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SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

COURSE TITLE: ENVIRONMENTAL ANALYSIS (OUTLINE & LAB MANUAL)

CODE NO.: FOR 364-6 SEMESTER: V

PROGRAM: FISH AND WILDLIFE TECHNOLOGY

AUTHOR: VALERIE WALKER

DATE: JANUARY 1993 PREVIOUS OUTLINE DATED: JANUARY 1992

APPROVED: _____ Jan 15/93

DEAN DATE

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I. PHILOSOPHY/GOALS:

This lab-based course provides the measurement and analysis of various parameters within the environment as well as a discussion of their significance. Topics include instrument operation, calibration and standardization and proper laboratory techniques. Labs will examine primary production, oxygen consumption in aquatic systems, response of organisms to a toxicant (bioassay) and the buffering capacity of lakes as related to acid precipitation. Outdoor Labs will examine temperature and oxygen stratificaiton of lakes in winter, the effect of ice on lake productivity and snow density and snow type and its impact on wildlife . In addition, organic molecules of importance as related to the nutritional requirements of wildlife, will be studied with a practical application to bomb calorimetry.

II. STUDENT PERFORMANCE OBJECTIVES:

Upon successful completion of this course the student will be able to:

1. Discuss the physical, biological and ecological relationships in lentic versus lotic environments.
2. Describe those factors affecting oxygen consumption and production in aquatic systems.
3. Define pollution and discuss the categories of contamination.
4. Outline the procedure for setting up a bioassay and discuss the determination of LC50's, ET50's and toxicity curves.
5. Demonstrate the use and standardization of pH and oxygen meters.
6. Conduct an accurate titration for total inflection point alkalinity and dissolved oxygen.
7. Demonstrate the use of a snow gauge and correct documentation of results.
8. Discuss the physics of snow and its impact on wildlife.
9. List and discuss the essential nutrients required in wildlife nutrition and determine the caloric value of food items through bomb calorimetry.

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III. TOPICS TO BE COVERED:

WEEK

1 Introduction

- evaluation
- course outline
- lab safety
- lab equipment

1 **Lab 1 Enzyme Method of Clearing and Staining**

1-3 Unit I: Freshwater Systems

- lotic and lentic environments
- food chains and food transfer effects
- recycling
- seasonal production cycles
- factors affecting primary productivity
- stability of ecosystems

2 **Lab 2 Temperature and Oxygen Consumption in Aquatic Animals**

4 Unit II: Oxygen Consumption in Aquatic Animals

- factors affecting oxygen consumption
- oxygen as a limiting factor

4 **Lab 3 Total Inflection Point Alkalinity**

5 **TERM TEST #1**

5,6,7 Unit III: Winter Surveys

- inverse stratification of lakes
- ice formation and its effect on light, production, oxygen
- snow compaction, chillometer
- physics of snow

8 **Lab 4 Winter Survey/Snow Study**

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III. TOPICS TO BE COVERED: CONTINUED

9,10 Unit IV: Aquatic Pollutants

- definition of pollution
- categories of contamination
- acidification (SPEAKER)
- toxicity terminology
- environmental factors affecting toxicity
- biomagnification
- bioassays
- (Videos - H_2 Overview, Early Warning)

11 **Lab 5 Bioassay**

11 - (Speaker: Sea Lamprey)

12 Unit V: Organic Molecules in Wildlife Nutrition

- required nutrients:
  - water
  - protein
  - carbohydrates
  - lipids
- energy metabolism
- macrominerals
- micro (trace) minerals

12 **Lab 6 (a) Bomb Calorimetry - Sample Preparation**

13 **LAB 6 (b) Bomb Calorimetry - Bombing**

14 **TERM TEST #2**

N.B. SCHEDULE SUBJECT TO CHANGE

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IV. EVALUATION METHOD:

A - 80%
B - 70%
C - 60%
R - less than 60%

Lab Reports	- 50%
Term Tests (2)	- 50%
	100%

Due to the practical nature of this course and the emphasis on laboratory technique and data interpretation, there will be no opportunity for a "rewrite".

Students with a final grade of less than 60% will receive an "R" grade. All labs must be submitted for a passing grade.

Lab attendance is **compulsory**. Students missing labs without documented reason run the risk of repeating the course.

V. REQUIRED STUDENT RESOURCES:

TEXTBOOK(S):

No textbook required for purchase. Lab manual is available at Campus Bookstore.

EQUIPMENT:

- lab coat
- safety glasses

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VI. ADDITIONAL RESOURCE MATERIAL AVAILABLE IN THE COLLEGE LIBRARY:

Adams, S. Marshall (ed.) 1990. Biological Indicators of Stress in Fish. American Fisheries Society Symposium 8. AFS. Bethesda, Maryland QL 639.1B55 1990

Alabaster, J.S. and R. Lloyd. 1982 Water Criteria for Freshwater Fish (2nd Edition). Butterworth's Inc., Yarmouth MA.

*American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1975, Standard Methods for the Examination of Water and Wastewater. 14th ed. Am. Publ. Health Assoc., Washington, D.C.

*American Society for Testing and Materials. 1977. Bacterial Indicators - Health Hazards Associated with Water. ASTM, Phil.

*American Society for Testing and Material. 1977. Aquatic Toxicology and Hazard Evaluation. ASTM, Philadelphia.

*Andrews, W. A. 1972. A Guide to the Study of Environmental Pollution. Prentice-Hall, Inc. Scarborough, Ontario.

Ashworth, W. 1989. The Late, Great Lakes: An Environmental History. Collins Publ., Stockton, California. QH 545.A1 A57 1989

Black, John A. 1977. Water Pollution Technology. Reston Publishing Company, Inc. Virginia.

Brewer, Richard. 1979. Principles of Ecology. Saunders, Philadelphia

Brown, Lester Russell. 1988. State of the Word: A Worldwatch Institution Report on Progress Toward a Sustainable Society. W. W. Norton, New York

Burns, Noel M. 1985. Erie: The Lake that Survived. Rowman & Allanheld Pub., Totowa, N.J.

*Cairns, John Jr. 1982. Biological Monitoring in Water Pollution. Pergamon.

Cairns, V.W., Hodson, Peter V. and Nriagu, J.O. 1984. Contaminant Effects on Fisheries. John Wiley & Sons, New York.

Chant, D. A. 1970. Pollution Probe. New Press, Toronto.

Colborn, Theodora E. 1990. Great Lakes, Great Legacy? Conservation Foundation and Institute for Research on Public Policy in Canada. Halifax, N.S. TD 181.G73 G73 1990

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VI. ADDITIONAL RESOURCE MATERIAL - 2

Delwiche, C.C. 1981. Denitrification, Nitrification and Atmospheric Nitrous Oxide. Wiley, New York

Edmondson, W. T. (1969). Eutrophication in North America. In - Eutrophication - Causes, Consequences, Correctives. pp. 124-49. National Academy of Sciences, Washington.

Environment Canada 1986. From Cradle to Grave. A Management Approach to Chemicals. Ministry of Supply & Services Ottawa. TD 196.C45T38 1986

Environmental Protection Agency. 198_. Water Quality Criteria. E.P.A. R3-73-033. Washington, D.C.

*Environmental Studies Board. 1983. Committee on Atmospheric Transport and Chemical Transformation in Acid Precipitation. Acid Deposition: Atmospheric Processes in Eastern North America. National Academy Press, Washington, D.C.

Evans, M. S. (ed). 1988. Toxic Contaminants and Ecosystem Health: A Great Lakes Focus. John Wiley and Sons, N.Y. TD180.A38V.21

Freeman, A.M., Robert Haveman and Allen Kneese. 1984. The Economics of Environmental Policy. R.E. Krieger Publishing Co., Inc., Florida

*Goldman, Charles R. and A. J. Horne. 1983. Limnology. McGraw-Hill, Toronto.

*Gordon, Malcolm S. 1982. Animal Physiology: Principles and Adaptations (4th edition). MacMillan Publishing Co., Inc. New York.

Gore, James A. 1985. The Restoration of Rivers and Streams: Theories and Experience. Butterworth Publishing Co., Boston

Hammer, Mark J., 1986. Water and Wastewater Technology. John Wiley and Son Inc., New York.

Heath, Alan G. 1987. Water Pollution and Fish Physiology. CRC Press Inc., Boca Raton, Florida. SH174.H43 1987

*Hoar, W. S. 1983. General and Comparative Physiology (3rd Edition). Prentice-Hall, Inc., New Jersey.

Hoar, W. S., and D.J. Randall, (eds.). 1979. Fish Physiology. Vol.7: Locomotion Academic Press, Inc., London.

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ADDITIONAL RESOURCE MATERIAL - 3

*Hoar, W.S., D.J. Randall and J.R. Brett (eds). 1979. Fish Physiology. Vol.8: Bioenergetics and Growth. Academic Press, Inc., London.

Hocutt, Charles H. and Jay R. Stauffer Jr. (eds). 1980. Biological Monitoring of Fish. Lexington Books, Lexington, Mass.

Huntley, R.V. and R.Z. Rivers (eds). 1986. Proceedings of the Acid Rain Evaluation Seminar. Dept. of Fisheries and Oceans, Ottawa.

*Hynes, H. B. N. 1970. The Ecology of Running Waters. University Toronto Press, Toronto.

_____. 1974. The Biology of Polluted Waters. University Toronto Press, Toronto.

Isom, Billy G., S.D. Dennis, J.M. Bates. 1986. Impact of Acid Rain and Deposition on Aquatic Biological System. ASTM, Philadelphia.

Johnson, Raymond E. 1982. Acid Rain/Fisheries: Proceedings of an International Symposium on Acidic Precipitation and Fishery Impacts in Northeastern North America, Cornell University, Ithaca, New York, August 2-5, 1981. American Fisheries Assoc., Bethesda, Md.

Kimball, John W. 1978. Biology. 4th Ed. Addison-Wesley, Don Mils, Toronto.

*Krenkel, P.A. and Parker, F.L. 1973. Nation Symposium on Thermal Pollution Proceedings: Biological Aspects of Thermal Pollution.

*Larkin, P.A. 1974. Freshwater Pollution Canadian Style. McGill-Queen's University Press, Montreal.

*Laws, Edward A. 1981. Aquatic Pollution - An Introductory Text. John Wiley and Sons, Toronto.

Mason, C. F. 1981. Biology of Freshwater Pollution. Longman.

McKane, L. and Kandel J., 1985. Micro-Biology Essentials and Applications. McGraw-Hill Book Co., Toronto.

*McNeely, R. N., V. P. Neimanis and L. Dwyer. 1979. Water Quality Sourcebook Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa.

McPhee, John 1989. The Control of Nature. Strauss, Farrar and Giroux, N.Y.

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ADDITIONAL RESOURCE MATERIAL - 4

Minns, Charles Kenneth 1986. Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Cdn. Special Publicaiton of Fisheries and Aquatic Sciences. Dept. of Fisheries & Oceans, Ottawa TD227.06 P73

Misener, A. D. and G. Daniel (eds.) 1982. Decisions for the Great Lakes. Great Lakes Tomorrow, Hiram, Ohio.

Morgan, James and Werner Stum. 1981. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibrium in Natural Waters. Wiley, New York

Murty, A.S. 1986. Toxicity of Pesticides to Fish. CRC Press. Bocaratoni, FLA.

*National Research Council of Canada. 1985. TFM and Bayer 73: Lampricides in the Equatic Environment. Pub. No. NRCC 22488, Ottawa.

Owen, O.S. 1985. Natural Resources Conservation - An Ecological Approach. MacMillan, New York

Palmer, C. Mervin. 1980. Algae and Water Pollution. Castle House Publications, Ltd., England.

Pavoni, J.L., 1977. Handbook of Water Quality Management Planning. Van Nostrand Reinhold Co., Litton Educaitonal Publishing Inc., New York.

Pickering, A.D. 1981. Stress and Fish. Academic Press, San Diego, California. QL639.1 S74 1981

Rand, Gary M and Sam, R. 1985. Fundaments of Aquatic Toxicology; Methods and Applications. Hemisphere Publications, Washington.

*Reid, George K. 1961. Ecology of Inland Waters and Estuaries. Van Nostrand Reinhold Co., Toronto.

*Ruttner, F. 1963. Fundamentals of Limnology. University of Toronto Press, Toronto.

Salle, A.J., 1967, Fundamental Principles of Bacteriology. 6th edition, McGraw-Hill Book Co., Toronto.

Schmidtke, N. W. 1986. Toxic Contamination in Large Lakes. World Conference on Large Lakes. Lewis Publishers QH545.W3 W67 1986

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ADDITIONAL RESOURCE MATERIAL - 5

Shubert, Elliot L. 1984. Algae as Ecological Indicators. Academic Press, San Diego, California. QK 565.A46 1984

*Smith, R. L. 1974. Ecology and Field Biology. Harper and Row Publishers, New York.

*Sprague, J. B. 1973. The ABC's of pollution bioassay using fish. Biological Methods for the Assessment of Water Quality, ASTM STP 528, American Society for Testing and Materials, 1973, pp. 6-30. (Reprint available)

Suffet, Irwin H. 1977. Fate of Pollutants in the Air and Water Environments. Wiley, New York.

Tinsley, Ian J. 1979. Chemical Concepts in Pollution Behaviour. Wiley Interscience, New York.

Tourbier, J. and R. W. Pierson, Jr. (eds.). 1976. Biological Control of Water Pollution. University of Pennsylvania Press, Inc., PA.

Tu, Anthony T. (ed). 1982. Survey of Comtemporary Toxicology, Vol. 2. Wiley, New York.

Vallentyne, J. R. 1974. The Algae Bowl. Lakes and Man. Canada Department of the Environment, Fish and Marine Service, Misc. Spec. Pub. No. 22: 186 pp.

Viessman, W.Jr. and M.J. Hammer. 1985 Water Supply and Pollution Control. Harper and Row, Publishers, New York.

Wagner R. H., 1971. Environment and Man. Norton, New York.

Warren, C. E. 1971. Biology and Water Pollution Control. Saunders, Philadelphia.

Wetzel, Robert G. 1983. Limnology (2nd Edition). Saunders. College Publishing, Toronto.

Wetzel, R. G., and G. E. Likens, 1979. Limnological Analyses. Saunders, Philadelphia.

*Wilber, Charles G. 1969. The Biological Aspects of Water Pollution. Charles C. Thomas. Illinois.

*Worf, D. L. 1980. Biological Monitoring for Environmental Effects. Lexington Books, San Diego, CA

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Wildlife Aging References

Bagenal, T.B. (ed). 1974. The Aging of Fish. Proceedings of an International Symposium (University of Reading, England, 1973), Unwin Brothers Ltd., Surrey, England

Nielsen, Larry A. and David L. Johnson (eds). 1983. Fisheries Techniques. American Fisheries Society. Southern Printing Co., Inc., Blacksburg, Virginia

Summerfelt, Robert C. and Gordon E. Hall (eds). 1987. Age and Growth of Fish. Iowa State University Press. Ames, Iowa

Weatherley, A. H. and H. S. Gill. 1987. The Biology of Fish Growth. Academic Press. Toronto, Ontario

*ON RESERVE AT THE COLLEGE LIBRARY

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REPORT WRITING

All lab reports should include the following components:

1. Purpose/Objective - a brief statement outlining the intent of the exercise. Objectives may be itemized, i.e.,

   a) to determine LC_{50} for zinc using rainbow trout
   b) to investigate the relationship between water temperature, pH, alkalinity and the toxicity of zinc to rainbow trout

2. Method/Procedure - a brief outline of how the exercise was conducted. In many instances "Refer to manual" will suffice.

3. Results - a presentation of results, and only results, in an organized format, i.e., TABLE FORMAT. There should be no sentences, no paragraphs--table and figures (graphs) only. Be sure all table and figures are entitled and numbered.

Table 1 - Physical Characteristics of the Great Lakes

Lake	Area (km^2)	Area of Drainage Basin (km^2)	Average Depth (m)	Volume (ckm)	Retention time (yr)
Superior	82,100	127,700	147	12,100	191
Michigan	57,800	118,000	85	4,920	99
Huron	59,600	134,000	59	3,540	22
Erie	25,700	78,000	19	484	2.6
Ontario	18,960	64,030	86	1,640	6

4. Calculations - one example of each different calculation used in presenting the results should appear in this section. Subsequent work using the same calculations should appear in the Appendix. Hence, with the exception of one example calculation, all calculations use to generate data in tables must be shown in the Appendix.

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5. Discussion of Results and Conclusions - results are interpreted and discussed. Carefully observe data to determine trends and relationships among all parameters measured.

Are apparent relationships consistent with established relationships present in literature? In this section, you are responsible for conducting a literature search to compare your findings with that of established authors.

Be sure to refer to your data using table and figure numbers - e.g., a direct linear relationship between white sucker weight and fork length is apparent in Figure 2. This relationship agrees well with that established for white sucker by J. A. Smith (1982), W. T. Jones (1974) and B. R. Brown (1971).

If your findings are not consistent with other studies or theories, offer some explanation for the deviation.

e.g., According to Saunders (1972), the principle component of lake trout stomach samples (n=785) in Round Lake prior to 1965 was lake herring (Coregonus artedii) at 72% by volume. Data from this study, however, indicates rainbow smelt (Osmerus mordax) as the dominant food item in 525 lake trout sampled, averaging 97% of stomach contents by volume (Figures 1 and 2). This change in forage species preference is attributed to the introduction of rainbow smelt in 1969 (Wilson, 1971).

All questions posed at the end of a lab exercise should be answered in this section.

N.B. There are several acceptable methods of citing references and referring to your data within the text of your report. Footnotes are not acceptable. Quotes are not acceptable.

N.B. Scientific names of species should appear in brackets only once after the first time the common name appears in the text.

In addition to interpreting and discussing, conclusions should be clearly stated, often itemized, at the end of this section.

6. Sources of Error - itemize all conceivable sources of error.

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7. Appendix

- present calculations for all values appearing in tables.

8. Reference Cited

- presented on a separate page at end of report,

- all citations in text of report must be listed alphabetically in this section and conversely all references listed in this section must be cited in the text of the report.

i.e.:

1) For paper presented in a journal:

Mason, C. F. and R. J. Bryant. 1974. The structure and diversity of the animal communities in a broad land reed-swamp, J. Zool., 172, 289-309.

issue no. page reference

2) For book references:

Hynes, H. B. N., 1970. The Ecology of Running Waters, Liverpool University Press, Liverpool.

3) For paper/chapter presented in publication:

Chapman, D.W. 1978. Production fish populations. In Ecology of Freshwater Fish Production (S. D. Gerking, ed.). Blackwell. Oxford.

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MAJOR DO'S AND DON'TS

1. Don't use first person in report text, i.e., I, we, our.
2. Do refer to tables and figures by number. Be sure all tables and figures in Results are numbered and entitled.
3. Use correct citation of references.
4. Do not use quotes.
5. Scientific names of species need only appear once in text of report. They are placed in brackets and underlined after the common name of the species appears for the first time.

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REPORT MARKING - ONE REPORT SUBMITTED PER STUDENT

	SECTION	MARK	MARKING BASED ON
1.	Purpose	1	Conciseness; completeness
2.	Method	1 (if applicable)	Conciseness; completeness
3.	Results	2	Organization; labels, numbers on tables, figures; neatness; correctness
4.	Calculations	1	Correctness, completeness
5.	Discussion	4 or 5 if method not applicable	Conciseness; organization; reference material used and cited; completeness
6.	Errors	1	Completeness
		TOTAL 10	
7.	Appendix	minus 1 mark if absent or incorrect	
8.	Reference	minus 1 mark if absent or incorrect	

N.B. Ten percent (10%) deducted per day for late reports.

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GLASSWARE PREPARATION

For accuracy, glassware must be properly cleaned fo all impurities prior to conducting lab exercises.

1. Wash all glassware needed in warm soapy water. Use brushes if necessary.
2. Rinse glasware 3 times under tap water.
3. Rinse glassware well with distilled water 3 times.
4. Place glassware upside down on paper towel to drain.

COMMONLY USED TERMINOLOGY

MEASUREMENTS & UNITS

mg/l	=	milligram per litre	=	part per million (ppm)
ug/l	=	microgram per litre	=	part per billion (ppb)
ng/l	=	nanogram per litre	=	part per trillion (ppt)
pg/l	=	picograms per litre	=	part per quadrillion (ppq)
mg/kg	=	milligram per kilogram	=	part per million (ppm)
ug/kg	=	microgram per kilogram	=	part per billion (ppb)
ng/kg	=	nanogram per kilogram	=	part per trillion (ppt)
L/d	=	litre per day		
m^3/d	=	cubic metres per day		
kg/ann (kg/yr)	=	kilograms per year		
t/ann (kg/yr)	=	tonnes per year		
uS/cm	=	microsiemens per centimetre (conductivity)		
mgd	=	millions of gallons per day		
cfs	=	cubic feet per second		

Acronyms

AOC — Area of Concern: An area recognized by the International Joint Commission where water uses are impaired or where objectives of the Great Lakes Water Quality Agreement or local environmental standards are not being achieved.

BOD — Biochemical Oxygen Demand: The amount of dissolved oxygen required for the bacterial decomposition of organic waste in water.

COA — Canada-Ontario Agreement

COD — Chemical Oxygen Demand: The amount of oxygen required to oxidize completely by chemical reagents the oxidizable compounds present.

CSO — Combined Sewer Overflow

DDT — Dichlorodiphenyltrichloroethane: A widely used, very persistent pesticide (now banned from production and use in many countries) in the chlorinated hydrocarbon group.

GLISP	Great Lakes International Surveillance Plan
IJC	International Joint Commission: A binational organization established in 1909 by the Boundary Waters Treaty. Through the IJC, Canada and the United States cooperatively resolve problems along their common border, including water and air pollution, lake levels, power generation and other issues of mutual concern.
LC_{50}	That concentration of a toxicant or effluent which is lethal to 50% of the test organism over a specified time period.
LD_{50}	That dose which is lethal to 50% of the test organism over a specified time period.
MDNR	Michigan Department of Natural Resources
MISA	Municipal-Industrial Strategy for Abatement: The principal goal of this program is to clean up Ontario's waterways. It represents a new approach to controlling point source water pollution. MISA will control and reduce the amount of toxic contaminants in all industrial and municipal effluents discharged into Ontario's surface waters. The ultimate goal of MISA is the virtual elimination of toxic contaminants from all municipal and industrial discharges into the province's waterways.
NOAA	National Oceanic and Atmospheric Administration
OMNR	Ontario Ministry of Natural Resources
OMOE	Ontario Ministry of the Environment
PAH	Polynuclear aromatic hydrocarbons
PTS	Persistent Toxic Substance: Any toxic substance with a half-life in water of greater than eight weeks.
RAP	Remedial Action Plan: This is a plan to be developed with citizen involvement to restore and protect water quality of the Great Lakes. There are 42 Areas of Concern in the Great Lakes Basin which will develop a RAP.

UGLCCS Upper Great Lakes Connecting Channels Study

U.S. EPA United States Environmental Protection Agency

STP/WPCP Sewage Treatment Plant/Water Pollution Control Plant.

WWTP Waste Water Treatment Plan

OTHER TERMINOLOGY

ALGA (ALGAE) - Simple one-celled or many-celled micro-organisms capable of carrying on photosynthesis in aquatic ecosystems.

ANOXIA The absence of oxygen necessary for sustaining most life. In aquatic ecosystems this refers to the absence of dissolved oxygen in water.

AMBIENT WATER The water column or surface water as opposed to groundwaters or sediments.

BENTHIC/BENTHOS Bugs which live in and on the bottom of the river.

BIOMASS Total dry weight of all living organisms in a given area.

BIOMONITORING The use of organisms to test the acute toxicity of substances in effluent discharges as well as the chronic toxicity of low-level pollutants in the ambient aquatic environment.

CARCINOGEN Cancer-causing chemicals, substances or radiation.

DISSOLVED OXYGEN The amount of oxygen dissolved in water. See BIOCHEMICAL OXYGEN DEMAND.

DRAINAGE BASIN A waterway and the land area drained by it.

ECOSYSTEM The interacting complex of living organisms and their non-living environment.

EFFLUENT Wastewaters discharged from industrial or municipal sewage treatment plants.

EPILIMNION The warm, upper layer of water in a lake that occurs with summer stratification.

EROSION The wearing away and transportation of soils, rocks and dissolved minerals from the land surface or along shorelines by rainfall, running water, or wave and current action.

EUTROPHICATION The process of fertilization that causes high productivity and biomass in an aquatic ecosystem. Eutrophication can be a natural process or it can be a cultural process accelerated by an increase of nutrient loading to a lake by human activity.

EXOTIC SPECIES Species that are not native to the Great Lakes and have been intentionally introduced or have inadvertently infiltrated the system.

FOODCHAIN The process by which organisms in higher trophic levels gain energy by consuming organisms at lower trophic levels.

GREAT LAKES WATER QUALITY AGREEMENT A joint agreement between Canada and the United States which commits the two countries to develop and implement and plan to restore and maintain the many desirable uses of the waters in the Great Lakes Basin.

GROUNDWATER Water entrained and flowing below the surface which is the supply of water to wells and springs.

HALF-LIFE The amount of time required for the concentration of a pollutant to decrease to half of the original value.

HYDROLOGIC CYCLE The natural cycle of water on earth, including precipitation as rain and snow, runoff from land, storage in lakes, streams, and oceans, and evaporation and transpiration (from plants) into the atmosphere.

HYPOLIMNION The cold, dense, lower layer of water in a lake that occurs with summer stratification.

LEACHATE Materials suspended or dissolved in water and other liquids usually from waste sites that percolate through soils and rock layers.

MASS BALANCE An approach to evaluating the sources, transport and fate of contaminants entering a water system as well as their effects on water quality. In a mass balance budget, the amounts of a contaminant entering the system less the quantity stored, transformed or degraded must equal the amount leaving the system. If inputs exceed outputs, pollutants are accumulating and contaminant levels are rising. Once a mass balance budget has been established for a pollutant of concern, the long-term effects on water quality can be simulated by mathematical modelling and priorities can be set for research and remedial action.

NON-POINT SOURCE Source of pollution in which pollutants are discharged over a widespread area or from a number of small inputs rather than from distinct, identifiable sources.

NUTRIENT A chemical that is an essential raw material for the growth and development of organisms.

PCBs Polychlorinated biphenyls - A class of persistent organic chemicals that bioaccumulate.

PATHOGEN A disease-causing agent such as bacteria, viruses, and parasites.

PHOTOSYNTHESIS A process occurring in the cells of green plants and some microorganisms in which solar energy is transformed into stored chemical energy.

PHYTOPLANKTON Minute, microscopic aquatic vegetative life.

POINT SOURCE A source of pollution that is distinct and identifiable, such as an outfall pipe from an industrial plant.

PUBLIC Any person, group, or organization.

RESUSPENSION (Of sediment) The remixing of sediment particles and pollutants back into the water by storms, currents, organisms and human activities such as dredging.

SEDIMENT The fines or soils on the bottom of the river.