and discipline

All rules and regulations of the University of Toronto and the School of Graduate Studies that apply to graduate students will govern student conduct in the Ph.D. in Environmental Science program.

3.3 Financial Support

The University of Toronto currently funds Ph.D. students in Science programs to the amount of \$15,500 annually plus the cost of tuition for four years. Anticipated sources of funding for this commitment will typically include a combination of scholarships generated from BIU and tuition income, external scholarships, endowed fellowships, teaching assistantships (maximum of 140 hours over two terms), and research assistantships. Faculty members have agreed to contribute \$8500 in RA per student.

3.4 Student registration and information systems

The usual University procedures for registration and enrolment will apply to the incoming Ph.D. in Environmental Science.

Appendix I: Canadian Graduate Programs in the Environment

Appendix Ia: Canadian Graduate Programs in Environmental Studies, Geography and Natural Resources (Note: University of Toronto programs are given in bold)

Carleton University - Geography and Environmental Studies
 Concordia University - Environmental Impact Assessment
 Dalhousie University - Resource and Environmental Studies
 Lakehead University - Master of Environmental Studies in Nature-Based Recreation & Tourism
 Royal Roads University - Graduate Certificate in Environmental Education and Communication
 Royal Roads University - Graduate Diploma in Environmental Education and Communication
 Royal Roads University – Environment and Management (MA, MSc)
 Royal Roads University - Environmental Education and Communication (MA)
 Ryerson University - Environmental Applied Science and Management
 Simon Fraser University - Resource and Environmental Management
 University of British Columbia - Resource Management and Environmental Studies
 University of British Columbia - Occupational and Environmental Hygiene
 University of Calgary - Energy and the Environment
 University of Calgary - Environmental Design (MA, PhD)
 University of Guelph - Resource and Environmental Economics (PhD)
 University of New Brunswick - Faculty of Forestry and Environmental Management
 University of Northern British Columbia - International Studies (MA - Regional Relations, International Development, Global Environmental Policy)
 University of Northern British Columbia - Natural Resources and Environmental Studies, MA
 (Geography, Environmental Studies, Tourism)
 University of Northern British Columbia - Natural Resources and Environmental Studies (PhD & MNRES)
University of Toronto - Environmental Geography and Resource Management (MA, PhD)
University of Toronto - Environmental Planning (MA)
University of Toronto - Environmental Studies (MA, PhD)
 University of Waterloo - Environment and Resource Studies
 University of Western Ontario – Environment and Sustainability (MSc, PhD)
 York University - Business and the Environment
 York University - Graduate Diplomas in Environmental/Sustainability Education
 York University - Graduate Diplomas in Environmental/Sustainability Education
 York University - Environmental Studies (MSc, PhD)

Appendix Ib: Canadian Graduate Programs in Environmental Engineering

(Note: University of Toronto programs are given in bold)
 Carleton University - Ottawa-Carleton Institute for Environmental Engineering
 Concordia University - Environmental Engineering
 Dalhousie University - Graduate Studies in Environmental Engineering
 Memorial University of Newfoundland - Environmental Engineering and Applied Science (MAsc)
 Royal Military College of Canada - Environmental Engineering
 University of Calgary - The Centre for Environmental Engineering, Research and Education
University of Toronto - Environmental Engineering
University of Toronto - Environmental Science and Engineering
 University of Ottawa - Environmental Engineering (PhD/?)
 University of Saskatchewan - Environmental Engineering
 University of Windsor - Environmental Engineering (MAsc/MEng/PhD)

Appendix Ic: Canadian Graduate Programs in Environmental Biology

(Note: University of Toronto programs are given in bold)
 Simon Fraser University - Environmental Biology
 University of Guelph - Environmental Biology (MSc/PhD)

Appendix Id: Canadian Graduate Programs in Environmental Health

(Note: University of Toronto programs are given in bold)

University of Toronto - Occupational and Environmental Health (MHSc/MSc)

Appendix Ie: Canadian Graduate Programs in Environmental Chemistry & Toxicology

(Note: University of Toronto programs are given in bold)

Carleton University - Ottawa-Carleton Collaborative Program in Chemical and Environmental Toxicology

University of Toronto - Environmental Chemistry (MSc, PhD)

University of Ottawa - Chemical and Environmental Toxicology (PhD)

Appendix If: Canadian Graduate Programs in Environmental Science

(Note: University of Toronto programs are given in bold)

McGill University – School of Environment (MA, MSc, PhD)

Memorial University of Newfoundland – Faculty of Science (PhD & Master of Environmental Science/Master of Science)

Royal Military College of Canada - Environmental Science

Trent University - Watershed Ecosystems (MSc, PhD)

University of Northern British Columbia (MSc, PhD)

University of Northern British Columbia - Natural Resources and Environmental Studies, MSc

(Biology, Environmental Science, Forestry, Geography, Recreational Resource Management)

University of Toronto Scarborough - Environmental Science (MEnvSc)

University of Windsor – Great Lakes Institute for Environmental Research (MSc, PhD)

REPORT ON LIBRARY RESOURCES
FOR A PROPOSED DEGREE OF
DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE
AT UNIVERSITY OF TORONTO SCARBOROUGH

BACKGROUND

The University of Toronto Scarborough Library is well positioned to provide the necessary scholarly resources and services required for a graduate program at the doctoral level in Environmental Science. Together with other libraries in the University of Toronto Library (UTL) system, the collection supports research in a full range of both traditional subjects of geology, geography, biology, ecology, chemistry, geophysics, engineering and the interdisciplinary subject of environmental sciences. Researchers in this program will draw on literature that is diverse in its coverage, from basic field and laboratory techniques to an examination of real world environmental problems.

All libraries are challenged by financial constraints in an environment characterized by an 'information explosion' of print and electronic resources. Accordingly, libraries are necessarily selective in materials that are purchased for their particular institution. The University of Toronto Library's holdings have been developed in a systematic way by U of T Scarborough and UTL selectors and through faculty requests to ensure that all commercially produced current imprints of books are received by the Library.

At U of T Scarborough, the best scholarly resources are purchased to support courses, programs and research activities at the campus. At the same time, U of T Scarborough enjoys the benefits of having access to the resources of all the other libraries in the UTL system. Access to the collection is provided through an integrated online catalogue of UTL records, searched by author, title, subject, or keyword. Using features of the online catalog, materials from any U of T library can be delivered to U of T Scarborough within 1-5 days through the InterCampus Delivery service. As such, irrespective of library affiliation, all users have access to the same UTL resources. Similarly, through Interlibrary Loan services, access to materials from academic institutions around the world can be requested in the library's online environment.

Currency is of utmost importance in all science disciplines. Continuous improvements in the Library's processing of materials ensure that newly acquired resources are made available to the University community as quickly as possible.

DESCRIPTION OF THE COLLECTION**Monographs**

The University of Toronto Library is ranked fourth over-all in holdings for North American libraries⁷.

It is the policy of UTL to acquire a single copy of all science books published in English that are considered to be of research value. These include print and/or electronic proceedings of conferences and symposia, professional society publications, review literature, technical handbooks, research monographs and reference books in the forms of handbooks, encyclopedias, dictionaries and biographies.

Given the interdisciplinary nature of environmental studies, environmental resources are distributed throughout the UTL system. In addition to holdings at U of T Scarborough, students and faculty in this program will find substantial resources in many other U of T libraries, such as Noranda Earth Sciences, Engineering and Computer Science, Robarts, Law, and the Gerstein Science Information Centre.

1. ARL Statistics 2007-08. Association of Research Libraries.
<http://www.arl.org/stats/annualsurveys/arlstats/arlstats08.shtml>. Accessed July 7, 2009.

Serials

Periodical publications are the primary means by which information is made known to scientists and the U of T libraries have extensive journal holdings. However, like all North American libraries, UTL is experiencing great difficulty in keeping up with the rising cost of serial subscriptions. This situation has improved significantly in the recent past due to the Library's commitment to purchase an ever-increasing number of electronic journals. At the present time a total of 61,448 electronic journals, 1,053 electronic journal indexes and 4,195 electronic news services are available to students and faculty at the university. Many of these have full text availability.

A search of the ISI journal citation reports for the subject area "Environmental Studies" shows the Library system holding a print or full text electronic version of 157 of the 163 top ranked journals.

ELECTRONIC RESOURCES

The electronic information services at the University of Toronto Library have been evolving since 1987, when the first online catalogue was mounted. Within a year, the online catalogue was available in all the campus libraries, and dial-in access was introduced with a small number of lines. Abstracts and indexes had been computerized since the early 1970's and through the 1980's, searched by trained intermediaries. Beginning in the late 1980's CD-ROMs and networked databases widened the access of electronic databases to the end-user to perform his or her own searches. Today most electronic resources are accessed through a web interface, and the U of T Library is a world leader in the provision of resources in this manner.

In support of Environmental Studies, the Library subscribes to major abstracting and indexing online services such as *Science Citation Index*, *Scopus*, *Environmental Sciences and Pollution Management*, *Environment Abstracts* and *Geobase*. Major organizations and agencies such as Environment Canada, the Environmental Protection Agency, and the United Nations are well represented in both electronic and print formats.

STAFF and SERVICES

Currently U of T Scarborough Library staff consists of 7.92 FTE librarians and 15.87 FTE library technicians. The Library is open 168 hours per week from September to May and 71.25 hours per week from May to August, which includes weekend hours of service. The library also provides 24/7 library services from mid-October to December and from February to early May.

Environmental science is complex and interdisciplinary in nature. Information research in today's environment is also complex with increasingly important reliance on electronic databases, the Internet and the vast quantity of resources available in all formats at the University of Toronto and beyond. Service is the key to ensuring that the most relevant resources are found for research purposes. It is the support through U of T Scarborough Library's Reference, Research and Instruction, Circulation and Media services which facilitates this efficiency in research. The Library has an information literacy specialist and librarians offer one-on-one instruction sessions to identify and optimize the use of scholarly resources.

The following are examples of the types of support available through the University of Toronto Library: connections to local, national and international scientific information networks, verification of citations, teaching and orientation in the use of the Library's collection, electronic indexes, networked databases, the Internet and more. During the Fall/Winter term, service in person, by telephone, email or chat is available in the U of T Scarborough Library until 10:30 p.m. (Fall) and 12 midnight (Winter) and in the Summer term, until 10:30 p.m.

Approximately 94 computers in the U of T Scarborough Library's Informatics Commons are available, in addition to the 476 computers on campus, to provide access to the Library catalogue and other online resources. All electronic resources are also available from desktops in offices or from home. Together

with the increasing online support services such as email and chat reference and online help guides, the complex world of information research is easily accessible to faculty and students beyond the limits of a physical library building.

SUPPORTING COLLECTIONS

While no one library can own every title that is published, we understand the importance of developing and maintaining efficient networks for quick and easy access to other libraries' resources. As already mentioned, U of T Scarborough Library's services enables users to obtain materials from other U of T libraries and from those outside of the University. U of T Scarborough places high priority in seeking ways to further expedite the process between when an item is ordered to when it arrives in the Library.

With a TCard, users have direct access and full privileges to all of U of T libraries. In addition, by presenting the card at any Canadian University, the holder may apply for direct borrowing privileges at that institution with no cost to the user.

BUDGET and LONG-TERM COMMITMENTS

The strength of the Library's financial commitment to purchasing material over the next five to seven years depends upon University policy and government funding. To date it has been the University of Toronto's stated policy to protect, as far as possible, the Library's acquisition budget from rising costs and maintain this protected status. This present financial policy allows the Library to maintain its current purchasing levels for publications relevant to Environmental Science and ensures continued support for the program.

Prepared by: Cristina Sewerin
Physical & Applied Sciences Book Selector

Victoria Owen
Head Librarian, University of Toronto Scarborough

Submitted by: Carole Moore
Chief Librarian
University of Toronto Libraries

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