The Effect of Clearcut Logging and Forest Fires on Hypolimnetic Oxygen Depletion Rates in Remote Canadian Shield Lakes

by:

Peter Douglas St. Onge

Department Of Biology

McGill University

Montreal, Québec

Canada

July 2001

A Thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the Master of Science.

0-612-75346-8

Thesis Abstract

Thirty-eight oligotrophic lakes located around the Réservoir Gouin in central Québec (48^oN, 75^oW) were sampled over three years to test the hypothesis that forest clearcutting and fires should be reflected in both higher nutrient export rates and ultimately in greater areal hypolimnetic oxygen deficit rates (AHOD). Significant differences in estimated total phosphorus export rates across treatments were found. However, no effect of clearcutting or forest fire on hypolimnetic oxygen consumption rates could be demonstrated as the result of a much greater and confounding variation in the effect of lake morphometry and the absence of information on the role of catchment-derived organic matter on the AHOD. Consequently, only lake morphometry (hypolimnetic volume to hypolimnetic surface area ratio) served as a predictor of the AHOD. Covariation of mean hypolimnetic water temperature with morphometric variables underlines the influence of lake morphometry on heat dynamics and hypolimnetic respiration rates in these lakes.

This research made considerable use of specialized data manipulation techniques involving a relational database management system, owing to the size of the dataset used (114 lake-years of data). The specific approach used in this thesis is presented in an appendix.

Résumé de Thèse

Trente-huits lacs oligotrophiques ont été échantillionés au cours de trois étés dans la région du Réservoir Gouin, au centre du Québec (48^oN, 75^oW) afin d'évaluer l'hypothèse que le déboissement devrait se manifester en forme d'augmentations des mesures d'exports des nutriments ainsi que les taux de consommation d'oxygene hypolimnétiques dissout (AHOD). Des différences sigificatives dans les taux d'exports du phosphore totale ont été trouvées parmi les traitements. Cepandant, aucun effet du déboissement sur les taux de consommation d'oxygène hypolimnétiques est manifesté pour cause d'une variabilité plus grande et confondante trouvée dans l'effet du morphométrie ainsi qu'une une incertitude concernant l'importance du matière organique dérivé du bassin versant sur l'AHOD. La morphométrie des lacs (rapport volume: aire hypolimnétique) était le préducteur des taux d'AHOD le plus utile parmi les modèles. La covatiation de la température moyenne hypolimnétique avec les indices morphométriques souligne l'influence de la morphométrie sur les dynamiques de chaleur et d'oxygène dans ces lacs.

Cette recherche a dû exploiter des techniques de gestion de bandes de données relationelles, à cause de la quantité des données impliquées (114 lacs-années). L'approche spécifique est présentée dans une appendice.

Contents

List of Tables

List of Figures

Preface

The Faculty of Graduate Studies and Research of McGill University requires that the following text be cited in the preface of any thesis to which it applies:

> "Candidates have the option, subject to the approval of their Department, of including, as part of their thesis, copies of the text or the duplicated published text of an original paper or papers, provided that these copies are bound as integral part of the thesis. If this option is chosen, connecting texts, providing logical bridges between different papers, are mandatory. The manuscript–style thesis must still conform to all other requirements of the "Guidelines Concerning Thesis Preparation" and should still be in a literary form that is more than mere collection of manuscripts published or to be published.
>
> The thesis must include, as separate chapters or sections a table of contents, a general abstract in English and French, an introduction which clearly states the rationale and objectives of the study, a comprehensive general view of the background literature to the subject of the thesis, when this review is appropriate, and a final overall conclusion and/or summary.

Additional material (procedural and design data, as well as descriptions of equipment used) must be provided where appropriate and in sufficient detail (e.g. in appendices) to allow a clear and precise judgment to be made of the importance and originality of the research reported in the thesis.

In the case of manuscripts co-authored by the candidate and others, the candidate is required to make an explicit statement in the thesis of who contributed to such work and to what extent; supervisors must attest to the accuracy of such claims at the Ph.D. Oral Defense. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to make perfectly clear the responsibilities of the different authors of co-authored papers."

This thesis consists of: (1) An abstract; (2) A general introduction (Chapter One) that provides a review of previous relevant work; (3) A chapter dealing with the effects of forest clearing on hypolimnetic oxygen depletion rates in Canadian Shield lakes (Chapter Two).

Chapter Two is in preparation for submission to a refereed journal (written in the style of the Canadian Journal of Fisheries and Aquatic Sciences). As such, the paper is co-authored by Dr. Jacob Kalff (Department of Biology, McGill University), and Dr. Richard Carignan (Département des sciences écologiques, Université de Montréal). Their comments and supervision throughout the duration of the research contributed to the development and ultimate completion of the thesis.

The main contribution of the thesis to original knowledge is in documenting the short- to medium-term effects of forest clearing in the form of clear cutting and forest fires on water quality and summary hypolimnetic oxygen depletion rates in Canadian Shield lakes in a multi-lake comparative study. Dissolved oxygen, temperature and water quality were measured 1 - 3 years after forest clearance. Data were collected from 18 disturbed sites with varying percentages of their watershed cleared and from 20 reference sites to assess the impact of current logging practices in on downstream lakes.

In addition, this study required the use of specialized data management techniques given the size of the data set involved (38 lakes over 3 years = 114 lake-years). The raw data are presented in Appendix 1; The specific approach used is detailed in Chapter 2, and the data manipulation queries used are presented in Appendix 3. This information is provided as a possible model for other researchers when dealing with very large datasets of complex data.

This research was supported by Operating and Strategic Grants under the Sustainable Forestry Management Program of the Network of Centres of Excellence to Drs. Jacob Kalff and Robert Peters.

Acknowledgments

An ancient proverb reads that "A journey of a thousand miles starts with but one step." There were a lot of steps in this journey thus far, and at each I met a lot of wonderful people.

My parents, Woodrow and Sandra St. Onge, as well as my grandmother Dolores, I can't thank enough for always being behind me, encouraging me and helping me, both with emotionally and financially.

Robert Henry Peters, thanks for so much – for being an interesting and interested scientist, for taking a chance on a slightly flaky kid from the barrens of northern Ontario, for showing me that science isn't so much a discipline as much as it is a way of looking at life. God bless your beautiful soul.

Jacob Kalff, for your patience, perspective and vision as my supervisor.

Stanley Hum and Stephanie Barbeau, for your camaraderie, and especially for the mountains you had to move to get a replacement laptop out to me in the field.

Tony Ricciardi, Irene Wisheu, Gray Stirling, Bob Latta, André Cimbleris, Renate Lehmann, Neil Rooney, Chris Richardson, Monique Richard, Elena Roman, Veena Sangwan, Nicholas Bertos, Suzanne Smith, Lynn Kernaghan, Claire Cooney, Anne Comeau – my friends, for showing me that there is more to research than papers and analyses, and for making this place a saner one in which to work.

Richard Carignan and Jim Ramsay - not only for being on my grad committee, but to Richard for his input and advice and for managing the beast otherwise known as the SFN project (and making access to such a large dataset possible), and to Jim for making statistics a living, breathing entity.

Pierre D'Arcy, Isabelle St-Onge, Hervé, Claude, Yannick, Leah Sandals, Éloi - for your help in and out of the field.

Renée Dallaire, Gino Zoccali, Anne Thomas and especially Boris Lau for your help, collegiality, advice and friendship throughout this project and the preparations for that yet to come. The foundation is laid, and thanks to you, the building can begin.

Dave Kernaghan, Ron Kara, Tony Walsh - smiths and craftsmen, you helped me take ethereal ideas and make them concrete and real, your help and kind words were unreserved and plentiful, and I am deeply indebted to you.

Martyn Futter, Peter Dillon and Mark Gross - Helping me focus my wide open eyes on the unbelievable reality of the possible, the pragmatic and the practical. You've changed how I see the world, for which I can never thank you enough.

André Christian Giroux, scholar, seer, housemate and friend. My life is far richer for having known you in more ways that I could ever count. I might otherwise be knowledgeable not having known you, but I would certainly not be educated.

Ernest Lo and Sunil Kukreja, for the grounding in LaTeX that allowed me to start this thesis rewrite, and to Sara Lourie for prodding me into doing the rewrite in the first place.

Ellen Bentzen, Dave Lasenby and David Lean, for starting me on this road less traveled and giving me the sketches of the roads I could follow.

Leesa Beauregard and Sophie Blais for their critical eyes and helpful suggestions over my various attempts at translations.

And finally, a great thanks to my colleagues and friends Roger Dingledine, Ales Hvezda (your help with CVS was a godsend!), Aaron Turner, Aaron Malone (your help with Python made the raw data appendix possible!), Summer Hartzfeld, Doug Loss, Jason Pincin, Daniel Markle, Martin Hammerschmid and Frank Castellucci for their friendship, help, collegiality and other fun over the last two years. The mischief has only just begun.

Chapter 1

General Introduction

Potential negative impacts of riparian development activities in particular and development activities in general are coming under greater legal scrutiny, and policies of "no net loss" of habitat (Minns 1997) are increasingly being implemented. The proactive approach to management advocated in "The Freshwater Imperative" (Naiman et al. 1995) depends upon the development of a sound predictive understanding of the behavior of aquatic ecosystems. A predictive understanding of the consequences of development or other changes to riparian and catchment habitat is important (Peters 1986). One such example of alterations to catchment land use is forest clearance, in the form of clear cutting or forest fires.

Clearcuts are an established and common practice in the forest industry (Kimmins 1987), and along with forest fires, are common features in the boreal forest landscape. The effects of forest clearance on terrestrial ecosystems are well known (Keenan and Kimmins 1993). The effects of forest clearance on aquatic ecosystems have also been investigated (Carignan and Steedman 2000). The removal of riparian forests has been shown to increase overwater wind speeds three-fold over two lakes in the Experimental Lakes Area (France 1997). Following riparian forest removal around a small Nordic headwater lake, Rask et al. (1993) noted an increase in the thickness of the oxic layer resulting from thermocline deepening. Thermocline depths in 63 northwestern Ontario lakes where riparian forests were removed a decade previously were on average 2 m deeper than nearby lakes with intact riparian forests (France 1997), thereby reducing the suitable water volume for cold water fish living in hypolimnia (Schindler et al. 1990, Schindler et al. 1996). Owing to the convex shape of lake basins, the loss of the top of the hypolimnion has a disproportionate negative impact on cold water habitat availability.

Forest clearance has indirect effects on aquatic systems as well. Different types of land use have specific nutrient export rates associated with them (Reckhow et al. 1980, Prairie and Kalff 1986, Arbuckle and Downing 2001), and these differences have been used to explain differences in chlorophyll concentrations (Meeuwig and Peters 1996). Changes to soil or land use characteristics are reflected in nutrient export rates. Likens et al. (1970) found that both the magnitude and the variability of nutrient fluxes increased in streams draining experimentally cut catchments, along with increases in stream water temperatures. Ramberg (1976) reported increases in runoff and particulate transport, water temperatures, nutrient (total nitrogen and total phosphorus) leaching, and a decrease in pH as a result of clearcutting.

The intensity and timing of forest fires are yet other important determinants of impact on aquatic systems. Bayley et al. (1992) observed significant increases in total nitrogen and total phosphorus export rates following a forest fire, with lake total nitrogen concentrations remaining elevated for 5 – 6 years after the burn while total phosphorus concentrations recovered in two to three years. On a landscape scale, Evans et al. (1996) used a paleolimnological approach to describe the long-term eutrophication of a large Ontario lake (722 km^2 Lake Simcoe) as a result of loss of forests to farmland and subsequent urbanization. Lastly, Wright (1976) noted increases in runoff and slight increases in total phosphorus export from two small Minnesota catchments burned during late spring, suggesting that the timing of the fire was important as there was less litter available for consumption, and because the stand was able to re-establish vegetation cover during the summer.

Korhola et al. (1996) described increases in diatom-inferred pH in a Finnish lake coinciding with a forest fire in 1890. Bradbury (1986) noted changes in diatom stratigraphy attributed to increased nutrient leaching from dust or logging roads, as well as an increased percentage of a eutrophic diatom species in Meander Lake (which was at its most eutrophic during that time) which they attributed to an increased nutrient export from the forest fire within its catchment. Tarapchak and Wright (1986) also reported increased exports of phosphorus from moderately burned catchments. Schindler et al. (1980) noted the same after an intense wildfire at ELA in Northwestern Ontario.

France and Peters (1995) identified riparian forests to be important sources of energy to aquatic systems, and suggested that removal of these forests would reduce energy inputs to aquatic systems by affecting available nutrient concentrations available for phytoplankton production, thereby lowering biomass at higher trophic levels. If sustained, such a reduction could be expected to have a negative impact on recreational fisheries, and be of concern in aquatic resource management.

Reduced water clarity has been documented as a result of forest clearance (Rask et al. 1993, Lamontagne et al. 2000) and an increased DOC export from the land basins. Fee et al. (1996) showed DOC concentrations to be the primary determinant of mixing depth in small (< 500 ha) Canadian Shield lakes. Increases in DOC concentrations in lakes following forest clearance should result in shallower mixing depths, given the more effective attenuation of solar energy higher in the water column (Fee et al. 1996, Rask et al. 1993, Bowling and Salonen 1990). The onset of stratification, therefore, should be earlier and more intense from greater heating of surficial water layers (de Stasio, Jr. et al. 1996). An earlier onset of summer stratification means a shorter overturn period, lower recharge of hypolimnetic oxygen at turnover or even an absence of deep-water mixing altogether in wind-protected humic forest lakes. More importantly, the abridged mixing time and stronger stratification results in a longer stratification period, enhancing hypolimnetic oxygen depletion as a consequence (Schindler et al. 1990, Schindler et al. 1996). Since absolute nutrient recycling rates in the mixed layer as a whole increase with the size of this layer (Fee et al. 1994), a thinner mixed layer caused by the shallower, stronger stratification would also result in a more rapid rate of particulate carbon sedimentation from the epilimnion (Fee et al. 1994, Fig. 7) and thus further enhance oxygen depletion rates.

Hypolimnetic oxygen consumption has been the subject of considerable interest among limnologists for decades. According to Hutchinson (1957), "a skillful limnologist can probably learn more about the nature of a lake from a series of oxygen determinations that from any other kind of chemical data." Hutchinson's comparison of oxygen depletion in four Wisconsin lakes (1938) ranks among the earliest efforts to describe hypolimnetic oxygen depletion rates in lakes, albeit as a means to quantify trophic status. Later authors have continued these efforts in a wide range of lakes and situations, from large lakes such as Erie (Burns 1976, Charlton 1980, Charlton et al. 1993, El-Shaarawi 1987) and the Swiss Aegerisee (Livingstone and Imboden 1996) to smaller and usually dimictic lakes elsewhere: in the prairies (Trimbee and Prepas 1988); temperate lakes in north central United States (Stefan and Fang 1994), Europe (Hargrave 1972), eastern Canada (Lasenby 1975, Welch et al. 1976, Cornett 1989, Molot et al. 1992, Ryan and Marshall 1994, Marshall 1994), and winter under ice (Barica and Mathias 1979, Mathias and Barica 1980, Jackson and Lasenby 1982, Linsey and Lasenby 1985); in small alpine lakes (Rask et al. 1993) as well as semi-tropical (Weithman and Haas 1984) and tropical reservoirs (Bolland and Griffiths 1995), and experimental enclosures (Mazumder et al. 1990).

The number of studies undertaken to examine hypolimnetic dissolved oxygen dynamics underlines the ecological importance of hypolimnetic DO depletion. In dimictic lakes, summer and winter DO depletion rates have a major bearing on the volume of habitat available to coldwater fish, such as lake trout, which require high DO concentrations and low temperatures. Habitat volume has been found to be a strong predictor of sustainable yield of some fish species like lake trout (Christie and Regier 1988, Marshall 1994, Marshall and Layton 1995 and references therein), and has been used in bioenergetic modeling (Mason et al. 1995). Nürnberg (1995a) reported a good relationship between the impact of anoxia (extent and duration related as the "anoxic factor" (Nürnberg 1995b) and the number of fish species in boreal forest lakes. Ryan and Marshall's (1994) work on several northwestern Ontario boreal forest lakes revealed an oxygen depletion threshold explaining presence / absence of lake trout (*Salvelinus namaycush*). Decreases in fishing success in an American cold water recreational fishery, and resulting economic loses, were shown to be related to decreases in ambient oxygen concentrations below 6 $mg\ O_2 \cdot l^{-1}$ (Weithman and Haas 1984). Thus, in temperate dimictic lakes subject to forest clearance, a predictive understanding of DO dynamics on fish stocks is crucial to their management.

Much work has been done to model DO depletion (Stefan and Fang 1994, Jackson and Lasenby 1982, Cornett and Rigler 1980, Molot et al. 1992, Livingstone and Imboden 1997), but few studies have been directed at measuring the impact of forest clearance on boreal forest lakes and their fish populations. This following study was carried out to determine the factors influencing whole-hypolimnion oxygen depletion in remote Canadian Shield lakes in north central Quebec, and to examine how clear cutting and forest fire affect DO depletion rates, with depletion rates determining the extent of any lake trout habitat.

References

ARBUCKLE, K. E. AND DOWNING, J. A. 2001. The influence of watershed land use on lake N:P in a predominantly agricultural landscape. *Limnol. Oceanogr.* 46:970–975.

BARICA, J. AND MATHIAS, J. A. 1979. Oxygen depletion and winterkill risk in small prairie lakes under extended ice cover. *J. Fish. Res. Bd. Can.* 36:980–986.

BAYLEY, S. E., SCHINDLER, D. W., BEATY, K. G., PARKER, B. R., AND STAINTON, M. P. 1992. Effects of multiple fires on nutrient yields from streams draining boreal forest and fen watersheds: nitrogen and phosphorus. *Can. J. Fish. Aquat. Sci.* 49:584–596.

BOLLAND, K. T. AND GRIFFITHS, D. J. 1995. Seasonal changes in the dissolved oxygen status of two tropical water storages. *Lakes and Reservoirs: Research and Management* 1:213–219.

BOWLING, L. C. AND SALONEN, K. 1990. Heat uptake and resistance to mixing in small humic forest lakes in southern Finland. *Aust. J. Mar. Freshwater Res.* 41:747–59.

BRADBURY, J. P. 1986. Effects of forest fire and other disturbances on wilderness lakes in northeastern minnesota. II. Paleolimnology. *Archiv. Für Hydrobiologie* 106:203–217.

BURNS, N. M. 1976. Oxygen depletion in the central and eastern basins of Lake Erie, 1970.

J. Fish. Res. Bd. Can. 33:512–519.

CARIGNAN, R. AND STEEDMAN, R. J. 2000. Impacts of major watershed perturbations on aquatic ecosystems. *Can. J. Fish. Aquat. Sci.* 57(Suppl. 2):1–4.

CHARLTON, M. N. 1980. Hypolimnion oxygen consumption in lakes: discussion of productivity and morphometric effects. *Can. J. Fish. Aquat. Sci.* 37:1531–1539.

CHARLTON, M. N., MILNE, J. E., BOOTH, W. G., AND CHIOCCHIO, F. 1993. Lake Erie offshore in 1990: restoration and resilience in the central basin. *J. Great Lakes Res.* 19:291–309.

CHRISTIE, G. C. AND REGIER, H. A. 1988. Measures of optimal thermal habitat and their replationship to yields for four commercial fish species. *Can. J. Fish. Aquat. Sci.* 45:301–314.

CORNETT, R. J. 1989. Predicting changes in hypolimnetic oxygen concentrations with phosphorus retention, temperature and morphometry. *Limnol. Oceanogr.* 34:1359–1365.

CORNETT, R. J. AND RIGLER, F. H. 1980. Prediction of hypolimnetic oxygen deficits: problems of interpretation. *Science* 209:722–723.

DE STASIO, JR., B. T., HILL, D. K., KLEINHANS, J. M., NIBBELINK, N. P., AND MAGNUSON, J. J. 1996. Potential effects of global climate change on small north-temperate lakes: Physics, fish, and plankton. *Limnol. Oceanogr.* 41:1136–1149.

EL-SHAARAWI, A. H. 1987. Water quality changes in Lake Erie, 1968-1980. *J. Great Lakes Res.* 13:674–683.

EVANS, D. O., NICHOLLS, K. H., ALLEN, Y. C., AND MCMURTRY, M. J. 1996. Historical land use, phosphorus loading, and loss of fish habitat in Lake Simcoe, Canada. *Can. J. Fish. Aquat. Sci.* 53 (Suppl. 1):194–218.

FEE, E. J., HECKY, R. E., KASIAN, S. E. M., AND CRUIKSHANK, D. R. 1996. Effects of lake size, water clarity, and climatic variability on mixing depths in Canadian Shield lakes. *Limnol. Oceanogr.* 41:912–920.

FEE, E. J., HECKY, R. E., REGEHR, G. W., HENDZEL, L. L., AND WILKINSON, P. 1994. Effects of lake size on nutrient availability in the mixed layer during summer stratification. *Can. J. Fish. Aquat. Sci.* 51:2756–2768.

FRANCE, R. 1997. Land-water linkages: Influences of riparian deforestation on lake thermocline depth and possible consequences for cold stenotherms. *Can. J. Fish. Aquat. Sci.* 54:1299–1305.

FRANCE, R. L. AND PETERS, R. H. 1995. Predictive model of the effects on lake metabolism of decreased airborne litterfall through riparian deforestation. *Cons. Biol.* 9:1578–1586.

HARGRAVE, B. T. 1972. A comparison of sediment oxygen uptake, hypolimnetic oxygen deficit and primary production in Lake Esrom, Denmark. *Verh. Internat. Verein. Limnol.* 18:134–139.

HUTCHINSON, G. E. 1938. On the relation between the oxygen deficit and the productivity and typology of lakes. *Int. Rev. Gesamten Hydrobiol. Hydrogr.* 36:336.

HUTCHINSON, G. E. 1957. A treatise on limnology. I. Geography, physical and chemistry.

John Wiley and Sons, Inc., New York, NY.

JACKSON, M. B. AND LASENBY, D. C. 1982. A method for predicting winter oxygen profiles in ice-covered Ontario lakes. *Can. J. Fish. Aquat. Sci.* 39:1267–1272.

KEENAN, R. J. AND KIMMINS, J. P. 1993. The ecological effects of clear-cutting. *Environ. Rev.* 1:121–144.

KIMMINS, J. P. 1987. Forest Ecology. Macmillan, New York.

KORHOLA, A., VIRKANEN, J., TIKKANEN, M., AND BLOM, T. 1996. Fire-induced ph rise in a naturally acid hill-top lake, southern Finland: a palaeoecological survey. *J. Ecology* 84:257–265.

LAMONTAGNE, S., CARIGNAN, R., D'ARCY, P., PRAIRIE, Y. T., AND PARÉ, D. 2000. Element export in runoff from eastern Canadian Boreal Shield drainage basins following forest harvesting and wildfires. *Can. J. Fish. Aquat. Sci.* 57(Suppl. 2):118–128.

LASENBY, D. C. 1975. Development of oxygen deficits in 14 southern Ontario lakes. *Limnol. Oceanogr.* 20:993–1999.

LIKENS, G. E., BORMANN, F. H., JOHNSON, N. M., FISHER, D. W., AND PIERCE, R. S. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook Ecological Watershed ecosystem. *Ecol. Monogr.* 40:23–47.

LINSEY, G. A. AND LASENBY, D. C. 1985. Comparison of summer and winter oxygen consumption rates in a temperate dimictic lake. *Can. J. Fish. Aquat. Sci.* 42:1634–1639.

LIVINGSTONE, D. M. AND IMBODEN, D. M. 1996. The prediction of hypolimnetic oxygen profiles: A plea for a deductive approach. *Can. J. Fish. Aquat. Sci.* 53:924-932.

LIVINGSTONE, D. M. AND IMBODEN, D. M. 1997. Reply - The prediction of hypolimnetic oxygen profiles: A plea for a deductive approach. *Can. J. Fish. Aquat. Sci.* 54:740–741.

MARSHALL, K. E. 1994. Fish productive capacity and littoral habitat: an annotated bibliography referencing lake trout, lake whitefish, northern pike and walleye in boreal forest lakes. Technical report, Department of Fisheries and Oceans, Canada.

MARSHALL, K. E. AND LAYTON, M. 1995. A bibliography of the lake trout, *Salvelinus namaycush* (Wabaum), 1990 through 1994. Technical report, Department of Fisheries and Oceans.

MASON, D. M., GOYKE, A., AND BRANDT, S. B. 1995. A spatially explicit bioenergetics measure of habitat quality for adult salmonines: comparison between Lakes Michigan and Ontario. *Can. J. Fish. Aquat. Sci.* 52:1572–1583.

MATHIAS, J. A. AND BARICA, J. 1980. Factors controlling oxygen depletion in ice-covered lakes. *Can. J. Fish. Aquat. Sci.* 37:185–194.

MAZUMDER, A., MCQUEEN, D. J., TAYLOR, W. D., AND LEAN, D. R. S. 1990. Pelagic food web interactions and hypolimnetoc oxygen depletion: Results from experimental enclosures and lakes. *Aquat. Sci.* 52:144–155.

MEEUWIG, J. J. AND PETERS, R. H. 1996. Circumventing phosphorus in lake management: A comparison of chlorophyll a predictions from land-use and phosphorus-loading models. *Can. J. Fish. Aquat. Sci.* 53:1795–1806.

MINNS, C. K. 1997. Quantifying no net loss of productivity of fish habitats. *Can. J. Fish. Aquat. Sci.* 54:2463–2473.

MOLOT, L. A., DILLON, P. J., CLARK, B. J., AND NEARY, B. P. 1992. Predicting end-of-summer oxygen profiles in stratified lakes. *Can. J. Fish. Aquat. Sci.* 49:2363–2373.

NAIMAN, R., MAGNUSSON, J., AND OTHERS., E. 1995. The freshwater imperative: a research agenda. Island Press.

NÜRNBERG, G. K. 1995a. The anoxic factor, a quantitative measure of anoxia and fish species richness in central Ontario lakes. *Trans. Am. Fish. Soc.* 124:677–686.

NÜRNBERG, G. K. 1995b. Quantifying anoxia in lakes. *Limnol. Oceanogr.* 40:1100–1111.

PETERS, R. H. 1986. The role of prediction in limnology. *Limnol. Oceanogr.* 31:1143–1159.

PRAIRIE, Y. AND KALFF, J. 1986. Effect of catchment size on phosphorus export. *Wat. Res. Bull.* 22:465–470.

RAMBERG, L. 1976. Effects of forestry operations on aquatic ecosystems. *Ecol. Bull.* 21:143–149.

RASK, M., ARVOLA, L., AND SALONEN, K. 1993. Effects of catchment deforestation and burning on the limnology of a small forest lake in southern Finland. *Verh. Int. Ver. Limnol.* 25:525–528.

RECKHOW, K. N., BEAULAC, M. N., AND SIMPSON, J. T. 1980. Modeling phorphorus loading and lake response under uncertainty: a manual and compilation of export coefficients. Technical Report EPA 440/5-80-011, United States Environmental Protection

Agency.

Ryan, P. A. and Marshall, T. R. 1994. A niche definition for lake trout (Salvelinus namaycush) and its use to identify populations at risk. *Can. J. Fish. Aquat. Sci.* 51:2513–2519.

Schindler, D. W., Bayley, S. E., Parker, B. R., Beaty, K. G., Cruikshank, D. R., Fee, E. J., Schindler, E. U., and Stainton, M. P. 1996. The effects of climatic warming on the properties of boreal lakes and streams at the Experimental Lakes Area, northwestern Ontario. *Limnol. Oceanogr.* 41:1004–1017.

Schindler, D. W., Beaty, K. G., Fee, E. J., Cruikshank, D. R., DeBruyn, E. R., Findlay, D. L., Lindsey, G. A., Shearer, J. A., Stainton, M. P., and Turner, M. A. 1990. Effects of climatic warming on lakes of the central boreal forest. *Science* 250:967–970.

Schindler, D. W., Newbury, R. W., Beaty, K. G., Prokopowich, J., Ruszczynski, T., and Dalton, J. A. 1980. Effects of a windstorm and forest fire on chemical losses from forested watersheds and on the quality of receiving streams. *Can. J. Fish. Aquat. Sci.* 17:328–334.

Stefan, H. G. and Fang, X. 1994. Dissolved oxygen model for regional lake analysis. *Ecol. Model.* 71:37–68.

Tarapchak, S. and H. E. Wright, J. 1986. Effects of forest fire and other disturbances on wilderness lakes in northeastern Minnesota. 1. Limnology. *Arch. Hydrobiol.* 106:177–

202.

TRIMBEE, A. M. AND PREPAS, E. E. 1988. Dependance of lake oxygen depletion rates on maximum oxygen storage in a partially meromictic lake in Alberta. *Can. J. Fish. Aquat. Sci.* 45:571–576.

WEITHMAN, A. S. AND HAAS, M. A. 1984. Effects of dissolved-oxygen depletion in the rainbow trout fishery in Lake Taneycomo, Missouri. *Trans. Am. Fish. Soc.* 113:109–118.

WELCH, H. E., DILLON, P. J., AND SREEDHARAN, A. 1976. Factors affecting winter resporation in Ontario lakes. *J. Fish. Res. Bd. Can.* 33:1809–1815.

WRIGHT, R. F. 1976. The impact of forest fire on the nutrient influxes to small lakes in northeastern Minnesota. *Ecology* 57:649–663.

Chapter 2

Clearcutting and Dissolved Oxygen Depletion

2.1 Introduction

The effects of land use in general and of forest clearance on lake water quality in particular have received a good deal of attention in the literature (see Keenan and Kimmins (1993) and Carignan and Steedman (2000)). Different types of land use are known to have specific associated rates of nutrient export (Reckhow et al. 1980, Prairie and Kalff 1986). Changes to soil or land use characteristics can thus be expected to manifest themselves in changed nutrient export rates. Even so, effects of forest clearance, in the form of forest fires or clear cut logging, on stream and lake water quality are highly variable among studies. Likens et al. (1970) found in the Hubbard Brook Experimental Forest that nutrient fluxes in streams draining different portions of an experimentally cut catchment ranged widely both in terms of their magnitude and variability. Ramberg's (1976) review of the literature pertaining to the effects of forestry on lakes indicated that watercourses in north temperate catchments subjected to clearcutting consistently experience higher runoff and particulate transport, higher water temperatures, increased nutrient leaching, and a decrease in pH. Similarly, Schindler et al. (1980) reported increases in nutrient exports for two years following an intense fire in the catchment of Lake 239 located in the Experimental Lakes Area (ELA), with nitrate exports increased by a factor of 9 in the post–impact catchment. Recently, Lamontagne et al. (2000) found increased TN and TP exports from cut and burned catchments in remote boreal forest lakes.

Removal of forest overstory vegetation affects not only the hydrology and nutrient inputs but also the mixing regime of lakes and their resulting dissolved oxygen (DO) concentrations. Winter clearcutting of about half of the catchment around a small, highly coloured Finnish lake markedly affected its thermal and oxic regimes the following summer, including a reduction in the depth of the oxygenated water layer from 3.4 – 4.5 m to 2.5 m, and temporarily to about 1 m immediately after burning of the logging slash. The lake, which did not mix completely prior to the silvicultural manipulation, became totally mixed in the fall as the result of the now greater wind exposure (Rask et al. 1993).

Indirect effects of forest clearance not only include thermocline deepening from increased wind exposure (Rask et al. 1993), but also stronger stratification from increased DOC or turbidity (Steedman and Kushneriuk 2000). The existence of nearby logging roads has been shown to increase nutrient exports, presumably through associated dust production and increased erosion (Lehmann 1996). But not all clearcuts or forest fires yield measurable impacts. McColl and Grigal (1977) observed no detectable changes in lake nutrient concentrations following a wildfire around two Precambrian Shield lakes, based on a comparison with a nearby unaffected lake. Similarly, Lehmann (1996) did not detect significant differences in seasonal mean nutrient concentrations between recently cut and neighbouring undisturbed reference lakes on the Canadian Shield in Québec. Tarapchak and Wright (1986) also saw no significant increases in nutrient exports in burned Minnesota catchments following a forest fire.

The lack of effect in some of the aforementioned studies may reflect a small disturbance far away from the lake or inflowing stream. A substantial disturbance on only a small portion of a drainage basin, or where the trapping of nutrients released by large, low–sloped basins that may include wetlands can mask the impacts. Furthermore, a post–hoc comparison with an inappropriate nearby "reference" basin (or one that resembles the affected basin more after than before the disturbance) would greatly reduce the likelihood of detecting effects. Lastly, post–hoc comparisons, such as in the study by Lehmann (1996) between multiple affected and unaffected basins, may fail to show an overall effect if the drainage basins vary sufficiently in size, form, runoff or lake morphometry to confound the effects of clearcutting or forest fires.

The most incisive studies showing effects of forest clearance have been those carried out in single drainage basins on lakes or rivers that were characterized limnologically prior to a major disturbance (e.g. Schindler et al. 1980, Rask et al. 1993). Studies of single systems have been of great importance in quantifying effects of clearcutting or fire. Unfortunately, they lack utility for predicting effects on waters elsewhere since the affected catchments differ from the well–studied one in size, relief, vegetation cover, climate, hydrology, lake morphometry, and the degree of disturbance. Clearly, there is a great need for quantitative models, developed on a large set of lakes, able to predict at least regionally the impact of clearcutting and forest fires. Such models could be used to modify cutting practices to minimize the impact on the aquatic environment. One primary goal of the Network of Centres of Excellence in Sustainable Forest Management (NCE–SFM) was to develop empirical models of the effect of clearcutting and forest fire on Canadian boreal forest lakes for use in management and research (Adamowicz 1999, Carignan and Steedman 2000). The present contribution to the overall 3 year (1996 – 98) study is an assessment of the impact of clearcutting and forest fire on the oxidation of organic matter, measured by dissolved oxygen utilization, in the hypolimnia of the study lakes.

2.2 Materials and Methods

2.2.1 Study region

The study region is located in central Québec (Fig. 2.1, $48°N$, $75°W$) on land characterized by frequently exposed granite and gneiss bedrock, overlain by thin soils, predominantly podzols (Clayton et al. 1978). The climate can be classified as continental, with mean annual precipitation of approximately 950 mm, half of which falls as snow (CNC-IHD 1978). Several large forest fires occurred in this area during the summer prior to our sampling (1995), and numerous catchments were logged in the region during the same period. Nine cut and nine burned catchments were selected alongside twenty nearby reference catchments (Carignan et al. 2000). One of the burned catchments (FP31) had to be eliminated for lack of lake morphometric data. Thus, the study was based on eight burned, nine cut and twenty reference catchments. Wetlands (beaver ponds or marshes) were present in some basins, but their size never exceeded 5% of the drainage area.

2.2.2 Water Chemistry, Dissolved Oxygen and Temperature Determinations

Each year (1996–1998), water samples, dissolved oxygen and temperature profiles were collected from a float aircraft in early– (June), mid– (July) and late– (August – September) summer (Raw data are presented in Appendix 1). Duplicate integrated water samples from the photic zone (delineated in the field by the 1% incident light level) were taken at the deepest area of each lake using a long, flexible PVC tube (Carignan et al. 2000). Water samples were stored in ice–filled coolers until processed later that day. Chlorophyll a samples were obtained by filtering 500 mL of each sample onto Whatman GFC filters. The filters were wrapped in aluminum foil and kept at −30°C until extracted in hot ethanol, with absorbance measurements taken at 665 and 750 nm using a spectrophotometer. Fifty millilitre water samples for total phosphorus (TP) samples were dosed with 0.5 g of potassium persulfate and autoclaved for 45 minutes at 120°C prior to addition of mixed reagent. Phosphorus concentrations were measured colourimetrically at 890 nm (Stainton et al. 1977). Dissolved organic carbon concentrations were determined using a Shimadzu TOC–5000 high–temperature platinum–catalyzed analyzer (Carignan et al. 2000). Oxygen and temperature data were obtained with a YSI Model 58 meter (YSI Inc) at the deepest portion of each lake during sampling sorties. Difficulties in identifying the location of maximum lake depth (compounded by wind–induced drifting of the float aircraft used for sampling) meant that the oxygen–temperature profiles were not always taken at the deepest point, especially in larger, wind–exposed lakes. Fortunately, deepest strata contribute least to oxygen depletion estimates because they contribute little to the hypolimnetic water volume.

The depth of the top of the hypolimnion, required for the determination of the water volume to be included in oxygen depletion calculations, is difficult to determine in wind–protected and highly coloured boreal forest lakes where thermoclines tend to be both shallow and irregular (Fig. 2.2). To ensure that the DO depletion estimates were unaffected by a small but infrequent spring metalimnetic oxygen maxima (Fig. 2.2), we first estimated the top of the hypolimnion to be beneath the stratum where water temperature change rate was ≤ 1°C·m^{-1}. The depths of the 1% light level were compared against the hypolimnion depths to ensure that the results were not being affected by a significant metalimnetic oxygen production (Light data are presented in Appendix 2). Although in some cases during the spring sampling the 1% light level was within the topmost portion of what was defined as the hypolimnion (Fig. 2.2), the calculations were not affected as the hypolimnion volume used was based on the shallowest recurring hypolimnion depth annually in each lake, which was always below the 1% light level. To account for the impact of between–lake differences in hypolimnetic water temperature, a Q_{10} of 2.0 was applied to AHOD rates to standardize these to 4°C (AHOD4C). Variables examined in this study are listed in Table 2.1.

2.2.3 Morphometry

Catchment and lake morphometric analyses were carried out and presented in Carignan et al. (2000), using 1:20 000 topographic maps as well as 1:15 000 aerial photographs and echosounder transects. A digitizing table and the MapInfo GIS were used to determine the area of each depth contour for volume determination, and was later used with aerial photography to measure the extent of logging and fire damage within the affected catchments (Carignan et al. 2000).

2.2.4 Phosphorus exports

As direct measurements of runoff were not available, we followed the approach used by Dillon et al. (1994) to estimate the specific total phosphorus (TP) export rate from the individual drainage basins ($kg \cdot ha^{-1} \cdot yr^{-1}$) and the specific phosphorus loading rate ($kg \cdot ha^{-1} \cdot yr^{-1}$) to the individual lakes from reference catchments,

$$[TP] = L_t \cdot \frac{(1 - R_p)}{(0.956 \cdot q_s)} \tag{2.1}$$

where [TP] is the mean summer total phosphorus (TP) concentration ($mg \cdot m^{-3}$), L_t is the estimated annual areal loading rate of total phosphorus ($mg \cdot m^{-2} \cdot yr^{-1}$), R_p is the fraction of total phosphorus lost to sedimentation (unitless). An empirically–determined fraction (0.956) of in–lake [TP] lost to outfluent waters of Central Ontario lakes (Dillon et al. 1994) is used to account for P loss to outflow and sediments, and q_s ($m \cdot yr^{-1}$) is the annual areal water load. Substituting $L_t = J_t/A_0$ (where J_t is the total input of phosphorus to a lake ($mg \cdot yr^{-1}$), and A_0 is the lake surface area (m^2) yields

$$[TP] = \frac{J_t}{A_0} \cdot \frac{(1 - R_p)}{(0.956 \cdot q_s)} \tag{2.2}$$

The annual TP load (J_t) is calculated by rearranging equation 2:

$$J_t = \frac{[TP] \cdot A_0 \cdot (0.956 \cdot q_s)}{(1 - R_p)} \tag{2.3}$$

As mentioned, we used the empirically–estimated R_p from Dillon and Kirchner (1975) as $R_p = 12.4/(12.4 + q_s)$ for boreal forest lakes in Ontario, while q_s (mean annual runoff) was estimated in two ways. A q_s of 0.55 $m \cdot yr^{-1}$, the long term mean runoff for the region obtained from the Hydrological Atlas of Canada (CNC-IHD 1978), was used initially. Subsequently applied was a second q_s estimated by Lamontagne et al. (2000) for each of the drainage basins based on the position of each catchment relative to the geographic centres of each of three large gauged catchments encompassing the study area and for which runoff had been previously obtained (Lamontagne et al. 2000). The effect of the different q_s approaches on phosphorus export is evaluated in the discussion section.

To estimate the phosphorus export from the partially cut and burned basins to the lakes, we first estimated the phosphorus mass exported annually from each of the the reference catchments ($kg \cdot yr^{-1}$). We then divided these values by the respective terrestrial basin areas to obtain specific export rates ($kg \cdot ha^{-1} \cdot yr^{-1}$) from undisturbed basins, as catchment size affects specific export rates (Prairie and Kalff 1986) (Fig. 2.4). Specific export rates for the treated catchments were calculated by first determining the reference contribution ($kg \cdot yr^{-1}$) to export by calculating the average specific export rate ($kg \cdot ha^{-1} \cdot yr^{-1}$) for a reference basin of the same size, then multiplying the unaffected area of the treated catchment by the specific export rate. Having obtained the total phosphorus mass export to the lake ($kg \cdot yr^{-1}$) using Eqn. 3 above, we next subtracted the reference contribution to obtain the phosphorus contribution from the treated portion of the catchment. With the total phosphorus mass contributed by the treated area of the catchment now available, it was divided by the treated area of the catchment to get a specific export rate ($kg \cdot ha^{-1} \cdot yr^{-1}$) for treated catchments of a given size. Catchment phosphorus loading of the lakes ($g \cdot m^{-1} \cdot yr^{-1}$) was computed by dividing the total export ($kg \cdot yr^{-1}$) by the lake surface area. The phosphorus contribution from direct deposition on lake surfaces, rather than from the drainage basin, was accounted for by using a value of 186 $g \cdot ha^{-1} \cdot yr^{-1}$ (Lamontagne et al. 2000).

Daily areal hypolimnetic oxygen depletion rates ($mg\ O_2 \cdot m^{-2} \cdot d^{-1}$) were computed by dividing the mass of oxygen consumed during each annual study period by the hypolimnetic surface area, and subsequently divided by the length of the study period (88–92 days) to yield a daily rate. These values were also corrected for temperature by using a Q_{10} of 2 (Charlton 1980) to remove the effect of temperature as a potential confounding influence.

A relational database management system (PostGreSQL) was used for data preparation to ensure consistency in calculations and facilitate later review (Queries used are presented in Appendix 3). Prior to analysis, all data were checked for normality using the R Statistical System (Ihaka and Gentleman 1996), which was also used for multiple regression and general linear model (GLM) analyses.

2.3 Results

Reference lakes and their basins were compared to those in the other treatment groups (Table 2.2) to ascertain whether differences in hypolimnetic DO depletion rates between treatments were due to differences in morphometry rather than differences in land use. No significant catchment or morphometric differences were found between treatment groups (anova, n.s.). Even so, there is much variation in the morphometric variables within the treatments, especially in the drainage basin size and the drainage ratio as well as mean and maximum depths (Table 2.2), potentially able to confound interpretations of land use effects on oxygen depletion rates.

Three year average total phosphorus, chlorophyll a and dissolved organic carbon concentrations are significantly higher in the treated catchments (Fig. 2.3). Further, there is a significant year effect across treatments (Table 2.3). TP and DOC are highly correlated (R = 0.61) as are TP and Chl a (R = 0.68), oxygen depletion rates correlate with morphometric variables like hypolimnetic volume : surface area ratio (R = 0.49); deeper lakes are characterised by higher hypolimnetic volume to surface area ratios (R = 0.86), lower hypolimnetic water temperatures (R = -0.61) and relatively large hypolimnetic volume to catchment area ratios (R = 0.86) (Table 2.4).

Specific export coefficients ($kg \cdot ha^{-1} \cdot yr^{-1}$) as a function of catchment area (Table 2.5) were computed to check if observed differences in average TP concentrations were the result of a higher export from the cut and burnt basins rather than from differences in flushing or catchment and lake morphometry. Indeed, the specific export coefficients decline (with one possible exception) with increasing catchment area (Fig. 2.4). Assuming the annual runoff to have been roughly the same over the whole study region during the three year study period and therefore using the long term average runoff (0.55 $m \cdot yr^{-1}$), both the average specific exports for the cut and burned treatments (Fig. 2.4a) were higher than for the reference basins (GLM, $F = 14.9$, $p < 0.001$), by a factor of approximately 1.8. However, there was no significant difference in specific export between the cut and burned treatments of the same size (Fig. 2.4a). If it is assumed instead that the runoff values obtained from the nearest encompassing gauged river basins (up to 150 – 250 km away) and interpolated over the drainage basins of the study lakes (see Lamontagne et al. (2000)) is more applicable than the long term mean runoff value (Fig. 2.5), the burned basins on average again export significantly more TP per unit area than do the reference basins (GLM, $F = 14.8$, $df = 109$, $p < 0.0005$), by a factor of about 1.5. However, the regression line describing specific export from the cut basins was not significant, suggesting no change in specific export with increasing catchment size (Fig. 2.4b). Since the three year mean runoff was not significantly different from the long term average runoff value (t–test, ns, Fig. 2.5), the following analyses are based on the results derived from the average runoff value. The results obtained under both runoff scenarios and their effects on phosphorus export are compared in the Discussion. Specific exports rates ($kg \cdot ha^{-1} \cdot yr^{-1}$) for phosphorus were greater in the treated catchments (Kruskal–Wallis, $H = 21.7$, $p < 0.001$, Fig. 2.4), and the total phosphorus export ($kg \cdot yr^{-1}$) was also greater in the treated catchments (Kruskal–Wallis, $H = 9.4$, $p = 0.009$). Similarly, phosphorus loadings ($g \cdot m^{-2} \cdot yr^{-1}$) were typically also higher in the lakes in the treated catchments than those located in the reference catchments (Kruskal–Wallis, $H = 12.3$, $p = 0.002$).

Despite the higher phosphorus loading to lakes in the treated catchments, neither nutrient loadings or phosphorus and DOC concentrations were significantly correlated with dissolved oxygen consumption in the hypolimnia, while the correlation between chlorophyll a with AHOD was far too weak ($R = 0.28$, $p < 0.01$) to allow it to serve as a predictor of oxygen depletion (Table 2.4). In contrast, there were systemic and somewhat stronger correlations between AHOD and measures of lake morphometry (Table 2.4), with the catchment area : hypolimnion volume ratio (CA:HV) explaining 24% of AHOD and 30% of the temperature–corrected AHOD (AHOD, $r^2 = 0.24$, $p < 0.001$; AHOD4C $r^2 = 0.30$, $p < 0.001$).

2.4 Discussion

2.4.1 Land use and Morphometry

The principal finding that areal hypolimnetic DO depletion rates are a function of differences in lake morphometry, and not of observable differences in among–treatment phosphorus loadings or its surrogate, TP concentration, was a surprise because we had expected these particular boreal forest lakes to differ much more in phosphorus concentrations than morphometry. Canadian boreal forest lakes are highly oligotrophic and respond strongly to nutrient addition (Schindler et al. 1971). Furthermore, the C:P ratios in our lakes ($\sim$ 700:1 by mass), are indicative of a severe phosphorus limitation (Cimbleris and Kalff 1998). It is apparent that the significant differences observed in phosphorus loadings among treatments were not reflected in DO consumption rates because these are confounded by a much larger variation imposed by differences in catchment and lake morphometries. Coefficients of variation for average catchment area to hypolimnetic volume ratios (CA:HV) are $\sim$ 270%, and much variation is also found in the catchment area (CA, $>$ 100%) and drainage ratio (CA:LA, $\sim$ 100%), which represents the land area from which nutrients are released into receiving waters and their subsequent dilution in the highly variable lake (LV, $\sim$ 70%) and hypolimnetic volumes (HV, $>$ 100%) (Table 2.2).

It is evident that boreal shield lakes of similar sizes in one region vary much more in lake basin and catchment attributes than can be revealed by an aerial reconnaissance. Similar variability in catchment and lake morphometry has also been noted elsewhere (Schindler et al. 1971), and reflects the irregular terrain characteristic of the Canadian Shield (Clayton et al. 1978). Although the lakes examined did not, on average, differ by more than a factor of two in lake area, volume, and depth (Table 2.2), and there were no significant differences in catchment slope or lake morphometric attributes between treatments, the differences in underwater morphometry were sufficient to confound the effect of differences in phosphorus loading or TP and DOC concentrations in the lakes. Even though lake morphometry was the best indicator of areal hypolimnetic oxygen depletion rates, the variability in underwater morphometry was ultimately insufficient to allow it to serve as a useful predictor of oxygen depletion rates (AHOD, $r^2 = 0.24$, $p < 0.001$) and AHOD standardized for differences in temperature (AHOD4C, $r^2 = 0.30$, $p < 0.001$, Table 2.6).

Significant differences are evident between the specific export coefficients for the treated and reference catchments (Fig. 2.4a). The negative slope of the equations (Table 2.5) indicate that smaller catchments export more phosphorus per unit area than larger ones, consistent with the findings of Prairie and Kalff (1986). The slope of the line describing specific exports for the reference catchments is significantly larger than those describing the cut and burned catchments (Fig. 2.4a), although these did not differ from each other (Table 2.5), indicating that both clearcut and burned catchments allow higher specific phosphorus exports than the reference basins, at least in the first three years after treatment. This is interesting because, on average, the burned catchments experienced $> 80\%$ of their areas burned, while the cut catchments had $\ll 65\%$ of their catchment areas cut. The similarities in nutrient export (specific and total) between the two treatments despite the differences in proportions of the catchments affected, together with the interannual variation in runoff, indicates that clearcut catchments export more phosphorus per unit area affected than do burned catchments. Lamontagne et al. (2000) found similar results in these catchments using a different (mass–balance) approach to determine phosphorus export (see below).

Runoff is a crucial component of nutrient export calculations (Dillon et al. 1994, Lamontagne et al. 2000), and uncertainties associated with the lack of local runoff data impart unavoidable uncertainties about the specific phosphorus export rates. We used the long–term average runoff value for the study area according to the Water Atlas (CNC-IHD 1978). However, average runoff may under– or overestimate runoff during a particular study year. The alternative method used by Lamontagne et al. (2000) estimated local runoff by interpolating runoff values obtained from the three large gauged river basins surrounding the study area. While this has the advantage of yielding annual runoff values for the individual years, there is considerable uncertainty as to whether the runoff computed for of each of the lakesprovides a better estimate of local runoff than the long–term average, given that the study lakes are located some 150 – 250 km from the nearest gauging sites, and runoff values are weighted by the distances of the each lake to the centres of each of the three large catchments (Lamontagne et al. 2000). It may not do so because the latter (interpolated) approach yields 6 cut catchments that do not appear to be exporting any phosphorus even though up to 46% of their drainage basin were cut (Fig. 2.4b). The same analysis using the long–term average runoff value yields only two such catchments (Fig. 2.4a). The two have exceptionally low fractions of their catchments cut (Lake C44a had 8% cut and no apparent export during 96–98; Lake C40a was 10% cut and no apparent exports during 1996), and support the warning by Lamontagne et al. (2000) that the risk of error in estimates of specific phosphorus export are greatest when the proportions of catchment disturbed is low. The effect of forest clearance on phosphorus export is then easily masked by basin topography or interception by riparian and marsh vegetation.

Based on the interpolated runoff values used by Lamontagne et al. (2000), six cut catchments apparently lack a specific phosphorus export altogether from the affected portions of their catchments. The placement of these catchments suggests the possibility of a spatial bias in the interpolated runoff information along a WSW–ENE axis in that study. According to Lamontagne (2000), the Bell and Gatineau catchments averaged less runoff (0.55 and 0.58 $m \cdot yr^{-1}$, respectively) than did the Chamouchouane catchment (0.62 $m \cdot yr^{-1}$), which is consistent with the increasing long–term average runoff gradient in this area running WSW to ENE presented in the Water Atlas (CNC-IHD 1978). However, much of the Bell and Gatineau catchments lie in lower precipitation zones, and runoff estimates based on the gauged runoff from the three catchments as a whole, including their lower runoff portions, would underestimate the runoff received by the study catchments. Indeed, runoff estimates based on the Lamontagne et al. (2000) approach were typically lower than the long–term average runoff value of 0.55 $m \cdot yr^{-1}$ (Fig. 2.5), thereby yielding lower specific phosphorus export rates than those obtained by using the long–term average runoff value, and thereby possibly explaining the surprising result of no phosphorus export from catchments that experienced up to 46% cutting of their drainage basins. Nevertheless, it cannot be resolved whether phosphorus export data obtained using one or the other approaches to determining runoff is more accurate. However, the similarity of our specific phosphorus export results (Table 2.5, Fig. 2.5) to others reported in the literature (Dillon and Kirchner 1975, 0.03 – 0.14 $kg \cdot ha^{-1} \cdot yr^{-1}$; Schindler et al. 1976, 0.02 – 0.11 $kg \cdot ha^{-1} \cdot yr^{-1}$; Table 6 in Reckhow et al. 1980, Lamontagne et al. 2000, 0.05 – 0.24 $kg \cdot ha^{-1} \cdot yr^{-1}$) suggests that the export estimates based on a simple long–term average runoff value are highly plausible.

Despite the high variability in catchment and morphometric variables, treatment effects were consistently expressed in increased specific export rates (Table 2.5), total exports (Kruskal–Wallis, $H = 9.4$, $p = 0.009$), lake loadings (Kruskal–Wallis, $H = 12.3$, $p = 0.002$) and finally higher total phosphorus concentrations (Table 2.3, Fig. 2.3). DOC concentrations covaried with total phosphorus (R=0.61; Table 2.4). The increases in TP and DOC concentrations are consistent with responses to clearcutting and forest fires on the Canadian Shield (Schindler et al. 1980, Lehmann 1996) and elsewhere (Ramberg 1976, Rask et al. 1993). Both methods for calculating runoff and phosphorus export allow the conclusion that forest clearance has a demonstrable effect on catchment nutrient export and water chemistry in lakes on the boreal shield of central Québec.

2.4.2 Oxygen depletion rates

In the absence of an effect of phosphorus export and loading on the AHOD, the most important and significant indicator of areal–based summary oxygen depletion rates was an index of lake morphometry, the hypolimnetic volume to hypolimnetic surface area ratio (Table 2.6). Temperature does not appear as a significant predictor of oxygen depletion rates despite its importance as a factor controlling microbial respiration and thus dissolved oxygen consumption (Wetzel 1983). The lack of a temperature effect appears largely attributable to the modest variation in mean hypolimnetic temperature among systems (averaging 7.6°C overall, with a range of 4.5 – 15.1°C) but also because mean hypolimnetic temperature co-varies significantly with all morphometric variables, indicating a morphometric influence on heat dynamics in these lakes. Despite the humic nature of the lakes, the variation in DOC appears to be too small (mean 5.7 $mg \cdot l^{-1}$, range 2.5 - 13.2 $mg \cdot l^{-1}$) to allow it to correlate significantly with mean hypolimnetic temperature (Table 2.4).

While our models estimating rates of areal hypolimnetic oxygen depletion on the basis of lake morphometry are significant, our best model based on the hypolimnetic volume to hypolimnetic surface area ratio explains only 30% of the variation and lacks predictive power (Table 2.6). The most important reason for this is probably the much smaller range scale of our predictor variables (eg. TP 4.5 – 17.3 $\mu g \cdot l^{-1}$, 4–fold) compared to those in other studies such as those of Cornett and Rigler (1979) (TP range 5 – 250 $\mu g \cdot l^{-1}$, 50–fold). The fraction of the variances explained typically rises with increasing range because of the effect of the predictor value is less confounded by the effects of other potentially important predictor variables (Kalff 2001). The only four–fold range in TP concentrations in our study is associated with a fourty–fold range in the AHOD rates measured ($10 - 400\ mg \cdot m^{-2} \cdot d^{-1}$), which are comparable to reported AHOD ranges in lakes of higher trophy (AHOD $50 - 2000\ mg\ O_2 \cdot m^{-2} \cdot d^{-1}$, 40–fold in Cornett and Rigler (1979)). As TP and AHOD have been shown to be well correlated over a wide range of both (Cornett and Rigler 1980), it is not surprising that nutrient loading or concentrations are poor predictors of AHOD in the oligotrophic boreal forest lakes of Québec.

Furthermore, since the range in DOC concentrations in our lakes is also small (5-fold $2.5 - 13.2\ mg \cdot l^{-1}$, Table 2.2), it is not surprising that the the much greater 15-fold (HV:SA $0.7 - 10.5\ m^{-1}$) variation in underwater morphometry would allow it to emerge as the most important determinant of AHOD in the study lakes. That underwater morphometry explains no more than 30% of the variation in AHOD is probably largely attributable to the HV:SA ratio being only a rough indicator of the actual lake morphometry.

Since the relative importance of water and sediment oxygen demand within a stratum changes as the area of sediment below the water column changes with depth, as well as with with mean hypolimnion thickness (Charlton 1980) as particles have had a greater probability of decomposition before reaching the sediment in deeper strata, consistent with the systemic decline in sediment respiration with depth in non–humic lakes recently noted by den Heyer and Kalff (1998). Unfortunately, the impact of morphometry within a basin is impossible to account for when depletion estimates, as in the present study, are based on the hypolimnetic volume as a whole.

Sediment area is usually estimated from either a hypsographic curve or read directly from a morphometric map. Both of these approaches make the incorrect assumption that the sediment area subtending a three dimensional stratum can be calculated accurately as the areal difference between the two stratum boundaries projected onto a plane. Errors in estimating sediment area are smallest when the size of the stratum being considered is small, and the morphometry of the lake is simple as well. Conversely the error is greater when the sediment area is estimated over a larger cross–section of the lake, such as over the hypolimnion as a whole; and the error will be greater yet if a lake is characterized by a complex morphometry. That patterns emerge nevertheless in the literature is the result of comparing lakes differing so much in morphometry that errors incurred in the rough determination of sediment area are smaller than the differences in morphometry noted. Since sediment oxygen demand is generally higher than water oxygen demand in relatively shallow lakes at least (Kalff 2001), the least precise sediment oxygen depletion estimates can be expected in shallow lakes.

Not only is the hypolimnetic volume to surface area ratio (HV:SA) an imperfect measure of the underwater morphometry, confounding the effect of morphometric differences on the measured AHOD, but oxygen depletion rates would also be affected by sedimentation and decomposition of catchment-derived organic matter. Cole et al. (2000) reported that up to 43% of total respiration in some oligotrophic lakes was due to allochthonous organic matter. del Giorgio and Peters (1994) reported planktonic community respiration up to 8 times greater than phytoplanktonic production in oligotrophic lakes, attributed to planktonic metabolism of allochthonous DOC. In a humic boreal forest lake in Sweden, bacterial respiration of allochthonous organic matter in the water column was found to be almost 100% of total bacterial respiration (Bergström and Jansson 2000). The great importance of allochthonous organic matter to bacterial respiration in other oligotrophic and humic lakes suggests that much of the bacterial respiration in our humic study lakes is strongly dependent on allochthonous organic matter rather than authocthonous primary production linked to phosphorus loading. Although we lack data on allocthonous carbon loading to compare the relative impacts of DOC loading and morphometry on the AHOD, DOC concentrations show no significant effect on AHOD, presumably because the among–lake variation in DOC and DOC loading, as with TP and TP loading, is too modest to allow DOC to emerge as a predictor of AHOD.

In summary, clearcutting and forest fires increase the specific export of phosphorus from drainage basins to the receiving lakes over a period of three years at least with the specific export ($kg \cdot ha^{-1} \cdot yr^{-1}$) decreasing with increasing catchment size. However, the resulting effects on the AHOD were insufficient to be measurable, apparently because the variation in phosphorus loading is small relative to the variation in lake morphometry and associated flushing, and their confounding effects on the AHOD. Our next step is to examine whether a more precise determination of hypolimnetic morphometry, at the stratum level, will yield a much better prediction of dissolved oxygen depletion rates.

References

ADAMOWICZ, W. L. 1999. Sustainable forest management and the SFM Network. *In* Proceedings of the 1999 Sustainable Forest Management Network Conference, Edmonton, Alberta, Canada, 14-17 February 1999.

BERGSTRÖM, A.-K. AND JANSSON, M. 2000. Bacterioplankton production in humic Lake Örträsket in relation to input of bacterial cells and input of allocthonous organic carbon. *Microb. Ecol.* 39:101–115.

CARIGNAN, R., D'ARCY, P., , AND LAMONTAGNE, S. 2000. Comparative impacts of fire and forest harvesting on water quality in Boreal Shield lakes. *Can. J. Fish. Aquat. Sci.* 57(Suppl. 2):105–117.

CARIGNAN, R. AND STEEDMAN, R. J. 2000. Impacts of major watershed perturbations on aquatic ecosystems. *Can. J. Fish. Aquat. Sci.* 57(Suppl. 2):1–4.

CHARLTON, M. N. 1980. Hypolimnion oxygen consumption in lakes: discussion of productivity and morphometric effects. *Can. J. Fish. Aquat. Sci.* 37:1531–1539.

CIMBLERIS, A. C. AND KALFF, J. 1998. Planktonic bacterial respiration as a function of C:N:P ratios across temperate lakes. *Hydrobiologia* 388:89–100.

CLAYTON, J. S., EHRLICK, W. A., CANN, D. B., DAY, J. H., AND MARSHALL, I. B. 1978. Soils of Canada. Vols. I and II. Department of Agriculture, Research Branch, Ottawa, Ont.

CNC-IHD 1978. Hydrological Atlas of Canada. Canadian National Committee for the International Hydrological Decade, Fisheries and Environment Canada, Ottawa, Canada.

COLE, J. J., PACE, M. L., CARPENTER, S. R., AND KITCHELL, J. F. 2000. Peristence of net heterotrophy in lakes during nutrient addition and food web manipulations. *Limnol. Oceanogr.* 45:1718–1730.

CORNETT, R. J. AND RIGLER, F. H. 1979. Hypolimnetic oxygen deficits: their prediction and interpretation. *Science* 205:580–581.

CORNETT, R. J. AND RIGLER, F. H. 1980. The areal hypolimnetic oxygen deficit: an empirical test of the model. *Limnol. Oceanogr.* 25:672–679.

DEL GIORGIO, P. A. AND PETERS, R. H. 1994. Patterns in planktonic P:R ratios in lakes: influence of lake trophy and dissolved organic carbon. *Limnol. Oceanogr.* 39:772–787.

DEN HEYER, C. AND KALFF, J. 1998. Organic matter mineralization in sediments: a within and among lake study. *Limnol. Oceanogr.* 43:695–705.

DILLON, P. J. AND KIRCHNER, W. B. 1975. The effects of geology and land use on the export of phosphorus from watersheds. *Water Research* 9:135–148.

DILLON, P. J., SCHEIDER, W. A., REID, R. A., AND JEFFERIES, D. S. 1994. Lakeshore capacity study - test of effects of shoreline development on the trophic status of lakes.

Lake and Reserv. Manage. 8:121–129.

Ihaka, R. and Gentleman, R. 1996. R: A language for data analysis and graphics. *J. Comp. Graph. Stat.* 5:299–314.

Kalff, J. 2001. Limnology. Prentice-Hall, Upper Saddle River, New Jersey.

Keenan, R. J. and Kimmins, J. P. 1993. The ecological effects of clear-cutting. *Environ. Rev.* 1:121–144.

Lamontagne, S., Carignan, R., D'Arcy, P., Prairie, Y. T., and Paré, D. 2000. Element export in runoff from eastern Canadian Boreal Shield drainage basins following forest harvesting and wildfires. *Can. J. Fish. Aquat. Sci.* 57(Suppl. 2):118–128.

Lehmann, R. E. 1996. Forest clearance and lake water quality on the Canadian Shield. Master's thesis, McGill University.

Likens, G. E., Bormann, F. H., Johnson, N. M., Fisher, D. W., and Pierce, R. S. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook Ecological Watershed ecosystem. *Ecol. Monogr.* 40:23–47.

McColl, J. C. and Grigal, D. F. 1977. Nutrient changes following a forest wildfire in Minnesota: effects in watersheds with differing soils. *Oikos* 28:105–112.

Prairie, Y. and Kalff, J. 1986. Effect of catchment size on phosphorus export. *Wat. Res. Bull.* 22:465–470.

Ramberg, L. 1976. Effects of forestry operations on aquatic ecosystems. *Ecol. Bull.* 21:143–149.

RASK, M., ARVOLA, L., AND SALONEN, K. 1993. Effects of catchment deforestation and burning on the limnology of a small forest lake in southern Finland. *Verh. Int. Ver. Limnol.* 25:525–528.

RECKHOW, K. N., BEAULAC, M. N., AND SIMPSON, J. T. 1980. Modeling phorphorus loading and lake response under uncertainty: a manual and compilation of export coefficients. Technical Report EPA 440/5-80-011, United States Environmental Protection Agency.

SCHINDLER, D., ARMSTRONG, F., HOLMGREN, S., AND BRUNSKILL, C. 1971. Eutrophication of lake 227, experimental lakes area, northwestern ontario, by addition of phosphate and nitrate. *J. Fish. Res. Bd. Can.* 28:1763–1782.

SCHINDLER, D. W., NEWBURY, R. W., BEATY, K. G., AND CAMPBELL, P. 1976. Natural water and chemical budgets for a small precambrian lake basin in central Canada. *J. Fish. Res. Bd. Can.* 33:2526–2543.

SCHINDLER, D. W., NEWBURY, R. W., BEATY, K. G., PROKOPOWICH, J., RUSZCZYNSKI, T., AND DALTON, J. A. 1980. Effects of a windstorm and forest fire on chemical losses from forested watersheds and on the quality of receiving streams. *Can. J. Fish. Aquat. Sci.* 17:328–334.

STAINTON, M. P., CAPEL, M. J., AND ARMSTRONG, F. A. J. 1977. The chemical analysis of freshwater. 2nd ed. Technical Report Can. Fish. Mar. Serv. Misc. Spec. Publ. No. 25, Department of Fisheries and Oceans.

STEEDMAN, R. J. AND KUSHNERIUK, R. S. 2000. Effects of experimental clearcut logging on thermal stratification, dissolved oxygen and lake trout (*Salvelinus namaycush*) habitat volume in three small boreal forest lakes. *Can. J. Fish. Aquat. Sci.* 57(Suppl. 2):82–91.

TARAPCHAK, S. AND H. E. WRIGHT, J. 1986. Effects of forest fire and other disturbances on wilderness lakes in northeastern Minnesota. 1. Limnology. *Arch. Hydrobiol.* 106:177–202.

WETZEL, R. G. 1983. Limnology, 2nd Ed. Saunders College Publishing, Toronto.

Table 2.1: Abbreviations and units of predictor and response variables used

Variable	Unit	Description
AHOD	$mg \cdot m^{-2} \cdot d^{-1}$	Areal Hypolimnetic Oxygen Depletion rate
AHOD4C	$mg \cdot m^{-2} \cdot d^{-1}$	Areal Hypolimnetic Oxygen Depletion rate, standardized to 4°C
CA	m^2	Catchment Area
CA:HV	m	Catchment Area : Hypolimnetic Volume ratio
CA:LA	unitless	Drainage ratio
CA:LV	m	Catchment Area: Lake Volume ratio
Chla	$\mu g \cdot l^{-1}$	Chlorophyll a concentration
Depth	m	Thermocline depth
DOC	$mg \cdot l^{-1}$	Dissolved Organic Carbon concentration
HTemp	°C	Volume Weighted Mean Hypolimnetic Temperature
HThick	m	Hypolimnetic Thickness
HV	m^3	Hypolimnetic Volume
HV:LV	unitless	Hypolimnetic Volume : Lake Volume ratio
HV:SA	m	Hypolimnetic Volume : Hypolimnetic Surface Area ratio
Jt	$kg \cdot yr^{-1}$	Total Phosphorus Export
LA	m^2	Lake Area
Lt	$kg \cdot ha^{-1} \cdot yr^{-1}$	Specific Total Phosphorus Loading Rate
LV	m^3	Lake Volume
Qs	$m \cdot yr^{-1}$	Water Loading
RET	yr	Empirically Estimated Phosphorus Retention
TP	$\mu g \cdot l^{-1}$	Mean Summer Total Phosphorus concentration
WRT	yr^{-1}	Water Renewal Time
Zmax	m	Maximum Depth

All variables are log transformed

Table 2.2: Physical and chemical characteristics of the study lakes and their catchments. See Table 2.1 for explanation of abbreviations used.

	Cut				Burned				Reference				Combined			
	N	Mean	SD	CV	N	Mean	SD	CV	N	Mean	SD	CV	N	Mean	SD	CV
LA (km^2)	8	0.6	0.7	119	8	0.4	0.2	38	20	0.5	0.2	50	36	0.5	0.4	78
CA (km^2)	8	3.5	3.1	87	8	5.3	6.5	122	20	2.2	1.3	60	36	3.2	3.7	116
CA:LA (*unitless*)	8	6.9	3.3	48	8	11.4	12.1	106	20	5.3	3.0	58	36	6.9	6.7	97
WS (%)	8	8.2	2.9	36	8	9.7	3.0	31	20	9.2	3.2	34	36	9.0	3.0	34
LV ($10^6\ m^3$)	8	1.9	2.8	147	8	1.2	2.2	181	20	1.1	1.3	119	36	2.3	1.6	71
HV ($10^5\ m^3$)	19	5.2	4.7	90	19	5.1	3.9	75	54	4.2	5.3	127	92	5.2	6.2	118
Zmean (m)	8	4.4	1.8	40	8	5.8	2.0	34	20	4.6	1.8	39	36	4.8	1.8	38
Zmax (m)	8	14.0	7.7	55	8	16.6	7.6	46	20	12.5	4.3	34	36	13.7	6.1	44
DOC ($mg \cdot l^{-1}$)	27	7.5	3.1	41	27	6.0	1.9	32	60	5.0	1.2	24	114	5.7	2.1	37
TP ($\mu g \cdot l^{-1}$)	27	9.5	3.1	32	27	12.0	3.3	27	60	6.9	1.7	24	114	8.4	3.0	35
Chla ($\mu g \cdot l^{-1}$)	27	2.1	0.6	28	27	3.1	1.1	35	60	1.7	0.6	32	114	2.1	0.9	41
CA:LV (m^{-1})	8	2.0	1.2	85	8	2.0	1.7	86	20	1.4	1.2	87	36	1.6	1.3	80
CA:HV (m^{-1})	24	24.0	36.0	146	23	25.3	44.6	176	54	16.1	24.5	152	101	33.5	91.0	271
WRT (yr)	24	1.3	1.0	77	24	2.3	1.6	70	54	1.7	1.0	59	102	1.6	1.1	72

Table 2.3: Repeated measures analysis of variance (ANOVA) tests for treatment and year effects on water chemistry data over the three years of the study (1996 – 98)

```
> summary(aov(LogTP ~ treatment * year + Error(lakename/(year)), data=test.df))

Error: lakename
               Df Sum Sq Mean Sq F value    Pr(>F)
treatment       2 3.9715  1.9858 11.0172 0.0002759 ***
year            2 0.3814  0.1907  1.0581 0.3601326
treatment:year  3 0.3406  0.1135  0.6299 0.6015909
Residuals      29 5.2270  0.1802

Error: lakename:year
               Df  Sum Sq Mean Sq F value    Pr(>F)
year            2 0.23890 0.11945  9.6579 0.0002491 ***
treatment:year  4 0.15394 0.03848  3.1116 0.0220903 *
Residuals      56 0.69261 0.01237

> summary(aov(LogDOC ~ treatment * year + Error(lakename/(year)), data=test.df))

Error: lakename
               Df Sum Sq Mean Sq F value Pr(>F)
treatment       2 1.3230  0.6615  2.1106 0.1394
year            2 0.0808  0.0404  0.1290 0.8795
treatment:year  3 0.6460  0.2153  0.6871 0.5672
Residuals      29 9.0890  0.3134

Error: lakename:year
               Df  Sum Sq Mean Sq F value    Pr(>F)
year            2 0.01037 0.00519  0.7247 0.4889519
treatment:year  4 0.15676 0.03919  5.4774 0.0008568 ***
Residuals      56 0.40069 0.00716

> summary(aov(LogChlA ~ treatment * year + Error(lakename/(year)), data=test.df))

Error: lakename
               Df Sum Sq Mean Sq F value    Pr(>F)
treatment       2 4.0691  2.0346 10.4775 0.0003762 ***
year            2 0.4437  0.2218  1.1425 0.3329691
treatment:year  3 0.2514  0.0838  0.4315 0.7320267
Residuals      29 5.6313  0.1942

Error: lakename:year
               Df  Sum Sq Mean Sq F value    Pr(>F)
year            2 0.95760 0.47880 12.7356 2.761e-05 ***
treatment:year  4 0.69899 0.17475  4.6481  0.002605 **
Residuals      56 2.10533 0.03760
```

Significant results at the 0.05, 0.01 and 0.001 levels are indicated by one, two or three asterisks, respectively.

Table 2.4: Pearson correlation matrix describing significant variables used in analyses of summary hypolimnetic dissolved oxygen depletion (AHOD). Data from all three study years (1996 – 98) were used in these analyses. See Table 2.1 for explanation of abbreviations used.

	Jt	Lt	WRT	DOC	TP	Chla	Zmax	HTemp	HV:SA	CA:HV	AHOD
AHOD4C	0.07	−0.07	−0.08	−0.2	0.07	0.27†	0.45‡	−0.45‡	0.55‡	0.41‡	0.99‡
AHOD	0.12	−0.03	−0.07	−0.18	0.09	0.28†	0.38‡	−0.32‡	0.49‡	0.38‡	
CA:HV	−0.17	−0.39‡	0.44‡	−0.40‡	−0.29‡	0.04	0.74‡	−0.40‡	0.84‡		
HV:SA	0.08	−0.05	0.01	−0.13	−0.01	0.07	0.86‡	−0.61‡			
HTemp	0.26†	−0.27†	0.11	0.15	0.1	−0.14	−0.66‡				
Zmax	0.04	0.04	0.14	−0.26†	−0.2	−0.02					
Chla	0.36‡	−0.05	−0.29†	0.22*	0.68‡						
TP	0.50‡	0.19	−0.60‡	0.61‡							
DOC	0.38‡	−0.17	−0.63‡								
WRT	−0.51‡	0.42‡									
Lt	−0.05										

Asterisks indicate significance level: * = 0.05, †= 0.01, ‡= 0.005

Table 2.5: Regression equations of nutrient exports as a function of catchment size under two different runoff regimes, after correction for atmospheric phosphorus inputs. Data from all three study years (1996 – 98) were used in these analyses.

Scenario 1: Based on long–term average runoff (from Water Atlas)

Treatment	Equation	r^2	SEE	F	p
Reference	log(EXP) = -0.390 log(CA) + 0.111	0.55	0.095	69.9	< 0.001
Burn	log(EXP) = -0.311 log(CA) + 0.136	0.57	0.116	35.4	< 0.001
Cut	log(EXP) = -0.305 log(CA) + 0.175	0.26	0.196	6.94	0.016

Scenario 2: Based on runoff estimates from Lamontagne et al. (2000)

Treatment	Equation	r^2	SEE	F	p
Reference	log(EXP) = -0.382 log(CA) + 0.099	0.57	0.089	76.36	< 0.001
Burn	log(EXP) = -0.304 log(CA) + 0.076	0.52	0.130	26.9	< 0.001
Cut	log(EXP) = -0.449 log(CA) + 0.248	0.1	0.601	1.421	0.254

EXP = Specific Export rate, CA = Catchment size, *ha*

Table 2.6: Best stepwise regression models describing areal hypolimnetic dissolved oxygen depletion rates. Data from all three study years (1996 – 98) were used in these analyses.

	Coefficient	SE	P	r^2	n
AHOD					
Intercept	-1.38	0.22	< 0.001		93
Hypolimnetic volume : hypolimnetic surface area ratio					
	0.58	0.11	< 0.001	0.24	
Temperature Standardized Log(AHOD) (4°C)					
Intercept	-1.51	0.22	< 0.001		93
Hypolimnetic volume : hypolimnetic surface area ratio					
	0.70	0.12	< 0.001	0.30	

Figure 2.1: Map of study area and location in North-Eastern North America (rectangle in inset). Map is adapted from Carignan et al. (2000)

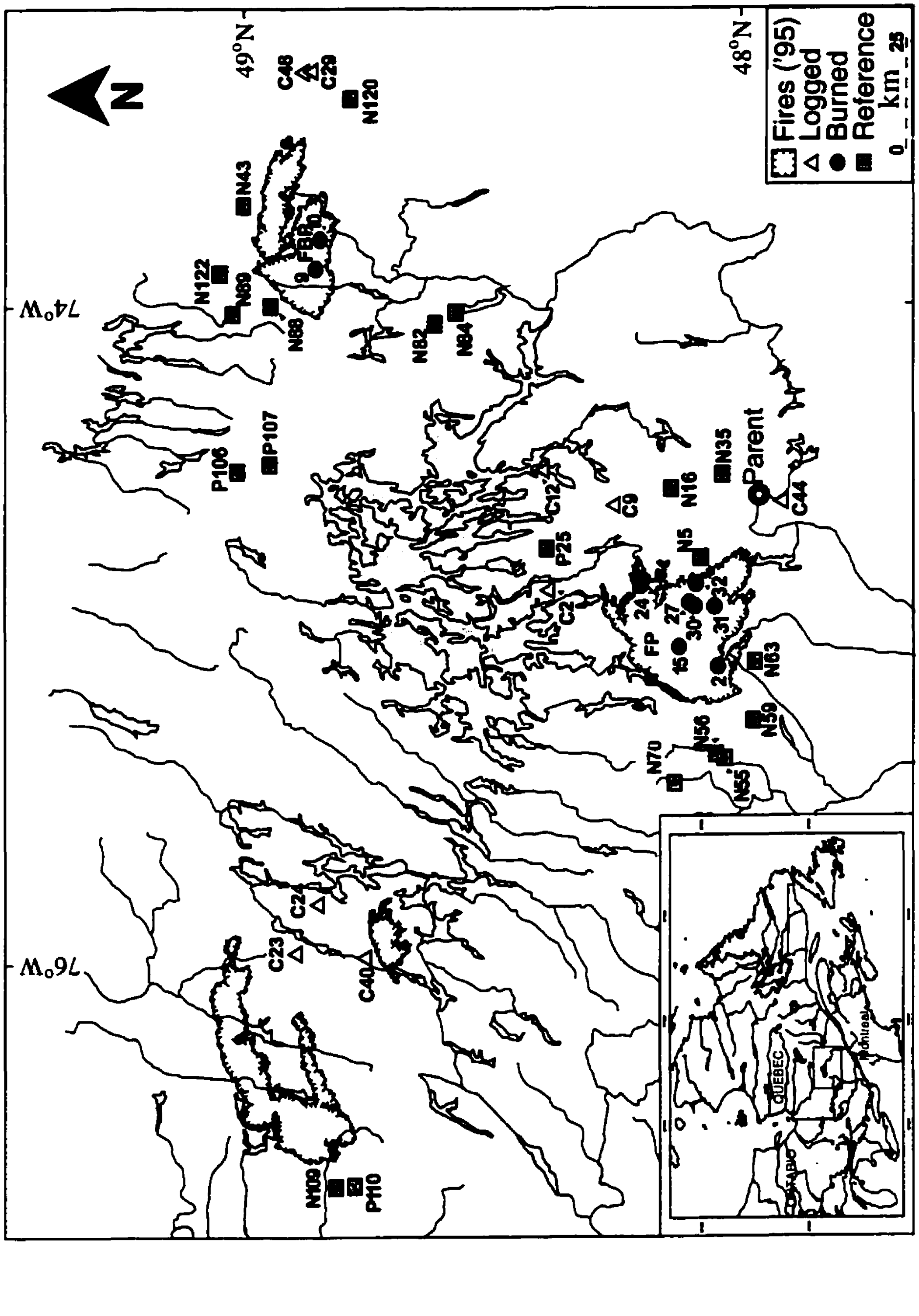

N
49°N
48°N
74°W
76°W
Fires ('95)
Logged
Burned
Reference
0 km 25
Parent
QUEBEC
ONTARIO
Montreal
N122
N89
N43
N88
N82
N84
N120
C46
C29
P106
P107
N35
N16
N5
C12
C9
C44
P25
C2
FP
24
27
30
31
32
15
2
9
N63
N59
N56
N70
N55
C24
C23
C40
N109
P110

Figure 2.2: Spring dissolved oxygen and temperature profiles taken from three lakes in reference (a – N82a, 19 Jun 1997), burned (b – FP27a, 09 Jun 1996) and cut (c – C44a, 12 Jun 1997) catchments demonstrating metalimnetic oxygen maxima. Horizontal lines indicate 1% (light solid line) and 0.1% (light dashed line) light depths, hypolimnion depth for the sampling date (dashed black line), and the hypolimnion depth of the following (mid–summer) sampling (solid black line) to show the typical lowering of the hypolimnion depth between the two sampling dates.

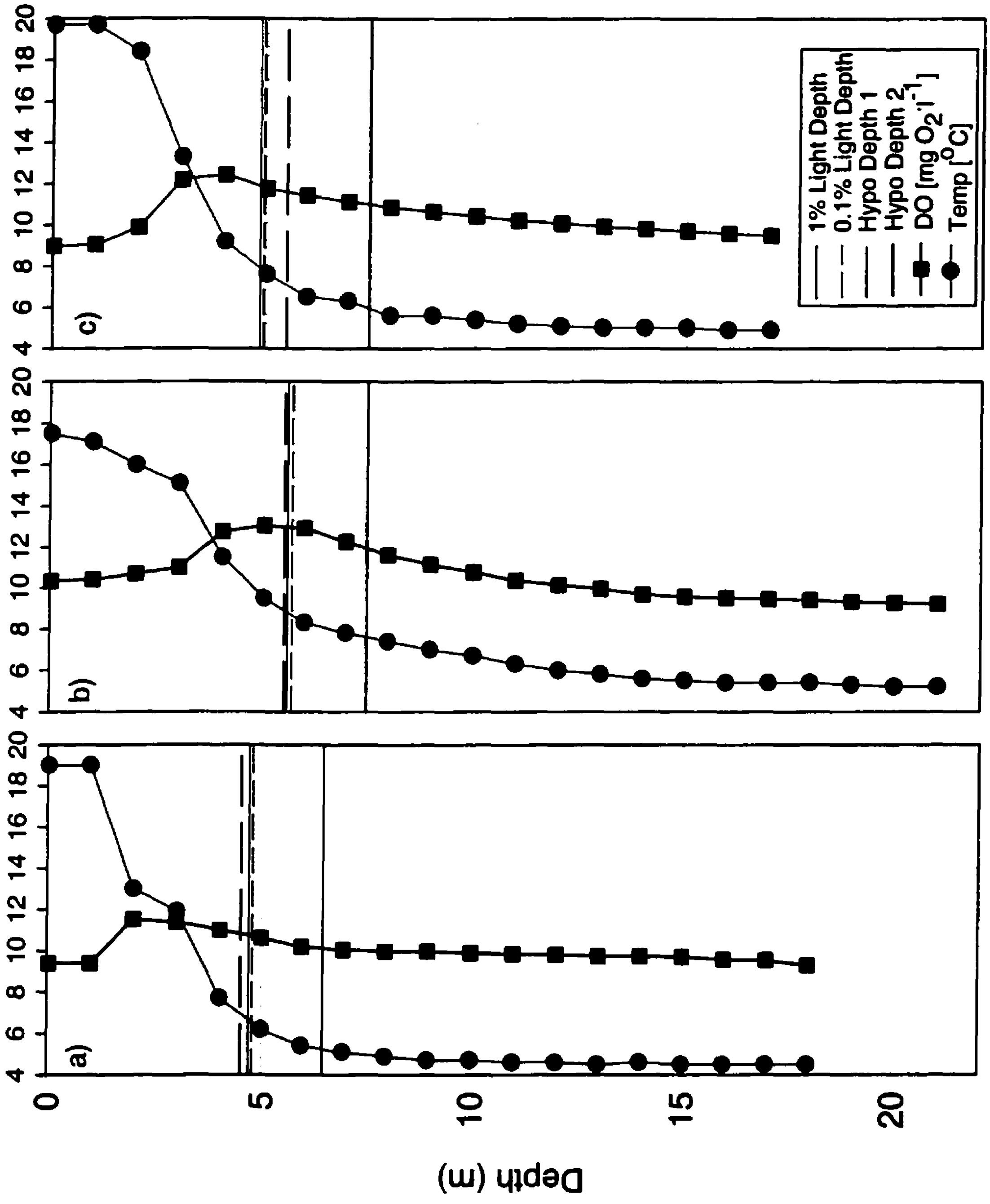

a)
b)
c)
1% Light Depth
0.1% Light Depth
Hypo Depth 1
Hypo Depth 2
DO [mg O2 l-1]
Temp [°C]
Depth (m)

Figure 2.3: Boxplots of total phosphorus (TP, $\mu g \cdot l^{-1}$), chlorophyll a (Chl a, $\mu g \cdot l^{-1}$) and dissolved organic carbon (DOC) concentrations ($mg \cdot l^{-1}$). Three year average concentrations are significantly different among treatments, and annual chlorophyll a concentrations are significantly different between years (See text).

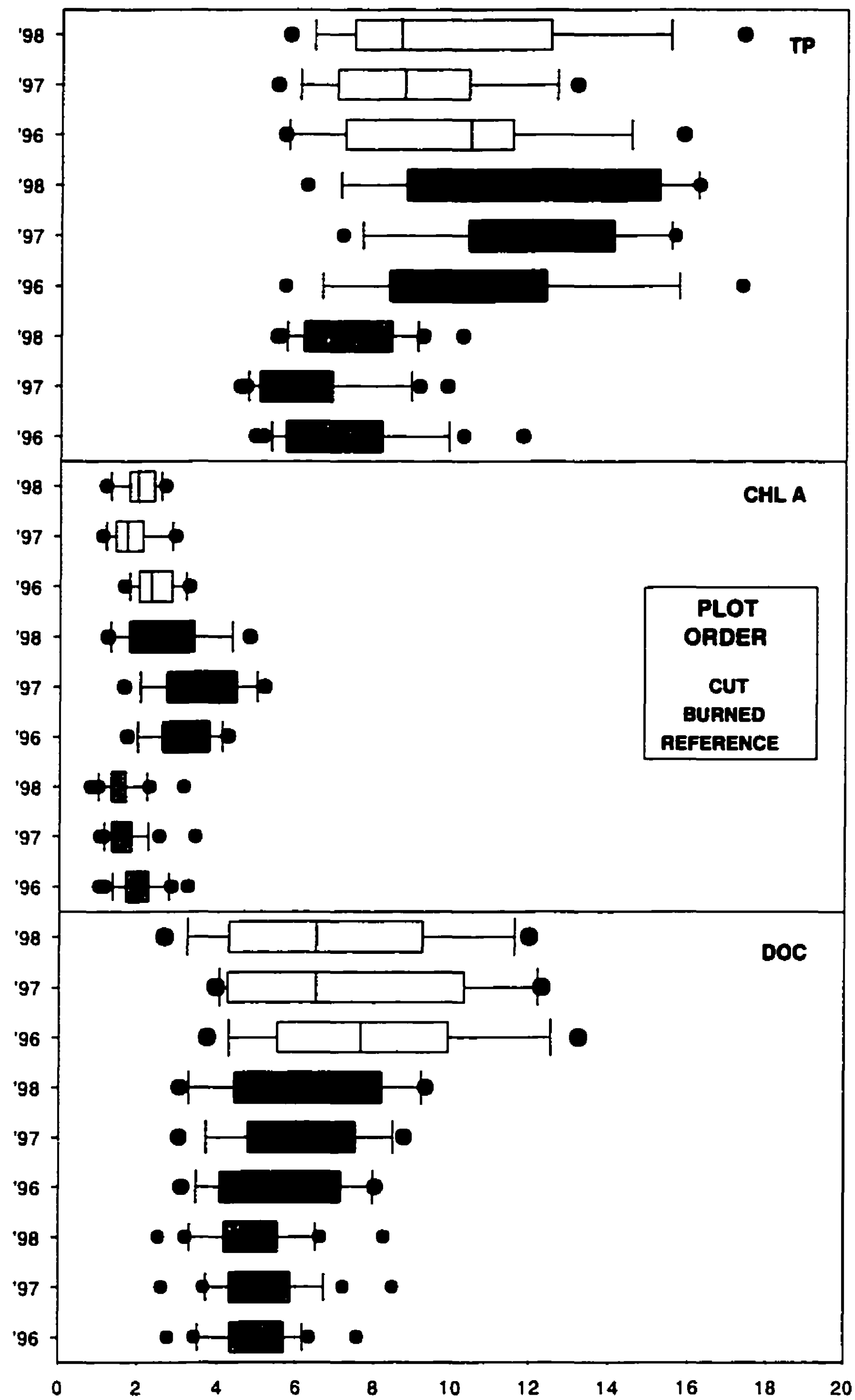
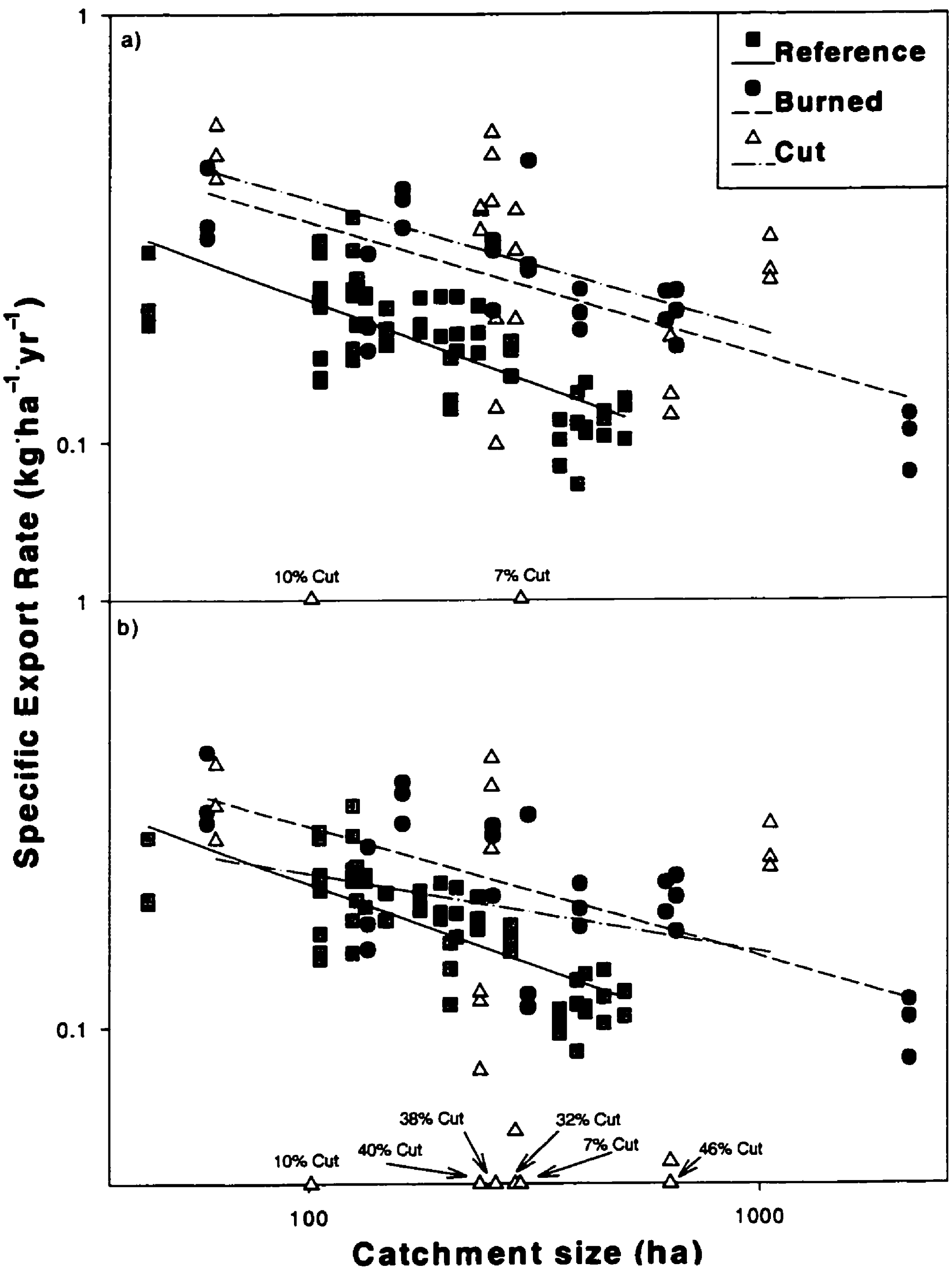
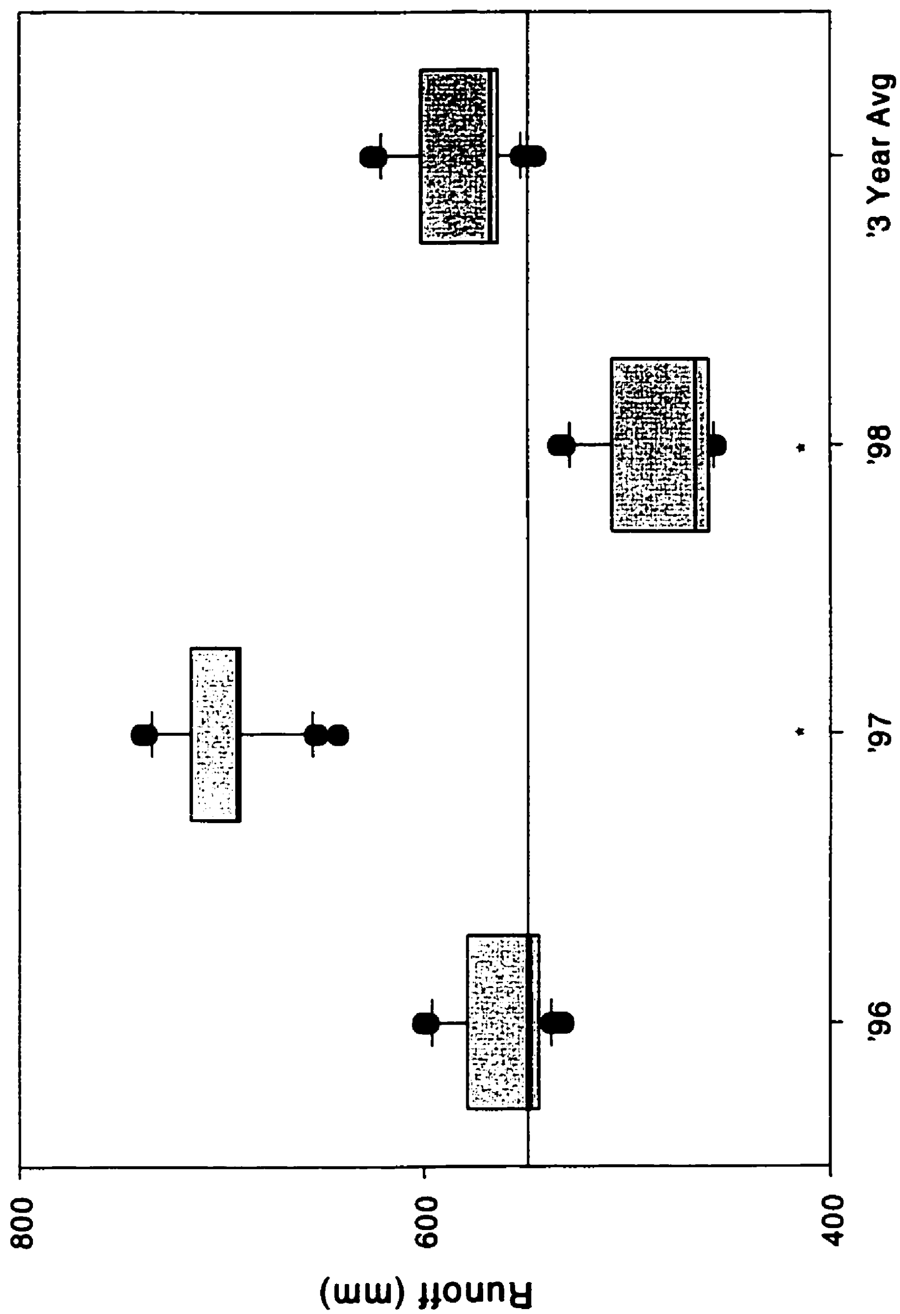

'98
'97
'96
'98
'97
'96
'98
'97
'96
TP
CHL A
PLOT ORDER
CUT
BURNED
REFERENCE
DOC
0
2
4
6
8
10
12
14
16
18
20

Figure 2.4: Specific phosphorus export rates as a function of catchment size for each of the study catchment types. The upper graph (a) uses a mean annual runoff (Q_s) of 0.55 $m \cdot yr^{-1}$, taken from the Water Atlas of Canada, and the lower graph (b) uses annual runoff estimates from three large gauged catchments surrounding the study catchments (S. Lamontagne, pers. comm.)



Specific Export Rate (kg·ha⁻¹·yr⁻¹)
1
0.1
a)
Reference
Burned
Cut
10% Cut
7% Cut
b)
38% Cut
32% Cut
7% Cut
46% Cut
40% Cut
10% Cut
100
1000
Catchment size (ha)

Figure 2.5: Boxplots comparing estimate runoff for the study lakes for the years 1996 – 98 and an average over all three years (boxplots) versus the long term average runoff (Q_s) value of 0.55 $m \cdot yr^{-1}$ (line) obtained from the Water Atlas of Canada (CHC-IHD 1978). Runoff data from 1996 as well as that averaged over the three years of our study was not significantly different from the long term average, whereas the data for 1997 and 1998 were significantly different from the long term average (indicated by *)


Runoff (mm)
800
600
400
'96
'97
'98
'3 Year Avg

Appendix 1

Raw Data

The following pages contain all physical data (60), water chemistry data (60), volumetric and hypsographic profiles (pages 61 – 69) as well as dissolved oxygen / light / temperature profiles (pages 71 – 108) used in this study.

Physical Data by Lake

Lake Name	Treatment	Latitude	Longitude	Fetch	Lake Area	Drainage Area	Watershed Area	Catchment Ratio	Slope	Percent Affected	Percent Marsh
C2a	Cut	48.340	74.900	1.1	0.4	2.9	3.3	7.5	7.0	33.2	1.8
C9b	Cut	48.133	74.633	1.9	0.7	6.3	7.0	8.8	9.7	45.7	1.0
C12a	Cut	48.347	74.537	1.0	0.4	2.5	2.9	6.6	6.3	59.6	3.9
C23a	Cut	48.847	76.013	1.1	0.3	2.4	2.7	7.9	5.8	39.9	6.0
C24a	Cut	48.804	75.850	1.0	0.2	2.6	2.8	12.8	5.7	38.1	2.0
C29a	Cut	48.815	73.318	1.3	0.3	0.6	0.9	2.0	9.7	65.1	2.4
C40a	Cut	48.705	76.021	1.0	0.3	1.0	1.3	3.3	7.0	9.8	1.4
C44a	Cut	47.873	74.652	1.4	0.3	3.0	3.3	8.9	14.9	7.5	0.4
C48b	Cut	48.857	73.327		2.4	10.6	12.9	4.4	7.3	96.4	3.1
FBP9b	Burn	48.809	73.941	2.2	0.6	6.2	6.8	10.0	8.1	94.6	1.7
FBP10a	Burn	48.793	73.833	1.6	0.4	1.4	1.7	3.6	7.6	94.5	
FP2a	Burn	47.990	75.133	2.0	0.4	3.1	3.4	8.2	6.2	50.1	1.4
FP15b	Burn	48.080	75.067	1.5	0.5	21.7	22.2	42.0	10.1	98.9	0.6
FP24a	Burn	48.151	74.870	0.9	0.2	0.6	0.8	3.2	7.7	100.0	
FP27a	Burn	48.050	74.967	1.5	0.7	1.6	2.3	2.5	12.6	91.3	
FP30a	Burn	48.038	74.950	1.2	0.4	4.0	4.3	11.2	15.4	92.2	0.6
FP31a	Burn	48.004	74.955	1.0	0.5	6.5	7.0	13.9	11.8	100.0	0.3
FP32a	Burn	48.031	74.879	1.0	0.3	2.6	2.9	8.2	7.9	100.0	1.6
N5a	Ref	48.044	74.800	1.1	0.2	2.1	2.3	10.0	15.2		3.2
N16a	Ref	48.087	74.598	3.0	0.9	4.1	5.0	4.8	12.5		2.6
N35a	Ref	47.989	74.535	1.2	0.2	1.2	1.4	7.6	15.0		4.0
N43a	Ref	48.958	73.708	1.1	0.3	4.5	4.8	14.8	4.9	1.0	6.0
N55a	Ref	47.986	75.410	1.5	0.3	1.8	2.0	6.3	8.4		
N56a	Ref	48.000	75.411	1.6	0.3	1.1	1.3	3.7	7.7		
N59a	Ref	47.930	75.293	1.1	0.2	0.4	0.6	2.7	12.5		
N63a	Ref	47.927	75.037	1.6	0.6	2.4	3.0	3.8	6.2		
N70a	Ref	48.088	75.483	1.4	0.7	1.2	1.9	1.9	7.6		
N82a	Ref	48.575	74.087	1.1	0.3	1.3	1.6	3.8	12.1		
N84b	Ref	48.528	74.054	1.5	0.8	2.8	3.6	3.4	6.3		1.7
N88a	Ref	48.904	74.049	1.7	0.6	3.9	4.5	6.6	7.6		14.7
N89a	Ref	48.971	74.036	1.8	0.7	2.0	2.7	2.8	8.2		4.3
N106a	Ref	48.970	74.538	1.2	0.4	1.3	1.8	3.1	8.5		0.8
N107a	Ref	48.907	74.522	1.4	0.5	3.6	4.1	7.6	11.8		5.1
N120a	Ref	48.735	73.409	1.0	0.4	1.1	1.5	2.6	7.0		0.8
N122a	Ref	48.996	73.987	1.0	0.2	1.1	1.3	5.1	7.5		6.9
P25a	Ref	48.340	74.773	1.1	0.3	1.5	1.8	4.3	12.6		2.1
P109a	Ref	48.760	76.714	1.0	0.5	2.1	2.6	4.2	6.5		3.6
P110a	Ref	48.726	76.723	1.3	0.8	5.0	5.9	6.0	6.1		2.2

Longitude and **Latitude** are N and W, respectively
Fetch in km and **Areas** in km^2
Catchment Ratio and **Slope** are unitless

Water Chemistry Data by Year

	1996				1997				1998			
Lakename	[TP]	[DOC]	[Chl a]	[TN]	[TP]	[DOC]	[Chl a]	[TN]	[TP]	[DOC]	[Chl a]	[TN]
C2a	11.1	9.3	2.3	303.4	8.7	8.5	1.7		10.1	7.6	2.2	264.3
C9b	8.4	5.6	2.7	240.2	7.0	6.5	2.7		7.3	5.8	2.4	245.7
C12a	15.8	11.4	3.3	314.7	13.1	9.8	2.9		17.3	8.6	1.9	296.4
C23a	12.5	13.2	2.8	385.9	11.8	12.1	1.4		12.6	12.0	1.9	359.6
C24a	10.4	9.4	2.0	315.5	9.9	12.3	1.1		12.4	11.1	2.4	302.8
C29a	7.6	3.7	2.0	209.4	7.0	4.3	1.7		8.4	2.7	1.5	188.6
C40a	5.9	6.2	1.6	207.2	6.9	4.2	1.3		5.7	4.1	1.2	194.9
C44a	5.6	5.1	2.0	265.1	5.4	3.9	1.7		7.4	4.3	2.7	209.9
C48b	10.5	7.6	3.0	245.0	9.0	6.4	1.9		8.6	6.5	2.0	253.2
FBP9b	12.0	8.0	3.5	369.9	12.0	8.0	4.1		13.8	9.1	2.1	357.6
FBP10a	5.6	4.1	1.7	215.1	8.4	4.7	1.6		6.2	3.6	1.2	169.4
FP2a	11.3	7.9	2.4	383.1	11.1	8.8	2.7		16.2	9.3	2.5	365.8
FP15b	11.0	6.9	2.8	334.3	13.6	7.3	3.1		14.8	7.9	2.4	337.5
FP24a	8.4	4.0	2.7	232.6	11.7	4.8	3.7		8.9	4.7	1.9	224.2
FP27a	8.0	3.1	3.2	206.2	7.1	3.0	2.7		8.4	3.1	1.4	173.2
FP30a	13.3	6.2	3.8	440.0	12.3	5.7	5.2		14.8	7.5	3.7	337.6
FP31a	17.3	6.2	4.2	746.7	15.6	6.2	4.4		13.1	6.6	3.3	327.4
FP32a	11.4	4.6	3.7	308.2	15.3	5.4	4.7		16.1	6.6	4.8	321.4
N5a	10.3	5.7	3.2	332.0	8.4	5.4	3.4		8.1	5.2	2.3	281.6
N16a	4.9	4.2	1.7	214.7	4.8	4.4	1.7		5.9	4.2	1.9	219.6
N35a	11.8	4.6	2.7	269.7	9.1	4.2	1.7		8.7	4.4	2.1	239.4
N43a	9.5	7.6	2.2	293.5	9.8	8.5	1.5		8.7	8.3	1.6	263.6
N55a	9.0	5.7	1.9	284.1	8.7	5.8	1.9		10.2	6.4	3.1	299.2
N56a	8.7	5.2	1.9	248.1	7.0	5.3	1.7		9.2	5.4	1.5	255.0
N59a	7.0	4.9	1.7	245.4	5.2	4.5	1.8		5.5	4.4	1.7	207.9
N63a	6.3	4.9	1.8	237.2	5.8	5.2	1.2		7.1	5.0	1.3	257.1
N70a	5.6	4.9	2.0	205.0	4.8	5.3	1.5		6.4	5.1	1.6	208.5
N82a	7.5	5.4	2.3	216.5	6.5	5.0	1.5		8.0	4.6	1.5	185.6
N84b	5.6	3.4	1.0	195.4	4.9	3.6	1.4		5.4	3.2	1.0	156.1
N88a	6.0	5.2	1.6	203.5	4.7	5.3	1.1		6.8	5.0	1.6	176.1
N89a	5.1	3.6	1.7	198.2	5.1	3.8	1.3		6.0	3.4	1.4	154.4
N106a	5.7	6.3	1.8	264.4	6.3	7.2	2.0		6.5	6.6	1.3	231.3
N107a	6.0	6.0	1.7	249.0	5.4	6.2	1.8		6.6	5.7	1.3	207.1
N120a	5.5	2.8	1.9	158.2	4.5	2.6	1.0		5.9	2.5	0.8	143.1
N122a	6.2	5.8	2.4	213.7	6.2	5.9	1.7		8.9	5.6	1.5	193.8
P25a	7.6	4.4	2.8	213.4	6.4	4.5	2.5		6.9	4.2	1.7	191.8
P109a	6.2	5.7	1.5	229.6	6.6	5.9	1.6		7.8	5.4	1.1	233.6
P110a	6.1	3.8	1.2	191.3	5.3	4.2	1.3		6.3	4.1	1.0	173.1

TP, **TN** and **Chl a** concentrations in $\mu g \cdot l^{-1}$,
DOC concentrations in $mg \cdot l^{-1}$
(**TN** concentrations were not available for 1997)

Lake Morphometry Data for Cut Lakes

		C2a			C9b			C12a	
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	380000	1274271	1	720000	4180537	1	390000	971594	1
0.5	343884	1093375	0	669762	3833172	0	345156	787919	0
1.0	307767	930546	1	619524	3510932	1	300312	626682	1
1.5	279558	783771	0	590472	3208463	0	268504	484553	0
2.0	251350	651107	1	561419	2920520	1	236695	358336	1
2.5	237417	528931	0	534641	2646533	0	211150	246436	0
3.0	223484	413724	1	507863	2385935	1	185605	147316	1
3.5	169823	315703	0	479002	2139254	0	120752	71305	0
4.0	116162	244630	1	450140	1907006	1	55898	28171	1
4.5	92468	192585	0	405998	1693066	0	29608	7139	0
5.0	68775	152421	1	361856	1501209	1	3317	0	1
5.5	56216	121226	0	324082	1329811	0			
6.0	43656	96324	1	286309	1177311	1			
6.5	38104	75899	0	263674	1039854	0			
7.0	32553	58253	1	241038	913718	1			
7.5	28134	43095	0	212087	800514	0			
8.0	23714	30149	1	183136	701797	1			
8.5	16946	20031	0	164580	614909	0			
9.0	10179	13321	1	146023	537305	1			
9.5	7763	8849	0	131741	467894	0			
10.0	5347	5591	1	117459	405628	1			
10.5	4176	3216	0	106948	349547	0			
11.0	3004	1429	1	96438	298723	1			
11.5	1532	315	0	87574	252738	0			
12.0	59	0	1	78711	211186	1			
12.5				68762	174346	0			
13.0				58813	142485	1			
13.5				45536	116468	0			
14.0				32259	97115	1			
14.5				30046	81542	0			
15.0				27832	67076	1			
15.5				24878	53905	0			
16.0				21923	42213	1			
16.5				19432	31880	0			
17.0				16942	22794	1			
17.5				14208	15016	0			
18.0				11474	8608	1			
18.5				8648	3594	0			
19.0				5821	0	1			

Area in m^2, Vol in m^3
Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Lake Morphometry Data for Cut Lakes, Con't.

	C23a			C24a			C29a		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	300000	665081	1	200000	696767	1	310000	1263196	1
0.5	248792	528083	0	174468	603223	0	281645	1115341	0
1.0	197585	416734	1	148936	522456	1	253290	981670	1
1.5	166438	325839	0	134524	451621	0	235711	859446	0
2.0	135290	250542	1	120111	387997	1	218132	746014	1
2.5	113214	188498	0	106778	331307	0	201303	641183	0
3.0	91137	137510	1	93445	281288	1	184474	544770	1
3.5	75296	95964	0	84019	236943	0	168342	456596	0
4.0	59454	62355	1	74593	197314	1	152210	376492	1
4.5	45200	36272	0	68148	161641	0	137042	304212	0
5.0	30947	17348	1	61704	129191	1	121875	239520	1
5.5	17846	5299	0	49056	101561	0	102211	183571	0
6.0	4745	0	1	36408	80274	1	82547	137469	1
6.5				32402	63081	0	66999	100150	0
7.0				28396	47892	1	51451	70623	1
7.5				22808	35117	0	42752	47105	0
8.0				17220	25143	1	34054	27945	1
8.5				13478	17487	0	22233	13978	0
9.0				9735	11709	1	10412	6001	1
9.5				7285	7469	0	6150	1907	0
10.0				4835	4460	1	1887	0	1
10.5				3384	2416	0			
11.0				1934	1103	1			
11.5				1132	346	0			
12.0				330	0	1			

Area in m^2, **Vol** in m^3
Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Lake Morphometry Data for Cut Lakes, Con't.

	C40a			C44a			C48b		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	310000	2323765	1	330000	1985663	1	1457550	6947301	1
0.5	286324	2174723	0	300254	1828158	0	1338138	6248592	0
1.0	262648	2037522	0	270507	1685532	1	1218725	5609608	1
1.5	238971	1912164	0	255866	1553956	0	1149538	5017627	0
2.0	215295	1798649	1	241225	1429701	1	1080350	4460244	1
2.5	203333	1694006	0	229407	1312056	0	1001732	3939848	0
3.0	191372	1595345	0	217589	1200320	1	923115	3458770	1
3.5	179410	1502666	0	200144	1095917	0	825688	3021795	0
4.0	167448	1415968	1	182700	1000239	1	728262	2633563	1
4.5	152322	1336056	0	166320	913016	0	654770	2287967	0
5.0	137195	1263709	0	149941	833986	1	581277	1979138	1
5.5	122068	1198931	0	140598	761364	0	517574	1704579	0
6.0	106942	1141720	1	131256	693414	1	453870	1461892	1
6.5	103918	1089007	0	119125	630843	0	407898	1246553	0
7.0	100894	1037805	0	106994	574340	1	361927	1054211	1
7.5	97870	988116	0	102207	522045	0	333586	880381	0
8.0	94846	939939	1	97420	472143	1	305245	720725	1
8.5	91854	893266	0	90350	425211	0	274392	575885	0
9.0	88862	848089	0	83281	381815	1	243540	446478	1
9.5	85870	804408	0	78558	341361	0	212072	332666	0
10.0	82878	762224	1	73836	303269	1	180605	234602	1
10.5	80521	721375	0	69462	267450	0	137540	155310	0
11.0	78164	681706	0	65089	233818	1	94474	97642	1
11.5	75807	643214	0	61376	202207	0	69636	56772	0
12.0	73450	605902	1	57662	172452	1	44797	28391	1
12.5	71266	569724	0	54348	144454	0	28804	10138	0
13.0	69083	534638	0	51034	118112	1	12812	0	1
13.5	66900	500644	0	45954	93876	0			
14.0	64716	467741	1	40874	72182	1			
14.5	62856	435849	0	34901	53258	0			
15.0	60995	404888	0	28928	37324	1			
15.5	59134	374857	0	23978	24117	0			
16.0	57274	345756	1	19028	13389	1			
16.5	55223	317633	0	11010	5970	0			
17.0	53172	290536	0	2993	2680	1			
17.5	51120	264465	0	2051	1426	0			
18.0	49069	239419	1	1109	648	1			
18.5	46542	215519	0	663	210	0			
19.0	44014	192883	0	217	0	1			
19.5	41486	171512	0						
20.0	38959	151404	1						
20.5	35567	132779	0						
21.0	32176	115850	0						
21.5	28784	100618	0						
22.0	25392	87083	1						
22.5	23450	74875	0						
23.0	21507	63640	0						
23.5	19564	53376	0						
24.0	17622	44083	1						
24.5	15426	35827	0						
25.0	13230	28670	0						
25.5	11035	22613	0						
26.0	8839	17654	1						
26.5	7694	13524	0						
27.0	6550	9967	0						
27.5	5406	6983	0						
28.0	4261	4572	1						
28.5	3286	2690	0						
29.0	2310	1298	0						
29.5	1335	398	0						
30.0	360	0	1						

Area in m^2, Vol in m^3

Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Lake Morphometry Data for Burned Lakes

	FBP9b			FBP10a			FP2a			FP15b		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	620000	2887531	1	380000	2279301	1	370000	1655305	1	520000	3817908	1
0.5	574604	2588952	0	356618	2095177	0	339895	1477885	0	481537	3567585	0
1.0	529209	2313076	0	333237	1922746	1	309790	1315522	1	443074	3336499	1
1.5	483814	2059905	0	318440	1759841	0	286105	1166587	0	426862	3119028	0
2.0	438418	1829441	1	303642	1604335	1	262420	1029499	1	410651	2909662	1
2.5	395480	1621058	0	284894	1457226	0	241198	903631	0	398310	2707430	0
3.0	352542	1434156	0	266147	1319493	1	219976	788379	1	385968	2511369	1
3.5	309605	1268735	0	249875	1190509	0	197498	684061	0	373036	2321627	0
4.0	266667	1124800	1	233603	1069662	1	175019	590988	1	360105	2138351	1
4.5	239856	998229	0	220122	956247	0	170468	504619	0	346768	1961643	0
5.0	213046	885070	0	206641	849574	1	165918	420525	1	333431	1791604	1
5.5	186235	785324	0	192054	749923	0	157042	339795	0	322092	1627732	0
6.0	159424	698996	1	177467	657567	1	148165	263504	1	310752	1469529	1
6.5	146140	622629	0	161826	572773	0	142692	190794	0	303360	1316005	0
7.0	132857	552907	0	146186	495803	1	137220	120820	1	295968	1166177	1
7.5	119574	489828	0	132863	426068	0	87754	65036	0	256154	1028266	0
8.0	106290	433395	1	119540	362996	1	38289	34368	1	216340	910283	1
8.5	94740	383165	0	107358	306299	0	26538	18250	0	202244	805656	0
9.0	83191	338713	0	95177	255696	1	14786	8062	1	188148	708080	1
9.5	71642	300041	0	85844	210461	0	8330	2359	0	178395	616455	0
10.0	60092	267150	1	76512	169894	1	1874	0	1	168642	529707	1
10.5	54974	238393	0	65387	134456	0				158610	447907	0
11.0	49857	212195	0	54262	104587	1				148579	371123	1
11.5	44740	188558	0	43214	80270	0				135872	300034	0
12.0	39622	167480	1	32165	61493	1				123166	235300	1
12.5	37229	148270	0	26857	46757	0				110778	176842	0
13.0	34836	130258	0	21549	34680	1				98390	124580	1
13.5	32443	113441	0	17478	24941	0				83530	79151	0
14.0	30050	97822	1	13407	17243	1				68669	41162	1
14.5	27802	83363	0	11098	11125	0				41984	13771	0
15.0	25553	70028	0	8789	6165	1				15298	0	1
15.5	23304	57818	0	6212	2433	0						
16.0	21056	46733	1	3635	0	1						
16.5	18401	36876	0									
17.0	15746	28348	0									
17.5	13092	21148	0									
18.0	10437	15279	1									
18.5	9044	10413	0									
19.0	7650	6244	0									
19.5	6257	2773	0									
20.0	4864	0	1									

Area in m^2, **Vol** in m^3
Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Lake Morphometry Data for Burned Lakes, Con't.

Depth	FP24a Area	FP24a Vol	FP24a Orig	FP27a Area	FP27a Vol	FP27a Orig	FP30a Area	FP30a Vol	FP30a Orig	FP32a Area	FP32a Vol	FP32a Orig
0.0	190000	796773	1	660000	6642660	1	360000	1955797	1	204400	936032	1
0.5	166906	707609	0	637495	6318302	0	333578	1782445	0	194906	836215	0
1.0	143813	630001	1	614990	6005198	0	307157	1622307	1	185412	741145	1
1.5	135068	560292	0	592484	5703347	0	293465	1472164	0	179782	649850	0
2.0	126322	494957	1	569979	5412749	1	279773	1328868	1	174153	561370	1
2.5	117880	433919	0	560613	5130105	0	268522	1191804	0	159606	477957	0
3.0	109437	377102	1	551246	4852143	0	257272	1060366	1	145058	401820	1
3.5	99254	324950	0	541880	4578865	0	246765	934365	0	121388	335296	0
4.0	89070	277892	1	532514	4310270	1	236258	813619	1	97718	280626	1
4.5	79152	235861	0	502015	4051675	0	209539	702237	0	80344	236182	0
5.0	69235	198792	1	471516	3808332	0	182820	604223	1	62970	200441	1
5.5	59493	166641	0	441016	3580242	0	164994	517307	0	55093	170948	0
6.0	49751	139366	1	410517	3367404	1	147168	439309	1	47216	145396	1
6.5	44838	115729	0	389240	3167488	0	131644	369642	0	39360	123781	0
7.0	39924	94551	1	367964	2978212	0	116120	307742	1	31504	106102	1
7.5	35604	75679	0	346688	2799576	0	99580	253870	0	29468	90862	0
8.0	31283	58969	1	325411	2631579	1	83040	208278	1	27431	76640	1
8.5	24816	44975	0	306152	2473713	0	75810	168579	0	26059	63269	0
9.0	18350	34225	1	286893	2325478	0	68579	132497	1	24687	50584	1
9.5	15408	25796	0	267634	2186874	0	56224	101347	0	22937	38681	0
10.0	12465	18840	1	248375	2057901	1	43870	76387	1	21187	27652	1
10.5	9759	13298	0	238890	1936093	0	38246	55874	0	18070	17849	0
11.0	7053	9114	1	229404	1819027	0	32621	38176	1	14952	9605	1
11.5	5802	5905	0	219918	1706705	0	27452	23176	0	9734	3480	0
12.0	4552	3323	1	210433	1599126	1	22284	10765	1	4517	0	1
12.5	3342	1357	0	201823	1496070	0	11468	2475	0			
13.0	2131	0	1	193213	1397318	0	651	0	1			
13.5				184603	1302873	0						
14.0				175993	1212732	1						
14.5				166654	1127081	0						
15.0				157314	1046100	0						
15.5				147974	969790	0						
16.0				138635	898151	1						
16.5				126832	831806	0						
17.0				115028	771365	0						
17.5				103224	716828	0						
18.0				91421	668197	1						
18.5				87009	623594	0						
19.0				82597	581197	0						
19.5				78185	541007	0						
20.0				73773	503023	1						
20.5				70134	467050	0						
21.0				66496	432896	0						
21.5				62858	400562	0						
22.0				59219	370047	1						
22.5				56315	341167	0						
23.0				53411	313739	0						
23.5				50507	287763	0						
24.0				47603	263239	1						
24.5				45010	240088	0						
25.0				42418	218235	0						
25.5				39825	197677	0						
26.0				37232	178417	1						
26.5				35189	160314	0						
27.0				33146	143233	0						
27.5				31103	127173	0						
28.0				29060	112135	1						
28.5				27562	97981	0						
29.0				26064	84577	0						
29.5				24565	71921	0						
30.0				23067	60015	1						
30.5				21540	48866	0						
31.0				20012	38480	0						
31.5				18484	28858	0						
32.0				16957	20001	1						
32.5				13509	12401	0						
33.0				10060	6530	0						
33.5				6612	2392	0						
34.0				3164	0	1						

Area in m^2, Vol in m^3
Orig indicates whether data was taken from existing map (1),
or interpolated between surrounding data (0).

Lake Morphometry Data for Reference Lakes

	N5a			N16a			N35a			N43a		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	210000	1129218	1	860000	3993019	1	160000	483762	1	300000	813862	1
0.5	191758	1028813	0	797494	3578744	0	139712	408891	0	252978	675784	0
1.0	173517	937532	1	734987	3195730	1	119424	344174	1	205957	561252	1
1.5	163396	853316	0	691208	2839237	0	109091	287064	0	178760	465153	0
2.0	153276	774162	1	647429	2504638	1	98758	235123	1	151562	382666	1
2.5	145196	699553	0	604650	2191679	0	88442	188347	0	128271	312788	0
3.0	137116	628984	1	561871	1900114	1	78126	146732	1	104980	254573	1
3.5	126302	563148	0	494077	1636309	0	65723	110814	0	85800	206958	0
4.0	115488	502721	1	426283	1406427	1	53320	81107	1	66621	168954	1
4.5	104918	447641	0	384334	1203863	0	41042	57584	0	57368	137986	0
5.0	94349	397847	1	342385	1022284	1	28765	40223	1	48115	111649	1
5.5	88922	352036	0	307392	859919	0	21320	27748	0	43720	88699	0
6.0	83494	308939	1	272398	715059	1	13874	19016	1	39326	67947	1
6.5	77724	268644	0	232014	589091	0	10710	12887	0	35083	49355	0
7.0	71953	231234	1	191630	483341	1	7546	8346	1	30840	32885	1
7.5	66024	196750	0	173195	392174	0	8349	4374	0	24488	19084	0
8.0	60094	165232	1	154760	310228	1	9152	0	1	18135	8468	1
8.5	54916	136489	0	136881	237364	0				9158	1771	0
9.0	49737	110337	1	119002	173445	1				181	0	1
9.5	44289	86843	0	97192	119488	0						
10.0	38841	66076	1	75382	76460	1						
10.5	32044	48382	0	50984	45067	0						
11.0	25247	34093	1	26587	26002	1						
11.5	19838	22849	0	18816	14707	0						
12.0	14430	14317	1	11046	7327	1						
12.5	10355	8149	0	6420	3013	0						
13.0	6280	4033	1	1793	1079	1						
13.5	4087	1461	0	1100	362	0						
14.0	1894	0	1	406	0	1						

Area in m^2, **Vol** in m^3
Orig indicates whether data was taken from existing map (1).
or interpolated between surrounding data (0).

Lake Morphometry Data for Reference Lakes, Con't.

	N55a			N56a			N59a			N63a		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	280000	605449	1	290000	807670	1	160000	826282	1	620000	2365275	1
0.5	230958	477906	0	252644	672116	0	144798	750114	0	563260	2069573	0
1.0	181915	374931	1	215288	555257	1	129597	681550	1	506521	1802253	1
1.5	162428	288891	0	194006	452980	0	120714	618985	0	474820	1556961	0
2.0	142941	212601	1	172725	361349	1	111831	560863	1	443118	1327522	1
2.5	123454	146062	0	156878	278980	0	104494	506793	0	413385	1113439	0
3.0	103966	89277	1	141030	204538	1	97156	456391	1	383652	914226	1
3.5	66641	46969	0	107890	142493	0	90420	409507	0	354222	729806	0
4.0	29316	23610	1	74749	97086	1	83684	365992	1	324792	560106	1
4.5	17784	11954	0	51448	65717	0	77098	325808	0	273604	410690	0
5.0	6251	6191	1	28147	46109	1	70511	288918	1	222417	286905	1
5.5	4642	3478	0	22060	33588	0	66311	254718	0	161189	191414	0
6.0	3033	1573	1	15972	24121	1	62111	222618	1	99961	126733	1
6.5	1642	422	0	13147	16853	0	57244	192787	0	73100	83642	0
7.0	250	0	1	10322	11000	1	52376	165391	1	46240	54062	1
7.5				7904	6456	0	48844	140092	0	34182	34033	0
8.0				5486	3127	1	45313	116558	1	22123	20065	1
8.5				2980	1042	0	41906	94736	0	14902	10868	0
9.0				475	268	1	38679	74573	1	7681	5321	1
9.5				276	83	0	34488	56291	0	5366	2077	0
10.0				76	0	1	30296	40106	1	3050	0	1
10.5							25551	26161	0			
11.0							20806	14593	1			
11.5							14704	5759	0			
12.0							8603	0	1			

Area in m^2, **Vol** in m^3
Orig indicates whether data was taken from existing map (1),
or interpolated between surrounding data (0).

Lake Morphometry Data for Reference Lakes, Con't.

	N70a			N82a			N84b			N88a		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	660000	4513961	1	330000	2801863	1	830000	3467854	1	590000	3144188	1
0.5	620602	4193861	0	319114	2639592	0	748046	3073520	0	545086	2860491	0
1.0	581203	3893464	1	308228	2482764	1	666092	2720184	1	500172	2599257	1
1.5	555949	3609199	0	299956	2330723	0	622954	2397982	0	475226	2355434	0
2.0	530695	3337562	1	291685	2182818	1	579816	2097354	1	450280	2124086	1
2.5	515470	3076030	0	283017	2039147	0	528742	1820313	0	429638	1904126	0
3.0	500246	2822111	1	274349	1899812	1	477669	1568818	1	408996	1694489	1
3.5	480958	2576826	0	264810	1765029	0	442518	1338827	0	393230	1493945	0
4.0	461671	2341185	1	255272	1635016	1	407367	1126417	1	377463	1301286	1
4.5	437034	2116537	0	239292	1511396	0	373132	931355	0	347849	1120008	0
5.0	412397	1904209	1	223313	1395768	1	338896	753416	1	318235	953542	1
5.5	383080	1705385	0	205968	1288477	0	289959	596361	0	280686	803910	0
6.0	353762	1521223	1	188623	1189861	1	241022	463805	1	243136	673067	1
6.5	303872	1356972	0	179003	1097965	0	191424	355931	0	218812	557633	0
7.0	253981	1217695	1	169383	1010880	1	141826	272928	1	194488	454368	1
7.5	229756	1096812	0	161026	928286	0	117840	208104	0	165434	364485	0
8.0	205530	988046	1	152668	849872	1	93855	155294	1	136380	289148	1
8.5	188557	889555	0	146530	775078	0	81086	111597	0	115310	226300	0
9.0	171584	799553	1	140392	703353	1	68318	74292	1	94239	174001	1
9.5	162377	716073	0	127882	636308	0	52350	44213	0	80419	130382	0
10.0	153170	637198	1	115372	575522	1	36382	22151	1	66599	93682	1
10.5	139643	564021	0	109966	519193	0	22556	7553	0	53674	63671	0
11.0	126116	497610	1	104560	465567	1	8731	0	1	40748	40140	1
11.5	115778	437154	0	98957	414694	0				30672	22345	0
12.0	105440	381870	1	93354	366623	1				20595	9611	1
12.5	94803	331833	0	87532	321409	0				10398	2007	0
13.0	84166	287117	1	81710	279107	1				200	0	1
13.5	75310	247269	0	73508	240321	0						
14.0	66453	211851	1	65306	205637	1						
14.5	59848	180290	0	60722	174137	0						
15.0	53244	152033	1	56138	144930	1						
15.5	47416	126882	0	51320	118074	0						
16.0	41589	104647	1	46501	93629	1						
16.5	36754	85074	0	39585	72131	0						
17.0	31920	67919	1	32669	54095	1						
17.5	29420	52589	0	26898	39226	0						
18.0	26921	38508	1	21126	27250	1						
18.5	22426	26188	0	18132	17445	0						
19.0	17930	16120	1	15138	9138	1						
19.5	12366	8589	0	9314	3084	0						
20.0	6802	3866	1	3489	0	1						
20.5	3969	1205	0									
21.0	1136	0	1									

Area in m^2, Vol in m^3
Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Lake Morphometry Data for Reference Lakes, Con't.

	N89a			N106a			N107a			N120a		
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	700000	2875777	1	430000	1958283	1	470000	4172095	1	400000	1933648	1
0.5	643734	2539942	0	391070	1753092	0	446227	3943064	0	364429	1742610	0
1.0	587467	2232248	1	352139	1567375	1	422454	3725921	1	328858	1569364	1
1.5	553795	1946974	0	336791	1395157	0	410678	3517645	0	312177	1409124	0
2.0	520123	1678539	1	321443	1230613	1	398901	3315257	1	295496	1257225	1
2.5	481674	1428151	0	309918	1072781	0	391526	3117653	0	280658	1113202	0
3.0	443226	1196993	1	298393	920713	1	384151	2923737	1	265820	976599	1
3.5	386284	989778	0	272124	778134	0	377514	2733323	0	252425	847052	0
4.0	329343	811061	1	245856	648695	1	370876	2546228	1	239030	724204	1
4.5	280842	658675	0	214818	533613	0	359847	2363554	0	214665	610835	0
5.0	232341	530571	1	183780	434065	1	348818	2186395	1	190300	509655	1
5.5	206086	421030	0	144494	352193	0	318506	2019621	0	171940	419133	0
6.0	179832	324625	1	105207	290027	1	288194	1868009	1	153580	337797	1
6.5	149720	242352	0	94350	240162	0	274283	1727405	0	128505	267368	0
7.0	119608	175160	1	83493	195729	1	260372	1593756	1	103430	209498	1
7.5	103556	119418	0	79649	154947	0	242264	1468124	0	90190	161131	0
8.0	87503	71709	1	75805	116088	1	224156	1351548	1	76951	119389	1
8.5	53517	36801	0	56331	83174	0	213162	1242230	0	65375	83847	0
9.0	19531	19237	1	36857	60048	1	202167	1138410	1	53799	54100	1
9.5	12430	11314	0	31954	42860	0	190652	1040220	0	40034	30727	0
10.0	5328	6098	1	27051	28126	1	179136	947788	1	26270	14271	1
10.5	4316	4591	0	21024	16139	0	166816	861318	0	14756	4152	0
11.0	3304	2692	1	14998	7176	1	154495	781010	1	3241	0	1
11.5	2182	1330	0	7673	1609	0	142906	706678	0			
12.0	1060	536	1	348	0	1	131316	638143	1			
12.5	563	137	0				126498	573693	0			
13.0	66	0	1				121680	511653	1			
13.5							105771	454837	0			
14.0							89862	405982	1			
14.5							84865	362307	0			
15.0							79868	321130	1			
15.5							71905	283204	0			
16.0							63942	249261	1			
16.5							59370	218441	0			
17.0							54797	189906	1			
17.5							51086	163441	0			
18.0							47375	138832	1			
18.5							43925	116012	0			
19.0							40475	94918	1			
19.5							36885	75585	0			
20.0							33295	58048	1			
20.5							28332	42658	0			
21.0							23368	29752	1			
21.5							19179	19133	0			
22.0							14990	10612	1			
22.5							10688	4223	0			
23.0							6387	0	1			

Area in m^2, Vol in m^3
Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Lake Morphometry Data for Reference Lakes, Con't.

		N122a			P25a			P109a			P110a	
Depth	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig	Area	Vol	Orig
0.0	210000	688256	1	350000	1630474	1	510000	1455145	1	840000	3943075	1
0.5	181597	590442	0	328585	1460855	0	429705	1220505	0	785877	3536681	0
1.0	153194	506845	1	307170	1301947	1	349410	1026072	1	731754	3157354	1
1.5	141863	433099	0	295978	1151168	0	303560	862964	0	697290	2800128	0
2.0	130532	365020	1	284787	1005986	1	257709	722803	1	662826	2460135	1
2.5	117539	303031	0	273036	866541	0	228370	601357	0	630512	2136834	0
3.0	104546	247541	1	261286	732971	1	199030	494591	1	598197	1829692	1
3.5	94283	197856	0	250056	605146	0	167046	403189	0	570310	1537593	0
4.0	84020	153305	1	238827	482936	1	135062	327803	1	542423	1259439	1
4.5	67234	115569	0	191718	375515	0	115163	265313	0	411554	1021696	0
5.0	50448	86249	1	144610	291709	1	95264	212785	1	280685	849677	1
5.5	39566	63800	0	111140	227955	0	83574	168107	0	368824	687800	0
6.0	28685	46810	1	77670	181002	1	71883	129280	1	456962	481747	1
6.5	24278	33585	0	66809	144916	0	62128	95807	0	299022	294141	0
7.0	19872	22566	1	55948	114267	1	52374	67216	1	141082	186558	1
7.5	14511	14005	0	47622	88402	0	40876	43963	0	99033	126839	0
8.0	9150	8141	1	39297	66706	1	29378	26478	1	56984	88315	1
8.5	6066	4363	0	34978	48148	0	19891	14238	0	58678	59401	0
9.0	2982	2147	1	30658	31750	1	10404	6791	1	60372	29640	1
9.5	2160	867	0	22834	18425	0	6874	2502	0	31396	7089	0
10.0	1339	0	1	15010	9033	1	3343	0	1	2420	0	1
10.5				9209	3037	0						
11.0				3408	0	1						

Area in m^2, **Vol** in m^3
Orig indicates whether data was taken from existing map (1), or interpolated between surrounding data (0).

Profile Data by Date For Study Lake C2a

Dissolved Oxygen

Depth	13 Jun 1996	24 Jul 1996	09 Sep 1996	13 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	7.87	8.62	8.1	8.11	8.61	8.99		7.55	9.03
0.1							8.66		
1.0	7.75	8.62	8.02	8.17	8.66	9.5	8.63	7.62	8.75
2.0	8.78	8.52	7.78	9.32	8.56	9.41	8.61	7.56	8.7
3.0	8.45	8.22	6.96	9.94	7.52	8.93	8.4	5.75	8.35
4.0	8.15	7.09	6.17	9.75	4.96	8.74	8.16	6.16	8.4
5.0	6.93	3.78	4.34	9.65	5.92	6.83	8.32	6.18	8.08
6.0	6.63	3.83	0.74	9.72	5.65	2.44	8.3	5.95	6.45
7.0	6.29		0.65	9.48	6.08	2.46	8.21	5.05	0.95
8.0	6.2		0.38	9.46	5.83	2.3	7.95	4.6	0.38
9.0	5.81		0.1	9.25	5.26		7.71	4.05	
9.5			0.08						
10.0	5.67			8.92			7.3		
11.0	5.55								

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	24 Jul 1996	09 Sep 1996	13 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	23.2	20.1	18.5	20.3	21.8	16.9		21.4	16.4
0.1							16.7		
1.0	23.3	20.1	18.5	20.4	19.6	16.9	16.6	21.0	16.4
2.0	18.0	19.3	18.2	19.5	18.8	15.2	16.6	20.8	16.2
3.0	16.2	18.0	16.8	10.8	17.7	14.8	15.3	16.7	15.6
4.0	9.6	15.8	16.0	8.8	14.7	14.6	9.6	11.1	15.2
5.0	7.9	9.3	14.5	7.9	9.6	13.8	7.7	9.9	14.9
6.0	7.1	8.3	10.8	7.4	9.0	10.2	7.1	9.4	13.9
7.0	6.6		8.6	7.2	7.7	8.5	6.9	8.9	10.2
8.0	6.3		7.8	7.1	7.3	7.8	6.8	8.6	8.8
9.0	6.1		7.5	6.9	7.2		6.7	8.4	
9.5			7.4						
10.0	6.1			6.9	7.1		6.6		
11.0	6.1			6.8					

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	24 Jul 1996	13 Jun 1997	23 Jul 1997	10 Sep 1997
0.02	0.675	0.66	0.579	0.553	0.57
1.0	0.115	0.066	0.086	0.086	0.072
2.0	0.025	0.008	0.02	0.019	0.014
3.0	0.005		0.007		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C9b

Dissolved Oxygen

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	23 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998	19 Sep 1998
0.02	8.59	8.86	8.19	8.72	8.61	9.06		8.75	8.91
0.1							9.57		
1.0	8.59	8.8	8.16	8.74	8.86	8.98	9.3	8.75	8.5
2.0	9.53	8.84	8.17	8.8	8.93	8.96	9.29	8.75	8.5
3.0	9.83	8.58	8.14	10.47	8.76	8.86	9.31	8.27	8.5
4.0	9.52	8.1	7.37	10.36	7.57	8.3	9.23	7.73	8.48
5.0	8.49	7.02	6.56	10.07	8.28	5.65	9.0	7.71	8.39
6.0	7.97	6.14	3.32	10.01	8.42	5.76		7.23	5.8
7.0	7.86	6.08	3.76	9.92	8.46	6.04		6.72	2.7
7.5						6.28			
8.0	7.64	5.94	3.93		8.48			6.76	3.48
9.0	7.52	5.83	3.83		8.51	6.45		6.77	3.75
10.0	7.54	5.71	3.97		8.58	6.67		6.73	4.2
11.0	7.26	5.37	3.65		8.51	6.35		6.67	3.5
12.0	6.8	5.1	3.28		8.22	6.27		6.67	3.45
13.0	6.8	4.99	3.15		8.24	6.13		6.5	3.43
14.0	6.64	4.96	3.02		8.28	6.07		6.44	3.55
15.0	6.44	4.94	2.86		8.33	5.62			3.35
16.0	6.4	4.18	2.01		8.22	5.17			2.95
17.0	5.6	2.67	0.1		7.01	3.75			
17.5			0.1						
18.0		1.67			7.73				
19.0		0.14							
20.0		0.07							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	23 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998	19 Sep 1998
0.02	22.1	18.8	18.2	19.0	22.9	16.4		22.2	14.7
0.1							15.7		
1.0	22.3	18.5	18.3	19.0	19.1	16.3	16.2	22.2	14.7
2.0	21.3	18.3	18.3	18.9	18.6	16.2	16.1	21.7	14.8
3.0	14.7	17.8	18.3	11.1	18.5	16.1	15.9	18.1	14.8
4.0	10.3	16.8	17.4	7.8	16.8	15.2	15.2	13.2	14.7
5.0	7.3	13.1	16.1	6.8	8.9	13.2	8.4	10.4	14.6
6.0	6.2	8.0	11.7	5.9	7.0	8.9		8.5	14.2
7.0	5.9	6.6	8.0	5.6	6.5	7.1		7.2	9.1
7.5						6.5			
8.0	5.3	6.0	6.8	5.7	6.0			6.4	7.3
9.0	5.3	5.5	6.2		5.7	5.8		6.2	6.8
10.0	5.1	5.4	5.8		5.5	5.6		5.9	6.2
11.0	5.0	5.2	5.5		5.3	5.5		5.7	5.9
12.0	4.9	5.1	5.4		5.3	5.4		5.7	5.8
13.0	4.9	5.0	5.2		5.1	5.3		5.5	5.7
14.0	4.8	5.0	5.2		5.1	5.2		5.5	5.6
15.0	4.7	4.9	5.1		5.0	5.2			5.5
16.0	4.7	4.8	5.0		5.0	5.1			5.5
17.0	4.6	4.7	4.9		4.9	5.0			
17.5			5.0						
18.0	4.6	4.7			4.9				
19.0		4.7			4.8				
20.0		4.7							

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	23 Jul 1996	13 Jun 1997	23 Jul 1997
0.02	0.763	0.75	0.577	0.594
1.0	0.261	0.197	0.156	0.154
2.0	0.104	0.059	0.054	0.035
3.0	0.043	0.02	0.011	0.015
4.0	0.016	0.007		
5.0	0.006			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C12a

Dissolved Oxygen

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	11 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	8.08	8.07	7.99	8.46	8.2	8.78		7.49	8.69
0.1							8.47		
1.0	8.15	8.03	7.96	7.23	8.19	9.02	8.4	7.45	8.3
2.0	7.92	7.78	6.4	6.65	8.07	9.0	8.38	7.19	8.33
3.0	6.52	6.68	5.2	6.1	7.45	8.98	7.99	2.01	8.36
3.5			4.3						
4.0	4.27	0.17			7.09				
4.5		0.11							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	11 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	23.9	19.5	18.9	21.3	21.1	16.9		22.4	16.3
0.1							16.0		
1.0	23.9	19.3	19.1	21.0	20.3	16.8	16.0	20.9	16.1
2.0	16.3	18.1	18.4	16.1	18.8	16.7	16.0	20.1	15.1
3.0	12.1	17.0	16.6	10.7	18.2	16.5	15.3	15.2	15.0
3.5			16.2						
4.0	10.1	14.0		9.5	17.9				
4.5		9.8							

Depth in m, Temperature in ^oC

Light

Depth	12 Jun 1996	24 Jul 1996	23 Jul 1997	10 Sep 1997
0.02	0.695	0.745	0.515	0.511
1.0	0.11	0.06	0.053	0.041
2.0	0.023	0.017	0.006	0.006
3.0	0.005	0.013		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C23a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	8.29	8.1	8.38	8.29	7.76	8.7		7.65	9.07
0.1							8.65		
1.0	8.3	8.06	8.36	8.36	7.73	9.11	8.51	7.55	9.07
2.0	8.27	7.84	8.38	8.45	7.55	8.97	8.49	7.5	9.02
3.0	7.87	7.46	6.98	9.05	7.32	8.54	8.33	6.33	8.95
4.0	7.86	7.46	6.66	8.94	7.07	7.66	8.03	3.49	8.91
5.0	7.28	7.14	6.18		2.32	6.57	7.3	3.43	8.56
5.25		7.0							
5.5			5.38						
6.0	7.02							3.2	8.55

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	22.1	18.4	20.1	20.2	17.4	14.7		21.1	16.0
0.1							16.3		
1.0	22.0	17.9	19.9	20.1	17.2	14.5	16.2	21.1	15.4
2.0	16.9	17.5	17.9	16.8	17.0	14.4	16.0	20.9	15.3
3.0	14.7	17.2	16.3	11.9	16.9	14.3	15.6	18.2	15.2
4.0	10.9	16.7	16.0	10.3	16.5	14.3	15.0	13.4	15.1
5.0	9.8	16.2	15.8		14.2	14.2	14.0	11.7	14.9
5.25		16.1							
5.5			15.6						
6.0	9.5							11.4	14.7

Depth in m, Temperature in ^oC

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.715	0.48	0.578	0.485	0.516	0.418
1.0	0.065	0.037	0.038	0.052	0.065	0.017
2.0	0.007	0.003	0.003	0.006	0.004	
3.0	0.0009					

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C24a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	8.26	8.34	8.13	8.79	8.17	8.73		8.96	9.68
0.1							9.0		
1.0	8.32	8.36	8.05	8.83	8.17	9.45	8.99	8.65	9.65
2.0	8.94	8.22	7.27	10.05	8.16	9.05	8.92	8.52	9.38
3.0	9.17	7.73	7.29	10.24	7.65	8.35	8.3	7.61	9.05
4.0	9.23	6.79	4.3	10.12	6.54	7.38	8.16	7.77	8.71
5.0	8.88	5.47	2.77	9.99	6.94	6.62	8.07	7.78	7.81
6.0	8.92	5.72	2.88	9.97	7.39	4.7	8.1	8.12	4.1
7.0	8.4	5.85	2.34	9.99	7.07	3.9	8.21	7.71	3.23
8.0	7.72	4.71	1.35	9.76	6.71	3.75	8.21	6.17	2.3
9.0	7.2	4.06	0.76	9.46	6.42	0.99	7.92	5.3	1.54
10.0	6.86	3.34	0.24	9.34	5.92			4.94	0.76
11.0	7.39	3.13	0.24						0.39
12.0			0.11						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	22.7	18.0	19.4	19.4	16.6	15.6		21.1	16.4
0.1							16.2		
1.0	22.2	17.2	19.2	19.6	16.5	14.6	15.1	21.0	15.0
2.0	13.6	16.8	17.1	10.6	16.2	14.1	14.8	18.1	14.8
3.0	10.1	15.7	15.3	8.4	15.1	14.0	11.3	11.6	14.5
4.0	8.9	13.6	13.9	7.7	11.6	13.8	6.9	9.1	14.1
5.0	8.4	9.5	11.5	7.4	9.3	13.2	6.2	8.8	13.5
6.0	8.2	8.7	9.3	7.1	8.3	10.6	6.1	8.5	9.6
7.0	7.7	7.9	8.4	6.9	7.5	8.1	5.8	8.2	8.4
8.0	7.2	7.4	7.7	6.7	7.1	7.5	5.7	7.5	7.7
9.0	6.9	7.2	7.4	6.4	7.0	7.5	5.6	7.2	7.6
10.0	6.7	7.0	7.4	6.3	6.9			7.1	7.4
11.0	6.8	7.0	7.4						7.3
12.0			7.4						

Depth in m, Temperature in ^oC

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.64	0.69	0.53	0.67	0.523	0.401
1.0	0.072	0.042	0.031	0.063	0.056	0.035
2.0	0.01	0.005	0.003	0.009	0.006	0.004
3.0	0.001					

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C29a

Dissolved Oxygen

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	9.79	8.72	9.23	9.1	8.44	9.22		7.32	8.79
0.1							9.6		
1.0	9.75	8.73	9.26	9.12	8.4	9.51	9.56	7.29	8.84
2.0	9.89	8.74	9.27	9.16	8.39	9.54	9.56	7.29	8.89
3.0	10.28	8.74	9.27	10.22	8.38	9.04	9.57	7.3	8.9
4.0	11.26	8.75	9.4	10.16	8.37	8.88	9.56	7.33	8.86
5.0	12.27	8.82	9.14	10.19	8.65	8.63	9.52	7.97	8.88
6.0	12.03	8.65	8.77	9.81	9.04	8.36	9.33	6.94	8.86
6.5					7.71				
7.0	11.55	7.73	8.14	9.01		7.67	8.88	4.31	0.0
8.0	10.99	5.11	1.76	8.12			7.83	2.51	
9.0	9.15	0.12	0.14	6.36			6.69	1.24	
10.0			0.12						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	17.1	17.6	18.2	16.0	17.1	14.8		19.6	14.3
0.1							12.4		
1.0	17.0	17.6	18.1	16.1	17.2	14.8	12.5	19.6	14.4
2.0	16.6	17.6	18.1	15.9	17.2	14.8	12.5	19.4	14.4
3.0	15.4	17.6	18.0	13.6	17.2	14.8	12.5	19.3	14.4
4.0	13.5	17.2	16.6	9.2	17.2	14.6	12.5	18.7	14.3
5.0	9.7	16.4	16.1	8.4	16.6	14.5	12.3	14.9	14.3
6.0	8.5	15.8	15.9	7.2	11.2	14.5	9.1	11.6	14.3
6.5					10.1				
7.0	8.0	13.9	15.7	6.6		14.3	7.6	10.3	14.3
8.0	7.6	10.2	13.6	6.3			7.1	9.9	
9.0	7.4	9.3	10.4	6.2			6.9	9.6	
10.0			9.7						

Depth in m, Temperature in ^{o}C

Light

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997
0.02	0.773	0.601	0.855	0.733	0.75	0.64
1.0	0.51	0.296	0.537	0.282	0.375	0.369
2.0	0.224	0.154	0.257	0.135	0.188	0.168
3.0	0.118	0.088	0.14	0.071	0.097	0.084
4.0	0.071	0.057	0.08	0.029	0.053	0.039
5.0	0.036	0.031	0.044	0.016	0.029	0.021
6.0	0.02	0.017	0.023	0.008	0.015	0.01
7.0	0.011		0.012			
8.0	0.006		0.008			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C40a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	8.85	9.01	8.55	9.09	8.74	9.46		8.44	9.84
0.1							9.21		
1.0	8.92	9.11	8.57	9.98	8.73	9.76	9.17	8.43	9.95
2.0	9.98	9.05	8.73	10.91	8.77	9.51	9.16	8.58	9.98
3.0	11.9	8.99	8.42	11.56	8.76	8.13	9.17	8.68	9.87
4.0	11.34	8.96	8.07	11.06	9.02	7.2	10.5	10.17	9.82
5.0	10.5	8.74	7.97	10.91	9.45	6.12	9.95	9.4	9.44
6.0	10.15	8.08	6.32	10.64	9.56	6.29	9.74	9.19	6.84
7.0	9.53	8.11	6.93	10.45	9.47	6.15	9.69	9.05	7.55
8.0	9.31	8.06	7.09	10.3	9.6	5.88	9.67	9.15	8.34
9.0	8.96	8.04	6.92	10.21	9.86	5.66	9.58	9.34	8.82
10.0	8.78	8.16	7.18	10.13	9.57	5.12	9.56	9.33	8.96
11.0	8.74	7.98	7.12	10.13	9.57	4.95	9.47	9.32	9.08
12.0	8.68	7.65	7.07	10.0	9.56	4.93	9.5	9.32	9.26
13.0	8.51	7.51	6.87		9.46	4.69	9.52	9.34	9.64
14.0	8.06	7.25	6.4		9.2	4.47	9.47	9.55	9.64
15.0	7.76	6.99	6.12		9.06	4.45	9.46	9.52	9.62
16.0		6.49	5.55		8.73	4.4	9.44	9.45	9.58
17.0		6.23	4.92		8.57	4.43	9.39	9.41	9.0
18.0		5.6	4.46		8.34	4.52	9.32	9.35	8.61
19.0		5.45	3.8		8.1		9.25	9.25	8.16
20.0		4.81	3.47		8.0	4.41	9.13	9.17	7.27
21.0		4.45	3.06		7.74		9.04	8.11	6.45
22.0		3.99	2.52		7.58	3.86	8.6	7.8	5.9
23.0		3.47	1.38		7.23		8.1		4.62
24.0		3.01	1.12		7.03	3.18			4.1
25.0		2.93	0.16		6.9				3.28
26.0		2.69	0.13		6.57	2.97			2.95
27.0		2.45			6.51				2.63
28.0		2.31			6.45	2.72			2.2
28.25		0.13							
29.0					6.39				2.15

Depth in m, [DO] in $mg \cdot l^{-1}$

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.713	0.74	0.724	0.781	0.813	0.696
1.0	0.252	0.339	0.233	0.272	0.241	0.194
2.0	0.097	0.126	0.08	0.117	0.093	0.094
3.0	0.039	0.053	0.032	0.044	0.037	0.04
4.0	0.017	0.022	0.012	0.018	0.014	0.016
5.0	0.006	0.009	0.004	0.005	0.006	

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	22.6	18.9	20.3	20.9	18.1	16.3		20.8	17.0
0.1							16.0		
1.0	21.8	18.1	20.2	19.5	18.2	15.6	16.2	20.8	16.6
2.0	17.4	17.8	19.4	15.2	17.9	14.9	16.2	19.9	15.8
3.0	12.1	17.6	17.3	9.6	17.8	14.7	14.7	18.8	15.6
4.0	9.6	16.9	16.6	7.1	13.9	14.6	8.3	12.3	15.4
5.0	8.3	11.3	12.8	6.4	8.8	12.3	6.5	10.1	15.0
6.0	7.5	8.2	9.2	6.0	7.6	7.7	5.7	8.6	11.1
7.0	6.5	6.7	7.3	5.6	6.7	6.6	5.1	7.1	8.3
8.0	5.7	5.7	6.4	5.3	6.2	6.0	4.9	5.8	6.4
9.0	5.2	5.2	5.5	5.1	5.5	5.7	4.7	5.1	5.6
10.0	4.8	4.9	5.0	5.1	5.3	5.4	4.5	4.7	5.0
11.0	4.6	4.6	4.8	5.1	5.2	5.3	4.4	4.5	4.8
12.0	4.5	4.4	4.6	5.0	5.1	5.1	4.3	4.4	4.6
13.0	4.3	4.3	4.4		5.0	5.0	4.2	4.3	4.3
14.0	4.2	4.2	4.3		5.0	5.0	4.2	4.2	4.2
15.0	4.1	4.1	4.2		4.9	4.9	4.1	4.2	4.2
16.0		4.1	4.1		4.9	4.8	4.1	4.1	4.1
17.0		4.1	4.1		4.8	4.8	4.1	4.1	4.1
18.0		4.1	4.1		4.8	4.8	4.0	4.1	4.1
19.0		4.1	4.1		4.8		4.0	4.1	4.1
20.0		4.0	4.1		4.7	4.7	4.0	4.1	4.1
21.0		4.1	4.1		4.7		4.0	4.1	4.1
22.0		4.0	4.1		4.7	4.7	4.0	4.1	4.1
23.0		4.0	4.1		4.7		4.0		4.1
24.0		4.0	4.1		4.7	4.7			4.1
25.0		4.0	4.1		4.7				4.1
26.0		4.0	4.1		4.7	4.7			4.1
27.0		4.0			4.7				4.1
28.0		4.0			4.7	4.7			4.1
28.25		4.0							
29.0					4.7				4.1

Depth in m, Temperature in ^oC

Profile Data by Date For Study Lake C44a

Dissolved Oxygen

Depth	13 Jun 1996	23 Jul 1996	06 Sep 1996	12 Jun 1997	25 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998	19 Sep 1998
0.02	8.39	8.74	8.36	8.97	8.28	8.87		6.83	8.67
0.1							9.45		
1.0	8.39	8.75	8.36	9.06	8.28	8.80	9.5	6.80	8.34
2.0	9.0	8.75	8.29	9.9	8.44	8.8	9.56	6.88	8.38
3.0	10.28	8.74	8.72	12.2	8.41	8.77	9.59	7.92	8.38
4.0	10.81	8.52	8.35	12.43	8.48	8.76	10.52	8.35	8.4
5.0	10.5	9.28	7.47	11.77	11.38	8.57	10.52	7.23	7.4
6.0	10.16	9.0	7.3	11.44	10.42	8.95	9.8	6.7	6.4
7.0	9.84	8.44	6.82	11.13	9.56	8.37	9.56	6.57	3.95
8.0	9.47	8.20	6.29	10.86	9.07	7.37	9.46	6.57	4.2
9.0	9.16	7.95	6.29	10.65	8.86	7.35	9.37	6.56	4.46
10.0	8.91	7.62	6.18	10.42	8.72	7.37	9.26	6.42	4.67
11.0	8.65	7.41	5.65	10.22	8.49	7.21	9.24	6.3	4.65
12.0	8.4	6.93	5.0	10.08	8.07	6.20	9.13	6.19	3.85
13.0	8.28	6.65	4.55	9.92		5.86	8.86	5.94	3.32
14.0	8.16	6.35	4.08	9.8		5.43	8.82	5.6	2.45
15.0	8.06	6.11	3.37	9.7		5.69	8.42	5.32	2.06
16.0	7.78	5.75	2.7	9.59		5.15	8.03	4.9	1.64
17.0	7.49	5.62	1.8	9.47				4.67	1.22
18.0		5.4	0.16					4.18	
19.0		4.98							
19.5		0.08							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	23 Jul 1996	06 Sep 1996	12 Jun 1997	25 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998	19 Sep 1998
0.02	21.8	18.7	21.8	19.7	21.0	16.2		22.4	15.2
0.1							17.3		
1.0	21.8	18.7	21.8	19.7	21.0	16.2	16.7	22.4	15.2
2.0	19.1	18.7	20.8	18.4	20.2	16.1	16.2	21.3	15.2
3.0	15.8	18.6	19.3	13.3	19.6	16.1	15.7	18.1	15.2
4.0	11.9	17.5	18.5	9.2	18.5	16.1	10.5	13.6	15.2
5.0	10.1	14.7	16.9	7.6	12.9	15.6	8.4	11.4	15.1
6.0	8.7	10.6	12.7	6.5	9.0	13.2	6.6	10.4	13.8
7.0	8.0	8.5	10.2	6.3	7.7	10.1	5.8	8.8	10.4
8.0	7.0	7.8	8.0	5.6	6.5	7.7	5.5	7.3	8.0
9.0	6.6	7.1	7.3	5.6	6.1	6.7	5.3	6.6	7.5
10.0	6.0	6.3	6.6	5.4	5.8	6.1	5.1	6.0	6.4
11.0	5.6	5.8	6.0	5.2	5.6	5.8	5.0	5.6	5.9
12.0	5.2	5.5	5.6	5.1	5.4	5.4	5.0	5.4	5.5
13.0	5.0	5.3	5.4	5.0	5.4	5.3	4.9	5.2	5.4
14.0	5.0	5.2	5.3	5.0		5.2	4.9	5.1	5.3
15.0	4.9	5.1	5.3	5.0		5.3	4.8	5.0	5.2
16.0	4.9	5.0	5.2	4.9		5.2	4.8	5.0	5.2
17.0	4.8	5.0	5.1	4.9				5.0	5.2
18.0		5.0	5.1	4.9				5.0	
19.0		5.0							
19.5		5.0							

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	23 Jul 1996	06 Sep 1996	12 Jun 1997	25 Jul 1997
0.02	0.805	0.792	0.709	0.745	0.785
1.0	0.404	0.322	0.275	0.357	0.334
2.0	0.213	0.158	0.122	0.18	0.154
3.0	0.111	0.077	0.06	0.091	0.075
4.0	0.061	0.037	0.024	0.046	0.034
5.0	0.035	0.017	0.013	0.023	0.017
6.0	0.02	0.009	0.006	0.011	0.008
7.0	0.011				
8.0	0.006				

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake C48b

Dissolved Oxygen

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	10.24	8.96	9.53	9.66	8.1	8.99		8.33	8.7
0.1							9.52		
1.0	10.32	8.93	9.58	9.66	8.11	9.34	9.48	7.94	8.66
2.0	10.27	8.93	9.54	9.68	8.12	9.15	9.47	7.85	8.66
3.0	10.2	8.93	9.13	9.71	8.1	9.06	9.44	7.65	8.65
4.0	10.08	8.92	9.04	9.87	8.1	8.78	9.39	7.41	8.65
5.0	10.24	8.56	8.97	10.3	8.06	8.65	9.38	6.83	
6.0	10.33	8.48	8.83	10.44	7.91	8.29	9.39	6.67	
7.0	10.5	8.34	8.8	10.5	7.24	8.11	9.41	6.31	
8.0	10.47	8.16	8.65	10.46		8.01	9.04	6.19	
9.0	10.5	7.88	8.13	10.52			8.81	5.85	
10.0	10.4	7.28	5.11	10.5			8.78		
11.0	10.35	5.29		10.47					
12.0	10.34	4.53		10.42					

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	15.4	17.6	16.6	15.1	17.0	15.1		20.3	14.4
0.1							12.4		
1.0	15.1	17.6	16.5	15.1	17.1	15.1	12.4	20.1	14.4
2.0	14.9	17.6	16.5	14.9	17.1	15.0	12.3	19.9	14.4
3.0	14.6	17.3	16.5	14.8	17.1	14.7	12.3	19.7	14.4
4.0	13.3	17.6	16.1	13.6	17.1	14.8	12.2	18.8	14.4
5.0	12.2	16.2	15.9	11.0	17.1	14.8	12.1	15.6	
6.0	11.1	15.9	15.9	9.6	16.9	14.6	12.1	13.4	
7.0	9.4	15.7	15.8	8.8	15.6	14.6	12.0	12.2	
8.0	8.8	15.3	15.8	8.2		14.5	11.2	11.3	
9.0	8.5	14.8	15.5	7.7		14.5	10.4	10.6	
10.0	8.3	13.8	15.5	7.5			9.4		
11.0	8.0	10.9		7.3					
12.0	7.9	9.9		7.2					

Depth in m, Temperature in ^oC

Light

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	22 Jul 1997	09 Sep 1997
0.02	0.681	0.575	0.644	0.519	0.593
1.0	0.141	0.115	0.178	0.125	0.086
2.0	0.034	0.032	0.062	0.033	0.026
3.0	0.01	0.009	0.026	0.009	0.009
4.0	0.007		0.007		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FBP9b

Dissolved Oxygen

Depth	10 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	9.81	8.93	8.55	9.35	8.35	8.75		9.46	9.1
0.1							8.89		
1.0	9.85	8.94	8.53	9.32	8.33	9.04	8.9	9.16	8.9
2.0	9.98	8.92	8.39	10.29	8.3	9.18	8.89	9.1	8.85
3.0	9.82	8.7	7.66	10.43	8.25	9.19	8.9	8.94	8.76
4.0	9.49	8.27	7.04	10.23	6.07	8.95	8.81	7.11	8.74
5.0	8.82	8.14	6.99	10.2	6.52	8.42	8.61	7.25	8.53
6.0	8.66	7.35	6.2	10.16	6.78	5.37	8.55	7.39	8.1
7.0	8.28	4.95	2.03	10.37	7.05	4.97	8.7	7.39	6.6
8.0		4.87	2.05	10.48	7.24	5.1	8.74	7.59	4.44
9.0			2.67	10.56	7.32	5.54	8.8	7.69	5.05
10.0			3.16	10.5	7.38		8.82	7.65	5.1
11.0			3.12	10.24	7.38		8.77	7.51	5.1
12.0			2.56		7.26		8.75	6.88	5.02
13.0			1.87		7.22		8.62	6.54	4.6
14.0			0.9		7.21		8.7	6.31	0.0
15.0					7.17		8.53	6.27	
16.0					7.14		8.3	6.24	
17.0					6.61		8.23	6.21	
18.0							7.77		
19.0							7.41		

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	10 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	20.1	17.2	18.3	19.6	18.3	15.0		18.9	14.2
0.1							13.8		
1.0	20.0	17.1	18.3	19.4	17.9	15.0	13.8	18.9	14.5
2.0	19.2	16.9	18.1	15.0	17.8	15.0	13.8	18.6	14.5
3.0	14.1	16.4	17.4	10.4	17.7	14.9	13.8	18.5	14.4
4.0	8.9	15.5	16.4	8.0	15.7	14.7	13.5	14.6	14.4
5.0	7.7	15.1	15.7	6.8	9.7	14.3	11.7	10.2	14.2
6.0	7.1	13.4	14.9	6.6	8.1	12.0	8.5	9.1	14.1
7.0	6.8	8.9	11.4	6.4	7.4	8.3	7.4	8.7	12.4
8.0		7.5	8.1	6.3	7.2	7.8	7.2	8.5	9.4
9.0			7.0	6.1	7.1	7.3	6.4	8.3	7.9
10.0			6.2	6.0	6.9		5.8	8.1	7.5
11.0			5.5	5.9	6.8		5.2	7.7	6.4
12.0			5.0	5.8	6.8		5.0	6.9	6.0
13.0			4.8		6.7		4.9	6.4	5.5
14.0			4.7		6.7		4.8	6.2	5.3
15.0					6.7		4.8	6.1	
16.0					6.6		4.7	6.1	
17.0					6.6		4.7	6.1	
18.0					6.6		4.7		
19.0							4.6		

Depth in m, Temperature in ^oC

Light

Depth	10 Jun 1996	24 Jul 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997
0.02	0.77	0.76	0.744	0.700	0.619
1.0	0.189	0.158	0.132	0.124	0.101
2.0	0.059	0.045	0.033	0.024	0.024
3.0	0.02	0.012	0.009	0.005	
4.0	0.006	0.007			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FBP10a

Dissolved Oxygen

Depth	10 Jun 1996	25 Jul 1996	08 Sep 1996	11 Jun 1997	23 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	9.62	8.96	8.62	10.5	8.29	8.84		9.06	8.66
0.1							9.42		
1.0	9.84	8.97	8.6	9.0	8.3	9.59	9.32	8.83	8.55
2.0	9.89	8.98	8.64	7.73	8.28	9.6	9.2	8.78	8.55
3.0	10.68	8.95	8.59	7.42	8.26	9.25	9.18	8.7	8.55
4.0	11.01	8.9	8.51	8.1	8.04	9.16	9.09	8.67	8.48
5.0	11.54	8.25	8.33	7.91	7.88	8.77	9.02	8.98	8.48
6.0	10.93	7.68	7.94	7.71	7.65	8.63	9.71	8.45	8.4
7.0	10.03	5.85	6.51	7.25	7.4	7.98	9.46	7.56	7.94
8.0	10.02	5.72	3.47	7.02	7.38	4.84	9.3	7.12	7.5
9.0	9.75	5.13	1.69	7.05	7.25	4.31	8.99		4.9
10.0	9.62	4.93	1.12	6.91	7.08	4.13	8.68		1.3
11.0		5.11	1.09	6.78	6.72	2.98			1.07
12.0		5.02	0.83	6.76	6.52				0.8
13.0		5.04	0.65	6.67	6.47				0.4
14.0			0.6	6.46	6.42				0.34
15.0			0.53	6.15					0.2
16.0			0.1						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	10 Jun 1996	25 Jul 1996	08 Sep 1996	11 Jun 1997	23 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	17.2	18.8	18.3	18.8	18.1	15.7		20.6	14.8
0.1							14.6		
1.0	17.1	18.8	18.3	18.7	18.3	15.6	14.6	20.5	14.8
2.0	16.9	18.7	18.2	17.3	18.2	15.1	14.6	20.5	14.8
3.0	13.9	18.5	18.1	16.2	18.2	15.1	14.5	20.5	14.8
4.0	13.0	18.3	18.0	11.6	17.9	15.0	14.6	20.4	14.8
5.0	12.0	16.6	17.8	9.1	17.2	15.0	13.9	15.8	14.8
6.0	9.2	15.5	17.0	7.7	11.6	14.9	9.3	10.8	14.7
7.0	8.1	12.9	15.4	7.2	9.1	14.3	8.5	9.7	14.6
8.0	8.0	9.8	12.9	7.1	8.4	11.4	7.7	9.4	14.1
9.0	7.8	8.7	10.6	7.0	8.0	9.2	7.3		12.5
10.0	7.6	8.4	9.4	6.8	7.6	8.2	7.1		9.5
11.0		8.3	8.8	6.8	7.5	7.7			9.4
12.0		8.2	8.6	6.7	7.4				9.1
13.0		8.1	8.5	6.7	7.3				9.0
14.0			8.4	6.7	7.2				8.9
15.0			8.4	6.6	7.2				8.8
16.0			8.3						

Depth in m, Temperature in ^oC

Light

Depth	10 Jun 1996	25 Jul 1996	23 Jul 1997	09 Sep 1997
0.02	0.845	0.771	0.783	0.457
1.0	0.525	0.328	0.348	0.262
2.0	0.3	0.155	0.145	0.119
3.0	0.167	0.075	0.075	0.055
4.0	0.095	0.038	0.035	0.026
5.0	0.056	0.02	0.017	0.012
6.0	0.034	0.01	0.009	
7.0	0.019			
8.0	0.011			
9.0	0.006			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FP2a

Dissolved Oxygen

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	9.1	8.17	7.65	8.5	7.38	8.41		7.6	8.05
0.1							8.16		
1.0	9.15	8.14	7.74	8.3	7.36	8.3	8.13	7.55	7.7
2.0	9.01	7.93	7.7	8.82	6.63	8.20	8.03	7.51	7.68
3.0	8.64	7.38	7.02	9.36	6.27	7.89	7.62	6.56	7.69
4.0	8.43	6.98	6.81	9.05	5.06	7.78	6.81	5.76	7.66
5.0	7.9	3.9	5.77	9.05	5.49	7.34	7.34	6.13	7.47
6.0	7.86	3.71	1.11	9.37	5.73	2.82	7.42	5.39	6.53
7.0	7.65	4.49	1.26	9.0	5.3	2.72	7.38	4.3	0.5
8.0	7.67	4.0	0.66	9.0	5.16	2.54	7.37	4.14	0.07
9.0	7.31	3.31	0.36	8.93	5.02	1.51	7.3		
9.25			0.16						
10.0	6.92	1.85		8.08	4.15				
11.0		0.1							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	17.9	19.7	20.7	20.7	19.9	16.7		21.9	15.1
0.1							15.4		
1.0	17.7	19.7	20.1	20.5	19.8	16.4	15.4	21.9	15.1
2.0	16.5	19.1	19.7	18.8	18.7	16.0	15.3	21.5	15.1
3.0	15.2	16.9	18.5	13.4	18.0	14.9	15.0	18.2	15.1
4.0	10.8	16.1	17.4	10.1	16.4	14.7	11.6	13.9	15.1
5.0	8.9	11.3	16.2	8.3	10.0	14.4	8.8	10.8	15.0
6.0	7.6	8.6	12.1	7.4	8.4	11.6	7.8	10.0	14.6
7.0	7.2	8.1	9.7	7.3	8.2	9.0	7.5	9.2	11.8
8.0	6.9	7.7	9.0	7.1	7.9	8.3	7.1	9.1	9.6
9.0	6.7	7.3	8.4	7.0	7.7	7.9	7.0		
9.25			8.2						
10.0	6.6	7.1		6.9	7.5				
11.0		7.1							

Depth in m, Temperature in ^oC

Light

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997
0.02	0.7	0.56	0.64	0.574	0.435	0.444
1.0	0.112	0.094	0.072	0.057	0.027	0.028
2.0	0.026	0.018	0.011	0.007	0.002	
3.0	0.004	0.004				
4.0	0.006					

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FP15b

Dissolved Oxygen

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	16 Jul 1998	18 Sep 1998
0.02	9.03	9.11	8.61	9.87	8.56	8.92	8.24	7.87
1.0	8.97	9.12	8.52	10.21	8.6	9.17	8.16	7.41
2.0	8.9	8.94	8.64	10.21	8.42	9.21	8.17	7.44
3.0	8.63	8.69	7.94	11.5	7.84	9.22	7.66	7.49
4.0	9.37	8.2	7.62	11.4	6.55	8.82	6.42	7.6
5.0	9.01	7.51	6.97	11.77	7.34	8.49	7.41	7.54
6.0	8.98	6.34	6.34	11.67	8.16	5.34	7.53	7.5
7.0	8.88	6.7	4.02	11.65	8.3	6.43	6.72	3.16
8.0	8.77	6.88	4.43	11.44	8.53	6.55	6.75	3.64
9.0	8.88	7.35	4.85	11.6	8.8	6.72	6.9	3.63
10.0	8.78	7.36	4.97	11.46	9.18	6.82	6.57	3.55
11.0	8.76	7.16	4.98	11.39	8.82	6.31	6.92	3.29
12.0	8.74	6.69	3.9	11.12	8.47	4.95	6.03	2.61
13.0	8.15	4.57	1.04	10.0	8.2	2.35	4.62	
14.0	7.09	3.17	0.14	8.62	8.0		3.94	
15.0			0.09					

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	16 Jul 1998	18 Sep 1998
0.02	17.5	19.7	20.8	20.9	20.3	15.5	21.4	14.6
1.0	16.8	19.7	20.9	20.5	20.1	15.6	21.5	14.7
2.0	16.7	18.8	20.1	19.4	19.1	15.6	21.3	14.9
3.0	15.6	18.6	18.0	11.4	18.0	15.6	19.3	14.9
4.0	11.0	17.5	17.3	8.5	16.0	15.0	14.6	14.9
5.0	8.5	15.8	16.5	7.0	9.9	14.5	10.6	14.9
6.0	6.7	9.4	13.6	6.6	8.1	10.5	9.2	14.7
7.0	5.7	7.3	9.2	6.4	7.3	7.6	8.3	11.2
8.0	5.5	6.2	7.2	6.3	7.0	7.1	7.3	8.1
9.0	5.2	5.9	6.4	6.3	6.7	6.5	6.9	7.2
10.0	5.1	5.5	6.0	6.2	6.5	6.3	6.4	6.6
11.0	5.0	5.3	5.6	6.1	6.3	6.1	6.1	6.5
12.0	4.9	5.1	5.4	6.1	6.1	5.9	5.7	6.3
13.0	4.8	4.9	5.1	5.9	6.1	5.9	5.6	
14.0	4.7	4.8	4.9	5.8	5.9		5.4	
15.0			4.9	5.6				

Depth in m, Temperature in ^oC

Light

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997
0.02	0.756	0.67	0.712	0.573	0.629
1.0	0.18	0.124	0.171	0.122	0.109
2.0	0.058	0.032	0.047	0.031	0.022
3.0	0.016	0.01	0.015	0.007	0.005
4.0	0.005		0.005		
5.0	0.001				

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FP24a

Dissolved Oxygen

Depth	13 Jun 1996	23 Jul 1996	07 Sep 1996	13 Jun 1997	23 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998	18 Sep 1998
0.02	8.23	9.0	8.49	8.95	8.93	8.67		9.15	8.34
0.1							9.14		
1.0	8.25	9.0	8.51	9.1	8.98	8.62	9.12	9.08	8.24
2.0	9.44	9.0	8.55	9.2	9.04	8.6	9.12	8.97	8.13
3.0	10.63	8.95	9.2	11.27	8.8	8.58	9.05	9.25	8.1
4.0	10.84	8.68	8.94	11.76	7.95	8.38	8.49	8.35	8.22
5.0	9.43	8.17	6.78	10.7	6.94	6.59	8.15	6.24	8.14
6.0	8.77	5.75	2.07	10.14	7.02	3.28	7.89	4.93	8.24
7.0	8.49	5.52	1.94	9.8	6.84	3.3	7.83	4.77	0.6
8.0	8.27	5.52	2.25	9.73	7.02	3.34	7.8	4.40	0.48
9.0	8.37	5.48	2.35	9.22	7.02	3.28	7.67	4.4	0.4
10.0	8.18	5.16	1.39	8.56	6.47		7.66	3.84	0.11
11.0	8.07						7.1	3.48	0.04
12.0	7.8							3.33	
12.8	7.38								

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	23 Jul 1996	07 Sep 1996	13 Jun 1997	23 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998	18 Sep 1998
0.02	22.4	18.2	21.1	19.7	21.9	15.8		21.6	14.5
0.1							15.2		
1.0	22.4	18.2	21.0	19.7	21.7	15.8	15.4	21.7	14.6
2.0	18.2	18.1	20.4	19.6	19.6	15.8	15.3	21.7	14.6
3.0	15.3	17.9	18.3	15.2	19.0	15.8	15.3	18.2	14.6
4.0	10.8	16.9	17.5	9.7	16.3	15.6	10.3	12.2	14.6
5.0	8.6	15.4	16.4	7.6	11.0	14.0	6.9	10.0	14.6
6.0	7.3	9.2	12.9	7.3	8.8	10.4	6.2	8.5	14.5
7.0	6.9	7.6	9.6	7.1	7.7	8.3	5.8	8.0	8.9
8.0	6.7	7.4	8.6	7.0	7.4	7.8	5.7	7.7	8.2
9.0	6.5	7.2	8.0	6.9	7.2	7.5	5.5	7.4	7.8
10.0	6.3	6.8	7.5	6.8	7.0		5.5	6.9	7.4
11.0	6.1				6.9		5.4	6.6	7.0
12.0	6.0							6.5	
12.8	5.9								

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	23 Jul 1996	07 Sep 1996	13 Jun 1997	23 Jul 1997
0.02	0.695	0.695	0.622	0.76	0.656
1.0	0.306	0.283	0.275	0.184	0.206
2.0	0.135	0.122	0.127	0.069	0.084
3.0	0.06	0.051	0.067	0.026	0.031
4.0	0.026	0.022	0.039	0.012	0.011
5.0	0.012	0.0099	0.024	0.003	
6.0	0.005		0.016		
7.0			0.011		
8.0			0.008		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FP27a

Dissolved Oxygen

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	10.33	9.65	8.8	11.02	9.11	9.18		7.86	8.14
0.1							9.37		
1.0	10.41	9.08	8.8	10.26	9.19	9.13	9.51	7.85	8.0
2.0	10.69	9.1	8.87	10.08	9.3	9.1	9.53	7.91	8.02
3.0	11.02	9.08	8.89	11.12	9.46	9.07	9.53	7.92	8.02
4.0	12.75	9.28	8.9	12.98	9.48	9.08	9.51	8.18	8.02
5.0	13.05	9.49	9.05	13.19	9.81	9.11	12.44	10.56	7.98
6.0	12.92	10.24	9.22	12.86	14.07	9.11	12.05	10.87	7.88
7.0	12.25	12.54	11.16	12.38	13.8	10.37	10.46	10.69	7.85
8.0	11.6	12.04	11.98	11.96	12.08	12.07	10.01	9.84	7.83
9.0	11.14	11.02	10.23	11.66	11.18	11.02	10.01	8.72	6.4
10.0	10.77	9.84	8.56	11.54	10.92	9.45	9.54	8.2	6.15
11.0	10.36	8.08	7.84	11.38	10.39	8.77		7.65	5.65
12.0	10.13	7.65	7.26	11.34	10.21	8.22		7.19	5.34
13.0	9.95	7.34	7.15	11.32	9.96	7.9		7.16	5.14
14.0	9.66	7.34	6.79	11.25	9.89	7.62		7.01	5.0
15.0	9.58	7.16	6.48	11.29	9.86	7.31		6.95	5.08
16.0	9.53	7.11	6.06	11.26	9.66	7.17		6.9	4.92
17.0	9.47	7.03	5.92	11.2	9.63	7.09		6.9	4.67
18.0	9.42	7.01	5.96	11.21	9.53	6.95			4.64
19.0	9.32	6.92	5.88	10.36	9.47	6.91			4.36
20.0	9.28		5.77	9.34	9.42	6.79			4.2
21.0	9.21		5.66		9.42	6.77			4.09
22.0			5.64		9.33	6.69			4.03
23.0			5.61		9.18				3.95
24.0			5.58		9.09				3.91
25.0			5.56		9.04				3.68
26.0			5.51		9.01				
27.0			5.5		9.0				
28.0			5.5		8.97				
29.0			5.5		8.87				
30.0			5.5		8.72				

Depth in m, [DO] in $mg \cdot l^{-1}$

Light

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997
0.02	0.88	0.8	0.832	0.768	0.823
1.0	0.56	0.524	0.512	0.473	0.495
2.0	0.253	0.327	0.306	0.281	0.326
3.0	0.143	0.2	0.204	0.174	0.207
4.0	0.08	0.126	0.122	0.098	0.128
5.0	0.031	0.075	0.077	0.052	0.083
6.0	0.013	0.05	0.049	0.027	0.052
7.0	0.005	0.031	0.03	0.015	0.032
8.0		0.017	0.019	0.008	0.019
9.0		0.011	0.012		0.012
10.0		0.008	0.007		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Temperature

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	17.5	19.3	20.5	18.19	21.2	15.7		21.6	15.1
0.1							15.5		
1.0	17.1	19.3	20.4	18.7	20.9	15.7	15.5	21.6	15.2
2.0	16.0	19.3	19.9	18.1	20.0	15.7	15.3	21.2	15.3
3.0	15.1	19.3	19.6	16.5	19.5	15.7	15.2	20.9	15.3
4.0	11.5	18.6	19.3	11.7	19.1	15.6	15.2	20.1	15.3
5.0	9.5	17.5	18.4	8.8	16.4	15.4	10.5	14.7	15.3
6.0	8.3	15.1	17.5	7.3	12.8	15.3	6.9	11.6	15.2
7.0	7.8	11.6	14.6	6.4	8.3	14.7	6.1	10.4	14.9
8.0	7.4	8.5	10.7	5.9	7.0	10.0	5.5	9.2	10.8
9.0	7.0	7.6	8.9	5.6	6.4	7.7	5.4	8.1	8.4
10.0	6.7	7.2	7.8	5.4	6.0	6.7	5.3	7.4	7.4
11.0	6.3	6.4	6.8	5.2	5.6	6.1		6.7	6.5
12.0	6.0	6.1	6.5	5.2	5.4	5.8		6.0	6.1
13.0	5.8	5.9	6.2	5.1	5.2	5.5		5.7	5.8
14.0	5.6	5.7	6.1	5.0	5.2	5.3		5.5	5.7
15.0	5.5	5.6	5.9	5.0	5.1	5.2		5.3	5.5
16.0	5.4	5.5	5.7	5.0	5.0	5.1		5.3	5.5
17.0	5.4	5.4	5.6	4.9	5.0	5.0		5.2	5.4
18.0	5.4	5.3	5.5	4.9	4.9	5.0			5.3
19.0	5.3	5.3	5.4	4.9	5.0	5.0			5.1
20.0	5.2	5.3	5.4	4.9	4.9	5.0			5.1
21.0	5.2		5.3		5.0	5.0			5.0
22.0			5.3		5.0	5.0			5.0
23.0			5.3		4.9				5.0
24.0			5.3		4.9				5.0
25.0			5.3		4.9				5.0
26.0			5.3		4.9				
27.0			5.3		4.9				
28.0			5.3		4.9				
29.0			5.3		4.9				
30.0			5.3		4.8				

Depth in m, Temperature in ^oC

Profile Data by Date For Study Lake FP30a

Dissolved Oxygen

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	9.49	9.41	8.76	8.32	9.62	8.96		8.08	8.0
0.1							9.87		
1.0	9.62	9.43	8.85	8.86	10.2	8.92	10.02	7.88	7.8
2.0	9.72	9.45	8.74	9.55	9.95	8.72	10.0	7.76	7.92
3.0	10.03	9.83	8.12	12.18	9.48	8.71	9.2	5.99	7.86
4.0	9.53	8.39	7.95	11.18	8.08	8.43	8.38	5.45	7.78
5.0	9.31	5.86	4.01	10.65	5.21	8.05	8.01	5.16	7.78
6.0	8.62	4.21	1.44	10.6	5.74	3.65	7.89	4.95	7.4
7.0	8.06	4.46	1.04	10.65	6.15	1.17	7.99	5.16	0.45
8.0	6.59	3.97	1.2	10.43	6.66	2.6	8.1	5.15	0.45
9.0	5.63	3.29	0.5	10.24	6.86	2.37	8.0	4.58	0.68
10.0	4.66	2.89	0.14	10.08	6.65	1.95	7.98	3.92	
11.0	4.43	2.63	0.1	9.46	6.79	1.91	7.89	3.43	
12.0	4.26	1.5	0.09	9.12	6.32	0.21		2.92	
13.0		0.08	0.08		4.58			2.15	
14.0			0.07						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	18.8	20.1	21.5	20.1	21.3	15.2		21.9	14.5
0.1							15.6		
1.0	18.6	20.2	21.5	20.1	19.5	15.2	15.5	21.9	14.5
2.0	16.0	20.1	19.6	18.4	18.6	15.2	15.4	21.8	14.6
3.0	12.5	17.3	18.1	13.2	17.8	15.2	13.7	17.5	14.6
4.0	10.7	16.2	16.7	8.7	17.2	14.9	12.5	12.0	14.6
5.0	9.1	13.3	14.5	7.5	12.1	14.7	7.4	10.6	14.6
6.0	8.7	10.0	12.4	7.0	8.9	12.5	6.4	9.8	14.4
7.0	8.1	8.4	9.4	6.7	8.0	9.8	6.2	9.3	10.9
8.0	6.7	7.5	7.8	6.4	7.4	8.0	6.0	8.9	9.6
9.0	6.1	6.5	7.0	6.1	6.8	7.0	5.8	8.5	9.1
10.0	5.5	6.2	6.5	6.0	6.5	6.6	5.6	8.2	
11.0	5.3	5.9	6.2	5.9	6.3	6.5	5.6	7.9	
12.0	5.1	5.7	6.0	5.7	6.1	6.2		7.4	
13.0		5.5	5.9		5.9			7.2	
14.0			5.9						

Depth in m, Temperature in ^oC

Light

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997
0.02	0.83	0.63	0.724	0.705	0.511
1.0	0.193	0.175	0.198	0.218	0.141
2.0	0.093	0.057	0.067	0.074	0.042
3.0	0.02	0.017	0.02	0.025	0.011
4.0	0.009	0.004	0.006	0.008	

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake FP32a

Dissolved Oxygen

Depth	09 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	24 Jul 1997	12 Sep 1997	28 May 1998	17 Jul 1998	18 Sep 1998
0.02	9.78	8.78	8.42	9.06	8.64	8.63		9.1	8.20
0.1							9.2		
1.0	9.9	8.75	8.4	9.27	8.65	8.57	9.26	8.81	8.18
2.0	10.24	8.45	8.38	9.41	8.14	8.54	9.23	8.19	8.13
3.0	11.19	8.2	8.35	10.55	6.87	8.4	8.58	5.42	8.13
4.0	10.17	7.72	4.79	9.21	1.15	8.07	6.77	4.18	7.84
5.0	9.51	7.47	1.64	10.28	3.75	6.42	7.21	5.19	7.29
6.0	8.7	4.94	1.18	10.69	6.27	2.33	8.17	6.61	3.78
7.0	8.75	5.7	2.21	10.69	7.63	3.73	8.68	6.83	2.57
8.0	8.66	5.79	2.5	10.38	6.54	3.22	8.67	5.90	2.36
9.0	8.5	5.55	1.81	10.12	5.89	1.48		5.18	1.7
10.0	7.88	3.7	0.09	9.72	3.95	0.06		4.3	0.39
11.0		1.66	0.12					2.37	0.15
11.5			0.11						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	09 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	24 Jul 1997	12 Sep 1997	28 May 1998	17 Jul 1998	18 Sep 1998
0.02	19.0	17.1	17.9	19.2	20.1	15.3		21.7	14.5
0.1							16.2		
1.0	18.7	17.0	17.9	19.2	19.6	15.3	16.0	21.8	14.7
2.0	16.9	16.8	17.0	19.2	18.5	15.3	14.6	20.7	14.7
3.0	13.3	16.5	17.9	10.8	17.6	15.2	13.9	16.0	14.7
4.0	10.3	16.2	16.9	8.8	13.3	15.0	10.3	11.6	14.7
5.0	9.3	15.5	14.8	7.8	9.6	13.7	7.9	10.3	14.7
6.0	7.0	8.6	10.6	7.3	7.9	9.8	6.6	9.7	12.9
7.0	5.4	6.3	7.6	7.0	7.0	7.5	6.0	8.8	9.4
8.0	5.1	5.5	6.1	6.7	6.7	6.7	5.8	7.8	8.1
9.0	5.0	5.1	5.5	6.5	6.3	6.3		6.6	7.2
10.0	4.8	4.8	5.1	6.3	6.1	6.1		6.0	6.3
11.0		4.7	4.9	6.1				5.6	6.1
11.5			4.8						

Depth in m, Temperature in ^oC

Light

Depth	09 Jun 1996	23 Jul 1996	13 Jun 1997	24 Jul 1997
0.02	0.888	0.715	0.747	0.635
1.0	0.256	0.185	0.181	0.124
2.0	0.103	0.06	0.051	0.03
3.0	0.034	0.017	0.014	0.007
4.0	0.012	0.005	0.003	
5.0	0.008			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N5a

Dissolved Oxygen

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	24 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998
0.02	8.47	8.85	8.09	8.59	8.06	8.64		8.94
0.1							8.92	
1.0	8.5	8.83	8.06	8.72	8.05	8.57	8.88	7.92
2.0	8.91	8.64	7.99	10.21	8.2	8.55	8.87	8.42
3.0	9.85	8.17	8.0	10.34	6.82	8.45	8.82	8.67
4.0	8.31	7.48	6.27	9.4	6.79	6.9	7.59	6.15
5.0	6.95	5.03	2.2	9.26	6.46	4.07	7.53	6.2
6.0	6.4	4.52	2.53	9.14	7.31	4.76	7.7	6.13
6.5					5.88			
7.0	5.8	4.09	2.3	9.12		4.95	7.67	6.13
8.0	5.29	3.48	1.97	8.8		4.17	7.25	6.03
9.0	4.94	3.24	1.18	8.64		3.87	7.25	5.46
10.0	4.93	2.84	0.8	8.39		2.91	7.03	4.91
11.0	4.7	2.47	0.12	8.14		2.1	6.83	4.57
12.0	4.47	2.09	0.06	7.73		1.35	6.52	3.98
12.25		1.57						
13.0	4.17		0.05	7.29		0.92	6.48	3.47
14.0	3.57		0.04	5.97		0.89		3.08
15.0			0.04					
15.5			0.04					

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	24 Jul 1997	12 Sep 1997	29 May 1998	17 Jul 1998
0.02	21.3	17.7	17.7	19.1	20.9	15.6		21.6
0.1							15.1	
1.0	21.3	17.7	17.9	19.2	20.0	15.6	15.3	21.7
2.0	17.5	16.9	17.9	16.0	19.0	15.6	15.3	21.0
3.0	14.0	16.2	17.8	10.1	17.4	15.5	15.2	17.2
4.0	9.6	14.9	16.3	7.5	11.4	14.3	7.9	11.6
5.0	7.5	10.1	12.8	6.3	7.8	10.4	6.6	8.3
6.0	6.4	7.3	9.0	5.9	6.4	7.8	5.8	7.2
6.5					5.8			
7.0	5.6	6.1	7.1	5.6		6.5	5.4	6.0
8.0	5.3	5.6	6.2	5.4	5.6	5.9	5.1	5.5
9.0	5.1	5.2	5.7	5.3		5.6	4.9	5.3
10.0	5.0	5.1	5.3	5.2		5.4	4.9	5.1
11.0	4.8	5.0	5.2	5.2		5.3	4.8	5.0
12.0	4.8	5.0	5.1	5.1		5.3	4.7	4.9
12.25		4.9						
13.0	4.7		5.0	5.1		5.3	4.7	4.9
14.0	4.7		5.0	5.1		5.3		4.9
15.0	4.7		5.0	5.0				
15.5			5.0					

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	23 Jul 1996	13 Jun 1997	24 Jul 1997
0.02	0.626	0.719	0.67	0.637
1.0	0.197	0.146	0.2	0.163
2.0	0.062	0.035	0.08	0.044
3.0	0.021	0.009	0.025	0.012
4.0	0.007		0.006	

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N16a

Dissolved Oxygen

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	25 Jul 1997	12 Sep 1997	17 Jul 1998	19 Sep 1998
0.02	8.57	8.79	8.16	8.19	8.01	8.83	9.14	8.8
1.0	8.69	8.8	8.14	8.37	8.25	8.83	9.1	8.53
2.0	10.05	8.86	8.1	8.7	8.34	8.83	8.74	8.5
3.0	10.69	8.67	8.11	9.4	8.24	8.73	9.2	8.52
4.0	10.66	8.63	7.7	9.22	7.72	8.57	9.65	8.51
5.0	10.0	8.33	6.74	9.05	7.53	7.91	7.69	8.51
6.0	9.72	7.13	3.43	8.78	7.34	4.4	6.51	8.29
7.0	8.69	6.43	3.87	8.78	7.42	5.39	6.24	2.32
7.5						5.11		
8.0	7.45	4.95	2.67	8.42	7.13		5.59	1.53
9.0	5.82	3.86	1.03	8.18	6.82	4.17		0.4
10.0	4.93	2.31	0.1	8.27	6.57	2.63		0.0
11.0	4.34	2.03	0.05	8.08	5.86	2.06		
12.0	3.99	1.16	0.05		5.66			
13.0	3.58	0.07	0.05		4.68			

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	13 Jun 1997	25 Jul 1997	12 Sep 1997	17 Jul 1998	19 Sep 1998
0.02	22.6	19.2	17.8	18.2	20.8	15.7	22.4	14.8
1.0	22.0	18.8	18.1	18.2	20.8	15.7	22.1	14.8
2.0	18.5	18.1	18.1	17.3	19.9	15.5	21.6	14.8
3.0	11.5	17.0	18.1	11.2	18.6	15.5	19.5	14.8
4.0	11.0	16.6	18.0	7.7	15.8	15.3	14.1	14.8
5.0	9.2	15.5	17.0	6.8	9.9	14.6	11.0	14.8
6.0	8.6	10.1	13.9	6.4	8.7	11.4	10.0	14.6
7.0	7.6	8.1	9.6	6.1	7.5	8.1	9.1	10.7
7.5						7.0		
8.0	6.3	6.6	7.5	5.9	6.4		7.6	8.1
9.0	5.5	5.9	6.3	5.6	5.9	6.0		7.0
10.0	5.1	5.4	5.7	5.4	5.5	5.6		6.6
11.0	4.9	5.2	5.4	5.3	5.3	5.4		
12.0	4.8	5.1	5.3		5.2			
13.0	4.7	5.1	5.3		5.1			
14.0					5.0			

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	23 Jul 1996	13 Jun 1997	25 Jul 1997
0.02	0.731	0.76	0.544	0.403
1.0	0.344	0.3	0.205	0.138
2.0	0.16	0.126	0.09	0.045
3.0	0.071	0.058	0.037	0.015
4.0	0.03	0.025	0.014	
5.0	0.013	0.011	0.004	
6.0	0.005	0.005		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N35a

Dissolved Oxygen

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	12 Jun 1997	25 Jul 1997	12 Sep 1997	17 Jul 1998	19 Sep 1998
0.02	7.96	8.29	7.69	8.42	7.87	8.46	8.32	8.23
1.0	7.98	8.28	7.68	8.5	7.84	8.42	8.2	7.79
2.0	9.06	8.11	7.66	9.63	7.74	8.39	7.98	7.83
3.0	9.36	7.93	7.62	10.36	7.32	7.93	7.31	7.88
4.0	8.63	7.5	6.63	10.16	5.66	7.46	6.23	7.71
5.0	5.13	0.04	3.97	9.69	4.25	4.84	4.16	7.53
6.0	2.2	0.06	0.11	8.19	1.42	0.12		0.09
7.0	1.28	0.04	0.07	6.93		0.08		0.0
7.5						0.07		
8.0			0.06					

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	23 Jul 1996	10 Sep 1996	12 Jun 1997	25 Jul 1997	12 Sep 1997	17 Jul 1998	19 Sep 1998
0.02	22.4	18.8	18.4	20.6	21.1	16.5	22.4	14.8
1.0	22.5	18.7	18.5	20.6	21.2	16.5	22.3	14.8
2.0	19.6	17.9	18.5	18.2	20.6	16.4	21.9	14.9
3.0	15.2	17.4	18.5	12.8	19.1	16.0	18.5	14.9
4.0	12.0	16.9	17.7	10.3	15.5	15.5	14.3	14.8
5.0	9.5	12.6	16.3	9.2	11.4	14.5	11.6	14.8
6.0	7.8	8.5	11.5	8.0	9.4	11.0		13.4
7.0	7.3	8.2	9.2	7.6		9.2		9.8
7.5						8.8		
8.0			8.6					

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	23 Jul 1996	12 Jun 1997	25 Jul 1997
0.02	0.73	0.783	0.696	0.609
1.0	0.271	0.245	0.22	0.205
2.0	0.111	0.09	0.082	0.07
3.0	0.045	0.038	0.032	0.022
4.0	0.018	0.014	0.01	0.007
5.0	0.006	0.005		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N43a

Dissolved Oxygen

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	9.24	8.74	8.65	8.66	8.07	8.58		9.09	8.71
0.1							6.98		
1.0	9.24	8.76	8.68	8.64	7.98	8.91	6.9	8.92	8.4
2.0	9.56	8.49	8.28	8.67	7.99	9.0	6.82	8.56	8.4
3.0	9.9	8.45	8.21	9.45	7.98	8.98	6.73	7.38	8.44
4.0	9.9	8.33	7.52	9.88	7.78	8.78	6.64	6.93	8.44
5.0	10.01	8.25	7.26	9.94	5.94	8.46	6.38	7.06	8.44
6.0	10.06	8.15	4.97	10.03	6.16	6.24	6.61	7.04	6.85
6.5					5.9				
7.0	9.91	7.9	0.78	9.93		2.9	6.42	6.38	1.55
8.0	9.75	4.79	0.26	9.75	4.84	1.46	6.08	5.9	0.05
8.5			0.12						
9.0	9.09	2.79							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	18.7	17.8	20.2	18.2	17.2	15.6		20.9	14.2
0.1							14.5		
1.0	18.0	17.2	20.1	18.2	17.2	15.0	14.4	20.8	14.2
2.0	15.2	16.2	16.8	17.7	17.3	14.4	14.3	19.7	14.2
3.0	12.6	15.5	15.7	12.6	17.2	14.4	13.8	17.3	14.2
4.0	10.0	15.1	15.3	9.0	17.0	14.3	13.4	10.9	14.2
5.0	8.4	14.8	15.0	8.2	11.2	14.1	9.6	9.1	14.2
6.0	8.3	14.6	14.6	8.0	9.4	13.0	6.9	8.7	13.5
6.5					8.7				
7.0	8.2	14.2	11.9	7.7		9.5	6.2	8.4	9.7
8.0	8.0	10.6	11.6	7.5	8.1	8.4	5.9	8.2	9.1
8.5			11.4						
9.0	7.5	8.8							

Depth in m, Temperature in ^oC

Light

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	22 Jul 1997	09 Sep 1997
0.02	0.785	0.691	0.697	0.539	0.543
1.0	0.14	0.086	0.121	0.061	0.072
2.0	0.037	0.019	0.025	0.014	0.013
3.0	0.002	0.005	0.006	0.002	
4.0	0.0005				

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N55a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	16 Jul 1998	14 Sep 1998
0.02	8.78	8.44	8.28	8.45	8.2	9.87		8.7	9.13
0.1							8.8		
1.0	8.92	8.42	8.27	9.04	8.01	9.01	8.79	8.4	8.2
2.0	8.74	8.25	8.04	9.27	7.96	9.58	8.78	8.23	7.77
3.0	8.59	8.16	6.92	9.2	7.6	8.59	8.23	6.25	7.55
4.0	8.08	8.09	6.04	8.65	2.27	7.32	5.25	0.31	7.24
5.0	5.76	0.1	1.47	8.2	0.29	6.56	4.0	0.05	7.0
6.0	3.52	0.08	0.1		0.04	1.07	1.37	0.05	0.24
7.0		0.07	0.08		0.02	0.64		0.05	

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	16 Jul 1998	14 Sep 1998
0.02	22.5	18.9	22.7	22.3	21.0	17.2		22.7	16.3
0.1							19.6		
1.0	20.8	18.6	22.5	20.4	20.9	16.2	19.6	22.7	16.2
2.0	19.8	18.4	20.3	18.4	20.6	15.5	18.8	22.6	15.7
3.0	15.7	18.0	18.4	13.3	19.5	15.4	16.2	20.2	15.3
4.0	11.5	17.8	17.4	10.7	16.0	15.1	14.2	15.9	15.2
5.0	8.6	13.3	15.5	9.0	11.8	14.9	8.9	11.2	14.5
6.0	7.0	9.3	11.2		10.5	10.7	7.4	10.3	12.2
7.0	7.0	8.6	9.9		9.6	9.9		9.9	

Depth in m, Temperature in ^oC

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.8	0.732	0.78	0.679	0.744	0.485
1.0	0.234	0.189	0.237	0.166	0.223	0.129
2.0	0.085	0.075	0.08	0.046	0.064	0.035
3.0	0.027	0.025	0.028	0.013	0.024	0.01
4.0	0.008	0.009	0.009	0.004	0.006	
5.0	0.003			0.005		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N56a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	8.98	8.98	8.4	9.05	8.41	9.77		8.64	9.03
0.1							8.62		
1.0	9.03	8.94	8.41	9.19	8.42	11.27	8.66	8.64	8.24
2.0	9.62	8.99	8.49	10.2	8.49	11.52	8.72	8.54	8.64
3.0	9.79	8.77	8.56	11.34	8.26	11.22	8.5	7.78	8.31
4.0	9.82	8.73	7.74	11.29	7.61	10.1	7.98	5.74	7.83
5.0	9.05	7.39	7.06	10.98	6.9	9.34	7.66	4.95	7.72
6.0	7.5	3.37	0.16	11.0	5.05	1.4	6.98	3.1	4.22
7.0	7.24	2.74	0.12		3.17	1.73	6.53	0.36	0.18
8.0	6.83	1.07	0.12			1.38		0.08	0.14
9.0	6.59	0.32	0.09			0.56		0.06	0.13
10.0	6.24	0.09	0.08						
11.0			0.08						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	22.3	19.5	21.5	21.3	20.5	16.7		21.1	16.8
0.1							19.0		
1.0	21.8	19.4	21.4	21.1	20.2	16.7	18.3	21.0	16.8
2.0	18.7	19.0	20.7	17.7	19.5	15.4	17.3	20.9	16.5
3.0	16.3	18.0	19.2	11.7	18.8	15.3	15.9	18.8	15.7
4.0	16.0	17.7	18.5	9.8	17.4	15.2	14.2	15.5	15.5
5.0	9.6	15.0	17.3	9.3	11.7	14.8	9.2	11.8	15.1
6.0	7.4	9.7	13.2	9.1	9.0	11.1	8.1	9.7	13.9
7.0	6.8	8.0	9.0		8.0	8.7	7.7	8.4	9.7
8.0	6.6	7.2	7.9			7.7		7.9	8.1
9.0	6.5	6.9	7.6			7.6		7.7	8.2
10.0	6.4	6.9	7.5						
11.0			7.5						

Depth in m, Temperature in ^oC

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.76	0.562	0.65	0.742	0.709	0.576
1.0	0.275	0.23	0.252	0.251	0.261	0.173
2.0	0.113	0.085	0.1	0.091	0.104	0.062
3.0	0.046	0.033	0.045	0.035	0.04	0.023
4.0	0.018	0.012	0.016	0.013	0.015	0.008
5.0	0.007	0.005	0.006	0.005	0.005	

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N59a

Dissolved Oxygen

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	21 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	9.34	8.7	8.05	9.16	8.22	9.01		8.42	8.52
0.1							8.95		
1.0	9.49	8.7	8.0	7.96	8.26	9.14	8.85	8.03	8.3
2.0	9.45	8.71	7.95	6.51	8.32	9.11	8.82	7.98	8.4
3.0	9.61	8.62	8.03	7.21	8.35	8.94	8.8	7.97	8.4
4.0	10.14	8.46	7.7	6.92	8.79	8.85	9.9	9.5	8.38
5.0	9.58	7.45	7.12	6.61	10.96	8.81	9.63	9.02	8.29
6.0	8.41	6.55	3.36	6.24	9.33	7.39	9.05	7.25	8.3
6.5					8.59				
7.0	7.83	5.62	3.51	6.01		7.37	8.64	5.56	1.9
8.0	7.45	5.71	3.22	5.72		6.43	8.57	5.06	1.5
9.0	7.23	5.31	3.08	5.61		6.23	8.39	4.48	1.24
10.0	7.14	4.31	2.52	5.53		6.19	8.37	5.07	1.16
11.0	7.38	5.32	1.27	5.45		4.9	7.68	4.27	0.74
12.0	7.1	4.94		5.19				3.34	0.45
13.0	6.84	3.74		4.78				2.99	
14.0	6.08								

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	21 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	17.5	20.5	19.8	20.1	21.3	15.9		22.2	15.5
0.1							16.0		
1.0	17.2	20.5	20.4	20.2	20.9	15.9	16.2	22.2	15.5
2.0	16.6	20.4	20.4	20.0	20.3	15.8	16.2	22.2	15.6
3.0	15.7	19.8	19.8	12.5	19.4	15.6	16.1	21.7	15.6
4.0	12.0	18.2	18.5	9.8	16.5	15.4	11.0	16.6	15.5
5.0	9.7	13.6	17.3	8.4	10.7	15.1	8.9	12.9	15.4
6.0	7.9	10.0	11.7	7.2	8.7	10.7	7.9	10.3	15.3
6.5					8.1				
7.0	6.6	7.3	8.6	6.7		8.6	7.2	8.8	10.7
8.0	6.0	6.8	7.4	6.2	6.5	7.2	6.7	7.4	8.3
9.0	5.7	6.4	6.8	5.9		6.6	6.5	7.0	7.7
10.0	5.4	6.0	6.5	5.9		6.2	6.4	6.7	7.3
11.0	5.3	5.8	6.4	5.6		6.0	6.3	6.6	7.2
12.0	5.2	5.6		5.5				6.4	6.9
13.0	5.3	5.5		5.5				6.3	
14.0	5.1								

Depth in m, Temperature in ^{o}C

Light

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	21 Jul 1997	11 Sep 1997
0.02	0.78	0.685	0.68	0.665	0.665	0.6
1.0	0.38	0.284	0.266	0.278	0.311	0.256
2.0	0.195	0.131	0.125	0.132	0.136	0.11
3.0	0.104	0.064	0.056	0.068	0.061	0.042
4.0	0.055	0.031	0.027	0.033	0.028	0.008
5.0	0.0292	0.015	0.015	0.016	0.012	
6.0	0.0154	0.007	0.005	0.007		
7.0	0.006					

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N63a

Dissolved Oxygen

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	9.33	8.94	7.95	11.1	8.43	8.6		8.5	8.58
0.1							8.63		
1.0	9.68	8.91	7.94	9.51	8.39	8.87	8.62	8.08	8.15
2.0	9.8	8.87	7.99	8.78	8.42	8.83	8.61	8.05	8.24
3.0	10.29	8.89	7.98	9.29	8.27	8.82	8.58	8.09	8.32
4.0	10.55	8.64	7.51	8.88	8.05	8.79	8.5	7.62	8.3
5.0	10.75	8.05	6.88	8.1	6.98	8.74	7.99	5.67	8.35
6.0	9.68	7.94	6.18	7.93	5.94	8.71	7.61	5.22	8.31
6.5					5.66				
7.0	9.58	7.22	5.7	8.32		8.59	7.61	4.93	8.33
8.0	9.38	6.88	5.04	8.7	5.34	8.49	7.51	4.8	8.28
9.0	9.32	4.99	0.18	8.69	5.22	8.12	7.46	4.63	8.29
9.5	8.5								
10.0			0.09		4.5		4.16	4.35	

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997	28 May 1998	16 Jul 1998	18 Sep 1998
0.02	17.5	19.3	20.5	19.2	19.3	15.3		21.8	15.0
0.1							14.7		
1.0	17.0	19.3	20.7	19.5	19.5	15.3	14.9	21.9	15.0
2.0	16.5	19.1	20.3	19.3	18.7	15.3	14.9	21.7	15.1
3.0	14.9	18.3	18.8	14.3	18.4	15.3	14.8	19.3	15.1
4.0	11.8	17.3	18.0	8.8	17.9	15.3	14.6	16.2	15.0
5.0	10.1	16.8	17.5	8.2	16.2	15.1	10.9	12.5	15.1
6.0	9.6	16.5	17.3	7.9	11.7	14.8	8.7	11.7	15.0
6.5					10.5				
7.0	9.4	16.1	17.1	7.7		14.6	8.2	11.2	15.0
8.0	9.4	15.8	17.0	7.7	10.1	14.5	8.1	11.2	15.0
9.0	9.3	13.7	14.6	7.7	9.8	14.4	8.0	11.1	15.0
9.5	9.1								
10.0			13.1		9.7		7.8	10.9	

Depth in m, Temperature in ^oC

Light

Depth	09 Jun 1996	26 Jul 1996	06 Sep 1996	12 Jun 1997	24 Jul 1997	11 Sep 1997
0.02	0.802	0.77	0.737	0.72	0.436	0.61
1.0	0.404	0.29	0.324	0.247	0.128	0.34
2.0	0.184	0.138	0.148	0.096	0.039	0.176
3.0	0.09	0.064	0.062	0.015	0.013	0.13
4.0	0.04	0.026	0.028	0.005		0.041
5.0	0.019	0.013	0.012			0.016
6.0	0.008	0.005	0.004			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N70a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	9.76	9.33	8.53	9.8	8.53	9.46		9.05	9.01
0.1							9.24		
1.0	9.9	9.35	8.63	9.85	8.55	9.27	9.25	9.07	9.25
2.0	10.36	9.35	8.7	10.68	8.54	8.91	9.34	9.04	9.11
3.0	10.78	9.31	8.74	11.26	8.53	8.56	9.20	8.94	8.56
4.0	11.18	9.27	8.61	11.73	8.42	8.11	9.09	8.46	8.0
5.0	11.33	9.17	8.16	11.52	8.18	7.73	9.17	7.83	7.7
6.0	11.23	8.96	7.47	11.44	8.29	6.78	9.33	7.89	8.65
7.0	11.25	8.41	5.12	11.44	8.73	6.12	9.46	7.94	7.55
8.0	11.04	8.48	5.55	11.38	8.99	6.32	9.72	8.0	4.4
9.0	10.58	8.49	5.87	11.33	8.92	6.14	9.68	8.13	4.66
10.0	10.49	8.45	5.91	11.32	8.81	5.98	9.7	8.06	4.64
11.0	10.46	8.39	5.89	11.29	8.84	5.76	9.7	8.01	4.73
12.0	10.46	8.26	5.83	11.25	8.88	5.58	9.7	8.03	4.56
13.0	10.37	8.17	5.68	11.18	8.75	5.38	9.69	8.0	4.49
14.0	10.26	8.04	5.67	11.16	8.77	5.25		7.91	4.13
15.0			0.14	11.15	8.7	5.15		7.89	0.0
16.0			0.1	11.13	8.66	5.02		7.8	
17.0				11.1	8.64			7.67	
18.0					8.59				
19.0					8.47				

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	21.7	18.0	20.9	20.0	19.2	15.8		20.4	16.5
0.1							16.9		
1.0	21.1	17.6	20.8	19.8	19.2	15.1	16.8	20.3	16.2
2.0	18.0	17.0	20.1	16.4	18.9	15.1	16.4	20.2	15.8
3.0	16.0	16.8	19.5	12.0	18.6	15.0	15.9	20.0	15.6
4.0	12.8	16.8	18.5	8.8	18.0	15.0	15.5	16.9	15.4
5.0	9.5	16.6	17.4	8.2	13.5	14.2	12.2	12.6	15.3
6.0	8.8	15.0	16.8	7.3	9.3	14.1	8.8	10.6	15.1
7.0	8.5	13.1	13.4	6.6	7.4	9.5	7.1	9.6	14.6
8.0	8.1	8.0	9.9	6.3	6.6	7.2	6.8	8.7	10.4
9.0	7.6	7.2	8.2	6.2	6.3	6.7	6.4	7.9	8.7
10.0	6.3	6.9	7.4	6.1	6.2	6.4	6.2	7.5	7.7
11.0	6.2	6.8	7.1	5.9	6.0	6.2	6.1	7.2	7.5
12.0	6.1	6.6	7.0	5.8	5.9	6.1	6.1	7.1	7.4
13.0	6.0	6.6	6.9	5.7	5.9	6.1	6.1	7.0	7.3
14.0	5.9	6.5	6.8	5.7	5.8	6.0		6.9	7.2
15.0			6.8	5.7	5.8	6.0		6.9	7.2
16.0			6.8	5.7	5.8	6.0		6.8	
17.0				5.7	5.8	5.9		6.7	
18.0					5.7				
19.0					5.7				

Depth in m, Temperature in ^{o}C

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.31	0.76	0.81	0.763	0.746	0.567
1.0	0.29	0.24	0.32	0.274	0.219	0.201
2.0	0.137	0.105	0.16	0.108	0.118	0.072
3.0	0.071	0.052	0.069	0.043	0.058	0.03
4.0	0.032	0.022	0.033	0.017	0.025	0.015
5.0	0.015	0.01	0.016	0.007	0.011	
6.0	0.007	0.007	0.007			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N82a

Dissolved Oxygen

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997	28 May 1998	14 Jul 1998	16 Sep 1998
0.02	8.75	9.07	8.57	9.39	8.54	9.44		8.87	9.3
0.1							9.34		
1.0	8.77	9.07	8.57	9.41	8.53	9.72	9.34	8.86	9.2
2.0	9.81	9.06	8.58	11.5	8.56	10.22	9.33	8.85	9.27
3.0	11.52	9.12	8.84	11.38	8.6	10.05	9.27	8.85	9.28
4.0	11.73	9.05	8.62	11.0	9.89	10.01	10.01	10.53	9.28
5.0	10.53	9.43	8.0	10.61	9.74	9.89	9.18	9.79	9.12
6.0	9.57	8.38	6.98	10.17	9.11	9.26	8.53	9.02	8.6
7.0	9.0	7.86	6.42	10.03	8.73	8.84	8.25	7.56	6.45
8.0	8.94	7.66	6.3	9.97	8.69	8.54	8.0	7.45	5.6
9.0	8.89	7.37	5.9	9.96	8.68	8.46	7.91	7.32	5.23
10.0	8.74	7.13	5.67	9.87	8.66	8.12	7.89	7.16	5.0
10.5		6.95							
11.0	8.74		5.47	9.82	8.28	7.84	7.85	7.09	4.96
12.0	8.69		5.47	9.8	8.2	7.34	7.78	7.03	4.75
13.0	8.55		5.02	9.72	8.05	7.07	7.66	6.81	4.65
14.0	8.49		0.12	9.71	7.88	6.83	7.6	6.72	4.44
14.5			0.08						
15.0				9.7	7.65		7.55	6.68	4.33
16.0				9.57	7.21		7.5	6.48	3.95
17.0				9.52	6.36		7.49	6.46	3.84
18.0				9.28				6.42	3.62
19.0									3.6

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997	28 May 1998	14 Jul 1998	16 Sep 1998
0.02	22.0	18.0	18.5	19.0	18.9	15.7		20.0	15.2
0.1							14.1		
1.0	21.7	17.9	18.7	19.0	18.7	15.6	14.3	20.0	15.3
2.0	18.4	17.5	18.7	13.0	18.4	15.5	14.2	20.0	15.1
3.0	16.2	16.7	18.4	11.9	18.2	15.5	13.8	19.8	15.1
4.0	9.4	15.9	16.6	7.7	13.4	15.4	10.8	13.9	15.0
5.0	7.4	12.4	14.4	6.2	9.4	13.5	7.2	10.2	14.0
6.0	6.1	7.2	10.4	5.4	7.2	8.5	6.0	9.0	10.3
7.0	5.6	6.4	7.5	5.1	5.8	6.4	5.4	6.2	6.8
8.0	5.3	5.7	6.5	4.9	5.3	5.2	5.1	5.9	6.2
9.0	5.3	5.4	5.7	4.7	5.0	4.9	5.0	5.6	5.5
10.0	5.1	5.2	5.4	4.7	4.8	4.8	4.9	5.3	5.4
10.5		5.1							
11.0	5.1		5.2	4.6	4.8	4.7	4.9	5.2	5.3
12.0	5.0		5.1	4.6	4.7	4.7	4.9	5.1	5.2
13.0	4.9		5.0	4.5	4.6	4.7	4.8	5.0	5.1
14.0	4.9		5.0	4.6	4.6	4.7	4.8	5.0	5.1
14.5			5.0						
15.0	4.8			4.5	4.6		4.8	5.0	5.1
16.0				4.5	4.5		4.8	5.0	5.1
17.0				4.5	4.5		4.8	5.0	5.1
18.0				4.5	4.5			5.0	5.1
19.0				4.4					5.1

Depth in m, Temperature in ^{o}C

Light

Depth	12 Jun 1996	24 Jul 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997
0.02	0.74	0.715	0.827	0.785	0.694
1.0	0.314	0.29	0.381	0.32	0.322
2.0	0.141	0.13	0.16	0.15	0.14
3.0	0.062	0.062	0.067	0.068	0.063
4.0	0.027	0.031	0.027	0.03	0.032
5.0	0.012	0.018	0.012	0.012	0.016
6.0	0.004	0.014	0.006		
7.0		0.012			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N84b

Dissolved Oxygen

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	8.71	8.82	8.24	9.42	8.6	8.88		8.53	8.3
0.1							9.27		
1.0	8.72	8.82	8.25	9.48	8.0	9.2	9.26	8.52	8.25
2.0	9.51	8.81	8.23	9.5	8.53	9.39	9.25	8.5	8.2
3.0	9.79	8.78	8.23	10.97	8.56	9.38	9.24	8.5	8.3
4.0	11.03	8.78	8.21	11.84	8.56	9.31	9.21	8.57	8.3
5.0	11.11	8.7	7.4	11.78	8.52	9.28	9.51	9.61	8.3
6.0	10.77	8.43	6.25	11.32	7.62	9.22	10.67	8.97	8.3
7.0	9.58	7.98	5.63	11.06	7.12	8.56	10.25	7.64	8.25
8.0		7.31	2.2	11.04	7.13	3.21	9.72	7.24	8.17
8.25		4.71							
9.0			0.44	10.87	7.0	2.68	9.47	6.76	7.1
10.0			0.08	10.67	6.42	1.42	9.46	5.84	0.4
11.0				10.63			8.98		
12.0							6.97		

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	22.2	18.7	19.1	19.0	20.7	16.2		20.6	15.6
0.1							14.9		
1.0	22.2	18.6	19.2	18.9	19.1	16.1	14.9	20.6	15.6
2.0	19.4	17.9	19.3	18.4	18.9	16.1	14.9	20.6	15.5
3.0	17.2	17.7	19.3	14.2	18.7	16.1	14.9	20.6	15.5
4.0	14.2	17.7	19.3	11.0	18.5	16.0	14.9	19.0	15.5
5.0	11.4	17.5	17.8	8.9	17.8	16.0	13.6	14.3	15.5
6.0	10.3	16.9	17.3	8.3	11.0	15.9	8.2	11.5	15.4
7.0	9.5	16.3	17.0	7.8	9.6	15.3	7.3	10.4	15.3
8.0		15.6	15.4	7.7	9.0	12.2	7.0	10.1	14.9
8.25		11.8							
9.0			13.3	7.6	8.5	9.4	6.7	9.8	14.4
10.0			10.9	7.5	8.4	8.6	6.6	9.5	10.6
11.0				7.4	8.3		6.4		
12.0				7.4			6.3		

Depth in m, Temperature in ^{o}C

Light

Depth	12 Jun 1996	24 Jul 1996	10 Jun 1997	23 Jul 1997	10 Sep 1997
0.02	0.755	0.845	0.793	0.787	0.715
1.0	0.402	0.435	0.455	0.402	0.366
2.0	0.222	0.28	0.167	0.182	0.177
3.0	0.124	0.163	0.066	0.091	0.095
4.0	0.07	0.111	0.051	0.044	0.054
5.0	0.041	0.056	0.025	0.02	0.03
6.0	0.024	0.039	0.011	0.011	0.017
7.0	0.013	0.027			0.01
8.0		0.021			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N88a

Dissolved Oxygen

Depth	12 Jun 1996	25 Jul 1996	08 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	8.9	9.14	8.63	10.23	8.68	9.44		9.49	8.64
0.1							9.68		
1.0	8.93	9.13	8.62	7.2	8.68	9.55	9.6	9.25	8.5
2.0	9.15	9.15	8.46	5.85	8.66	9.4	9.67	9.25	8.45
3.0	10.09	9.14	8.41	5.44	8.68	9.2	9.7	9.2	8.43
4.0	10.37	9.03	7.99	5.42	8.67	9.23	9.62	9.13	8.43
5.0	10.14	8.63	6.78	5.2	8.56	9.03	9.63	8.28	8.43
6.0	9.86	7.71	4.95	4.93	8.46	7.08	9.87	7.64	8.39
6.5					8.28				
7.0	9.84	7.41	4.25	4.78		5.93	9.6		6.0
8.0	9.93	7.29	3.93	4.66	8.26	5.44			2.47
9.0	9.88	6.92	3.3	4.54	8.19	5.19			0.0
10.0	9.8	6.41	2.85	4.47	8.11	4.65			
10.25		6.25							
11.0	9.77		0.11	4.31		3.71			

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	25 Jul 1996	08 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	20.9	19.0	18.2	18.5	18.7	16.0		19.5	14.6
0.1							15.5		
1.0	20.3	18.9	18.3	18.4	18.7	15.8	15.5	19.4	14.6
2.0	19.3	18.8	18.3	17.1	18.6	15.1	14.7	18.1	14.7
3.0	15.0	18.7	17.5	12.8	18.4	14.8	14.4	18.0	14.4
4.0	11.0	17.0	16.0	8.7	18.0	14.7	13.5	15.7	14.7
5.0	10.2	15.3	14.4	7.4	12.8	14.5	11.0	11.5	14.7
6.0	7.8	11.1	11.5	6.8	7.7	13.2	8.4	9.7	14.6
6.5					7.2				
7.0	7.7	8.5	9.8	6.5		8.9	7.7		13.2
8.0	7.5	8.1	9.2	6.3	7.2	8.1			9.7
9.0	7.4	7.7	8.5	6.2	7.1	7.8			9.5
10.0	7.1	7.5	8.3	6.1	6.9	7.6			
10.25		7.5							
11.0	7.0		8.2	6.1	6.8	7.4			

Depth in m, Temperature in ^oC

Light

Depth	12 Jun 1996	25 Jul 1996	22 Jul 1997	09 Sep 1997
0.02	0.745	0.781	0.688	0.651
1.0	0.25	0.302	0.299	0.213
2.0	0.1	0.126	0.114	0.07
3.0	0.042	0.052	0.048	0.028
4.0	0.016	0.024	0.021	0.012
5.0	0.006	0.01	0.008	

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N89a

Dissolved Oxygen

Depth	12 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	8.91	8.99	8.85	9.29	8.6	8.83		9.09	8.57
0.1							9.25		
1.0	8.96	9.02	8.85	9.06	8.57	9.46	9.18	8.81	8.59
2.0	9.46	9.08	8.87	9.16	8.58	10.15	9.21	8.79	8.6
3.0	10.45	9.08	8.83	10.71	8.59	9.67	9.19	8.69	8.6
4.0	11.44	8.9	8.61	11.17	8.6	9.46	9.25	9.4	8.59
5.0	11.16	8.75	8.59	10.88	8.54	8.89	9.35	9.78	8.59
6.0	10.8	8.6	8.34	10.15	8.15	8.79	9.44	8.26	8.59
6.5					7.75				
7.0	10.64	7.89	7.24	10.92		4.75	9.12	7.27	8.61
8.0	10.54	6.34	1.75	10.76	7.27	3.48	8.9	6.65	8.58
9.0	10.29	5.85	0.97	10.71	6.97	2.38	8.58	5.97	0.09
10.0	9.84	5.23	0.72		6.72	1.98	8.49	5.64	0.08
10.25		5.09							
11.0	9.6		0.6		6.68	1.62	8.42	5.34	0.06
12.0			0.54		6.55	1.26	8.24		
13.0			0.15		6.3		8.10		

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	20.6	18.6	19.5	18.1	18.2	15.8		21.4	14.8
0.1							15.0		
1.0	20.6	18.5	19.5	17.9	18.2	15.6	14.8	21.0	14.8
2.0	19.2	17.7	19.3	17.7	18.1	15.5	14.3	20.4	14.8
3.0	15.6	17.2	18.5	14.0	18.1	15.1	14.1	19.7	14.8
4.0	11.4	16.8	17.0	10.7	18.0	15.1	13.8	17.5	14.8
5.0	9.2	16.6	16.7	8.3	17.8	15.0	12.3	13.0	14.8
6.0	8.4	16.3	16.6	7.7	10.7	14.9	8.4	10.9	14.8
6.5					8.7				
7.0	8.3	14.1	16.2	7.4		12.3	7.2	10.0	14.8
8.0	8.1	9.4	12.1	7.2	8.2	9.6	6.9	9.7	14.8
9.0	7.9	8.7	9.9	7.0	7.8	8.6	6.7	9.2	10.5
10.0	7.7	8.4	9.4		7.7	8.3	6.6	9.1	9.7
10.25		8.4							
11.0	7.6		9.1		7.7	8.2	6.5	8.9	9.5
12.0			9.0		7.6	7.5	6.5		
13.0			8.8		7.6		6.5		

Depth in m, Temperature in ^oC

Light

Depth	12 Jun 1996	25 Jul 1996	05 Sep 1996	22 Jul 1997	09 Sep 1997
0.02	0.743	0.689	0.845	0.745	0.765
1.0	0.389	0.361	0.328	0.433	0.343
2.0	0.203	0.199	0.173	0.183	0.149
3.0	0.102	0.116	0.085	0.097	0.069
4.0	0.056	0.063	0.041	0.04	0.035
5.0	0.028	0.031	0.02	0.019	0.017
6.0	0.015	0.018	0.01	0.012	0.008
7.0	0.008	0.008			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N106a

Dissolved Oxygen

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	22 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	8.64	8.7	8.58	8.97	8.74	9.08		8.9	8.7
0.1							9.14		
1.0	8.64	8.69	8.58	9.0	8.75	9.4	8.85	8.82	8.45
2.0	8.92	8.69	8.57	9.72	8.77	9.38	8.5	8.79	8.5
3.0	10.05	8.63	8.51	10.36	8.77	9.07	8.65	8.78	8.45
4.0	10.21	8.5	8.2	10.1	8.12	9.13	8.46	8.35	8.5
5.0	10.1	8.28	7.83	9.84	6.3	8.97	8.0	7.57	8.5
6.0	9.8	7.53	7.3	9.57	6.61	7.72	7.33	7.2	8.1
7.0	9.61	6.34	5.74	9.45	6.55	3.65		6.68	7.7
8.0	9.32	6.25	3.81	9.18	6.26	3.08		6.28	6.9
9.0	9.15	6.02	2.7	9.12	5.46	1.26		5.81	0.2
10.0	8.8	4.28	0.11	9.04				4.45	
11.0	8.33	2.85	0.08	8.57				2.95	
12.0		0.08							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	22 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	20.3	17.2	18.3	18.0	18.5	15.2		19.2	14.1
0.1							13.4		
1.0	20.4	17.2	18.4	18.0	18.4	15.2	13.6	19.2	14.3
2.0	19.2	17.2	18.4	15.8	18.3	15.2	13.5	19.2	14.5
3.0	14.5	16.9	18.0	11.0	18.2	14.8	13.6	19.2	14.5
4.0	10.0	16.4	16.3	8.0	16.5	14.6	13.6	15.4	14.5
5.0	8.4	15.9	15.8	7.1	10.1	14.4	10.3	10.4	14.5
6.0	7.8	14.1	15.4	6.6	7.8	13.7	7.6	9.7	14.4
7.0	7.4	9.1	13.7	6.2	7.3	10.6		9.3	14.1
8.0	7.1	7.7	9.5	5.9	6.8	7.6		9.2	13.4
9.0	7.0	7.3	7.6	5.8	6.4	6.5		8.9	9.5
10.0	6.7	6.9	7.0	5.7				8.6	
11.0	6.6	6.7	6.6	5.6				8.4	
12.0	6.4	6.5							

Depth in m, Temperature in ^{o}C

Light

Depth	12 Jun 1996	24 Jul 1996	10 Jun 1997	22 Jul 1997	10 Sep 1997
0.02	0.65	0.61	0.634	0.713	0.554
1.0	0.223	0.22	0.201	0.225	0.169
2.0	0.089	0.083	0.074	0.083	0.062
3.0	0.037	0.032	0.027	0.035	0.022
4.0	0.015	0.013	0.009	0.014	0.006
5.0	0.006	0.006		0.007	

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N107a

Dissolved Oxygen

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	22 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	8.75	8.74	8.77	9.22	8.7	8.87		8.78	9.1
0.1							8.92		
1.0	8.78	8.73	8.8	9.13	8.8	9.12	8.92	8.78	8.9
2.0	9.59	8.75	8.8	9.92	8.83	9.35	8.9	8.78	8.85
3.0	10.68	8.64	8.68	11.1	8.8	9.43	8.96	8.8	8.76
4.0	10.54	8.56	8.54	10.93	8.51	9.31	9.4	9.90	8.74
5.0	10.31	8.47	7.54	11.06	9.54	8.99	9.04	9.57	8.53
6.0	10.13	8.31	6.78	10.88	9.65	8.05	8.78	9.03	8.1
7.0	10.02	8.32	6.59	10.47	9.84	8.13	8.62	8.37	6.6
8.0	9.9	8.25	6.23	10.51	9.74	8.17	8.58	7.97	4.44
9.0	9.64	8.26	6.8	10.63	9.68	8.42	8.64		5.05
10.0	9.59	8.18	6.47	10.34	9.66	8.23	8.64		5.1
11.0	9.58	8.13	6.69	10.57	9.65	8.13	8.54		5.1
12.0	9.52	8.09	6.68	10.63	9.61	7.94	8.54		5.02
13.0	9.48	7.98	6.67	10.5	9.55	7.78	8.54		4.6
14.0	9.45	7.96	6.4	10.47	9.59	7.7	8.41		0.0
15.0	9.35	7.8	6.19	10.57	9.56		8.31		
16.0		7.67	6.01	10.44	9.48		8.0		
17.0		7.61	5.89	10.58	9.4				
18.0		7.47	5.75	10.64	9.37				
19.0		7.44	5.55	10.44	9.15				
20.0		7.4	5.49	10.11	9.08				
21.0		7.32							
22.0		7.26							

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	24 Jul 1996	08 Sep 1996	10 Jun 1997	22 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	20.1	18.3	18.2	17.4	19.0	15.1		20.3	14.2
0.1							14.2		
1.0	20.1	18.4	18.3	17.3	18.7	15.1	14.5	20.3	14.5
2.0	17.6	18.3	18.3	16.0	18.5	15.1	14.6	20.3	14.5
3.0	12.2	17.4	17.6	11.1	17.4	15.0	13.3	20.2	14.4
4.0	9.1	16.2	17.1	8.1	15.6	14.4	10.6	12.2	14.4
5.0	6.9	10.2	13.7	6.7	8.3	13.9	8.1	9.5	14.2
6.0	6.5	7.4	9.1	6.3	6.9	9.7	6.9	8.2	14.1
7.0	6.2	6.6	7.4	5.7	6.6	7.0	6.0	7.5	12.4
8.0	6.0	6.4	6.9	5.6	6.3	6.5	5.9	7.3	9.4
9.0	5.7	6.2	6.6	5.4	6.1	6.2	5.6		7.9
10.0	5.6	5.9	6.3	5.3	5.9	6.1	5.5		7.5
11.0	5.6	5.8	6.1	5.2	5.7	5.8	5.4		6.4
12.0	5.6	5.7	5.9	5.2	5.6	5.8	5.3		6.0
13.0	5.5	5.6	5.8	5.1	5.5	5.7	5.3		5.5
14.0	5.4	5.4	5.7	5.1	5.4	5.6	5.2		5.3
15.0	5.3	5.4	5.6	5.1	5.3		5.2		
16.0	5.2	5.3	5.5	5.0	5.3		4.9		
17.0		5.3	5.5	5.0	5.2				
18.0		5.3	5.4	4.9	5.2				
19.0		5.2	5.4	4.9	5.1				
20.0		5.2	5.4	4.8	5.1				
21.0		5.2							
22.0		5.2							

Depth in m, Temperature in ^oC

Light

Depth	12 Jun 1996	24 Jul 1996	10 Jun 1997	22 Jul 1997	10 Sep 1997
0.02	0.629	0.76	0.793	0.582	0.643
1.0	0.204	0.189	0.236	0.187	0.177
2.0	0.075	0.065	0.079	0.065	0.054
3.0	0.032	0.022	0.03	0.021	0.013
4.0	0.013	0.008	0.011	0.007	
5.0	0.005		0.004		

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N120a

Dissolved Oxygen

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	9.84	8.78	8.46	9.6	8.48	8.94		8.8	0.0
0.1							9.16		
1.0	9.9	8.8	8.48	9.6	8.4	8.88	9.17	8.8	0.0
2.0	10.41	8.82	8.5	9.61	8.39	8.58	9.16	8.81	0.0
3.0	10.92	8.85	8.53	10.7	8.38	8.23	9.17	8.87	0.0
4.0	12.25	8.88	8.44	11.15	8.37	7.77	9.17	9.0	0.0
5.0	12.32	8.86	8.37	10.79	8.41	7.29	9.41	10.35	0.0
6.0	11.89	8.75	8.15	10.29	9.51	6.97	9.45	9.2	0.0
7.0	11.41	8.23	6.97	10.07	8.49	6.51	8.92	7.98	
8.0	10.92	6.1	1.86	9.96	7.66	4.16	7.95	6.43	
9.0	10.84	4.25	0.29	9.77	7.04	2.96	7.44	5.86	
10.0		3.91	0.13	9.58	6.6	2.06		4.64	
11.0		0.12	0.1	9.56	5.67				

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	17.6	17.8	18.2	15.7	17.1	14.6		19.4	0.0
0.1							12.7		
1.0	17.1	17.7	18.1	15.7	17.1	14.6	12.7	19.4	0.0
2.0	15.7	17.6	18.1	15.7	17.1	14.6	12.7	19.4	0.0
3.0	14.3	17.1	17.5	14.1	17.1	14.6	12.7	19.1	0.0
4.0	12.4	16.5	16.7	10.0	17.1	14.6	12.7	18.3	0.0
5.0	9.5	16.1	16.4	7.7	17.2	14.5	11.6	13.0	0.0
6.0	8.3	15.4	16.2	7.1	10.2	14.5	8.5	11.3	0.0
7.0	7.8	13.0	15.1	6.5	8.5	14.3	7.2	10.2	
8.0	7.5	9.7	11.5	6.4	7.8	9.6	6.6	9.6	
9.0	7.5	8.6	9.9	6.3	7.3	8.4	6.4	9.4	
10.0		8.5	9.4	6.2	7.1	7.9		9.2	
11.0		8.4	9.4	6.2	7.0				

Depth in m, Temperature in ^oC

Light

Depth	10 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997
0.02	0.84	0.545	0.804	0.668	0.708	0.606
1.0	0.475	0.3	0.444	0.268	0.304	0.327
2.0	0.25	0.163	0.264	0.137	0.167	0.17
3.0	0.141	0.104	0.139	0.065	0.088	0.09
4.0	0.032	0.06	0.079	0.03	0.047	0.05
5.0	0.025	0.037	0.049	0.013	0.028	0.03
6.0	0.019	0.021	0.028	0.007	0.018	0.017
7.0	0.015	0.013	0.016		0.009	0.01
8.0	0.007	0.007	0.009			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake N122a

Dissolved Oxygen

Depth	12 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	8.42	8.73	8.78	9.25	8.22	9.11		7.94	8.92
0.1							8.88		
1.0	8.34	8.73	8.78	9.28	8.16	9.36	8.83	7.9	8.92
2.0	10.47	8.85	9.27	9.43	8.14	9.55	8.84	8.02	8.93
3.0	11.98	8.67	9.3	11.35	8.04	9.4	8.71	8.15	8.92
4.0	11.21	8.33	8.81	10.91	7.65	9.16	8.17	8.15	8.80
5.0	10.08	7.13	7.07	10.55	6.94	8.73	6.3	7.19	8.4
6.0	8.98	6.39	3.43	10.38	7.2		4.93	6.45	3.3
6.5					6.91				
7.0	6.55	4.93	1.94	10.13			3.42	3.0	0.67
8.0	6.02	4.02	1.04	10.05			2.58	2.21	0.09
8.25		3.55							
9.0	5.81			9.83				1.88	0.06
10.0	5.59			9.66					

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	12 Jun 1996	25 Jul 1996	05 Sep 1996	11 Jun 1997	22 Jul 1997	09 Sep 1997	27 May 1998	15 Jul 1998	17 Sep 1998
0.02	22.2	19.5	19.9	17.8	17.5	15.7		21.9	14.4
0.1							14.3		
1.0	22.1	19.3	19.9	17.7	17.2	15.6	14.1	21.8	14.4
2.0	16.8	18.0	17.4	16.5	17.1	15.3	13.8	21.0	14.3
3.0	11.5	16.8	16.7	11.4	17.0	14.8	13.4	16.9	14.3
4.0	9.4	15.8	16.0	7.9	16.6	14.8	12.4	12.0	14.3
5.0	8.2	12.1	15.0	7.1	9.5	14.6	7.8	10.4	14.1
6.0	7.2	8.5	9.7	6.4	7.9		5.9	8.5	12.2
6.5					6.9				
7.0	6.0	7.2	7.9	6.1			5.3	7.1	8.7
8.0	5.8	6.7	7.3	5.8			5.0	6.8	7.5
8.25		6.4							
9.0	5.7			5.7				6.6	7.1
10.0	5.7			5.5					

Depth in m, Temperature in ^oC

Light

Depth	12 Jun 1996	25 Jul 1996	05 Sep 1996	22 Jul 1997	09 Sep 1997
0.02	0.724	0.81	0.248	0.74	0.649
1.0	0.246	0.25	0.083	0.236	0.184
2.0	0.079	0.103	0.034	0.082	0.046
3.0	0.041	0.041	0.016	0.029	0.022
4.0	0.018	0.015	0.007	0.011	0.009
5.0	0.006	0.007			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake P25a

Dissolved Oxygen

Depth	13 Jun 1996	24 Jul 1996	09 Sep 1996	13 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	8.24	8.9	8.38	8.6	8.63	8.83		8.39	8.48
0.1							9.42		
1.0	8.26	8.94	8.34	8.8	8.81	9.14	9.43	8.52	8.5
2.0	9.66	8.93	8.31	10.78	8.75	9.28	9.45	8.54	8.55
3.0	11.08	8.93	8.27	12.18	8.88	9.03	9.46	8.63	8.45
4.0	10.76	8.59	7.67	10.79	9.27	8.98	9.45	9.22	8.4
5.0	8.23	7.88	5.58	10.33	7.03	7.79	9.32	6.95	8.2
6.0	6.87	5.26	0.35	10.24	6.12	2.26	8.38	4.85	7.4
7.0	6.36	3.29	0.08	9.76	5.88	2.31	8.23	4.06	0.38
8.0	6.25	2.95	0.08	9.56	5.83	2.13	8.02	3.62	0.1
9.0	5.7	2.32	0.06	8.45	5.07	1.6	7.46	3.11	0.07
9.5			0.06						
10.0				7.07	3.61	0.31	7.13		0.06

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	13 Jun 1996	24 Jul 1996	09 Sep 1996	13 Jun 1997	23 Jul 1997	10 Sep 1997	26 May 1998	14 Jul 1998	16 Sep 1998
0.02	22.1	18.2	19.1	19.9	21.5	16.3		21.1	16.5
0.1							16.0		
1.0	22.1	18.0	19.1	19.9	19.9	16.1	16.0	20.6	16.6
2.0	18.0	17.8	19.1	17.3	19.4	16.0	15.9	19.9	16.4
3.0	15.0	16.9	19.1	12.3	18.7	15.7	15.8	19.4	15.8
4.0	10.6	16.6	17.7	8.5	14.6	15.5	14.9	15.6	15.7
5.0	9.1	16.1	16.9	7.7	10.6	15.0	8.3	11.6	15.6
6.0	7.4	13.0	14.0	7.2	8.4	10.6	6.9	9.6	15.1
7.0	6.8	8.1	10.9	6.9	7.6	8.4	6.3	8.2	12.2
8.0	6.4	7.3	8.5	6.8	7.2	7.7	6.0	7.6	8.5
9.0	6.1	6.6	7.7	6.6	6.8	7.4	5.5	7.2	7.7
9.5			7.1						
10.0				6.5	6.6	6.9	5.3		7.1

Depth in m, Temperature in ^oC

Light

Depth	13 Jun 1996	24 Jul 1996	13 Jun 1997	23 Jul 1997	10 Sep 1997
0.02	0.645	0.825	0.632	0.816	0.704
1.0	0.265	0.395	0.198	0.36	0.251
2.0	0.128	0.165	0.075	0.133	0.104
3.0	0.059	0.09	0.031	0.058	0.047
4.0	0.026	0.089	0.011	0.027	0.022
5.0	0.011			0.011	0.009
6.0	0.005				

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake P109a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	8.42	8.42	9.32	8.56	8.23	8.7		8.40	9.65
0.1							8.82		
1.0	8.45	8.41	8.31	8.64	8.18	8.84	8.81	8.5	9.57
2.0	9.03	8.32	8.27	9.24	8.06	8.65	8.8	8.51	9.52
3.0	9.33	8.29	8.44	10.66	7.96	8.25	8.7	8.44	9.42
4.0	9.8	8.18	8.04	10.86	7.35	7.63	8.65	8.17	9.31
5.0	9.27	6.57	7.24	10.32	7.02	6.92	8.98	8.07	9.14
6.0	8.79	5.37	2.41	10.19	6.7	4.35	8.73	7.7	5.7
7.0	8.48	3.73	0.64	10.08	5.9	3.05	8.21	5.42	0.77
7.5		3.13							
8.0	7.57		0.12		5.86	1.86	7.65	4.23	0.14
9.0	6.05		0.09		4.88	0.72	7.52	3.17	
9.5						0.52			
10.0	5.58		0.08						

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	21.7	18.6	20.2	19.7	17.9	15.0		21.5	15.9
0.1							16.2		
1.0	21.4	18.6	20.3	19.7	17.8	15.0	16.2	21.4	15.7
2.0	18.4	18.5	20.1	17.4	17.8	15.0	16.1	21.0	15.6
3.0	15.9	18.2	18.9	11.9	17.7	14.9	15.6	19.2	15.4
4.0	10.9	17.7	17.2	9.3	16.5	14.9	12.3	12.8	15.3
5.0	10.1	15.2	16.5	8.0	9.9	14.6	7.4	10.4	15.1
6.0	9.3	10.4	13.1	7.2	8.2	11.3	6.4	9.4	13.2
7.0	9.0	9.0	9.9	7.2	7.4	8.4	5.9	8.2	8.7
7.5		8.9							
8.0	8.5		8.9		7.2	7.5	5.8	7.7	8.2
9.0	8.2		8.5		7.0	7.2	5.8	7.5	
9.5						7.2			
10.0	8.0		8.3						

Depth in m, Temperature in ^{o}C

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.749	0.676	0.69	0.812	0.656	0.646
1.0	0.222	0.18	0.25	0.22	0.155	0.224
2.0	0.086	0.058	0.101	0.077	0.043	0.09
3.0	0.031	0.021	0.039	0.027	0.008	0.036
4.0	0.01	0.007	0.015	0.009		0.014
5.0	0.003		0.006			0.009

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Profile Data by Date For Study Lake P110a

Dissolved Oxygen

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	8.9	8.51	8.4	9.34	8.29	8.9		9.13	9.04
0.1							9.62		
1.0	8.99	8.48	8.39	9.48	8.31	8.08	9.61	9.04	8.93
2.0	9.57	8.47	8.39	10.39	8.34	8.94	9.0	9.01	9.02
3.0	9.95	8.46	8.39	11.69	8.41	9.54	8.14	8.93	8.98
4.0	11.22	8.39	8.22	11.78	8.51	9.2	7.95	8.84	8.98
5.0	10.85	8.36	7.88	11.3	8.3	8.48	7.9	7.1	8.7
6.0	9.66	8.2	6.96	10.9	5.37	9.13	7.61	5.58	8.4
6.5		8.0							
7.0			5.28	10.47		9.06	7.18	4.17	2.0
8.0			3.28			8.18			
9.0						1.3			
9.5						0.79			

Depth in m, [DO] in $mg \cdot l^{-1}$

Temperature

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997	25 May 1998	13 Jul 1998	14 Sep 1998
0.02	20.2	18.2	19.2	18.9	17.4	15.0		20.6	15.7
0.1							16.1		
1.0	20.0	18.2	19.3	18.8	17.5	15.1	16.1	20.6	15.5
2.0	17.8	18.2	19.3	16.4	17.5	15.1	15.8	20.5	15.5
3.0	16.5	18.2	19.2	14.7	17.5	15.0	15.2	20.5	15.5
4.0	12.7	18.1	17.8	10.0	17.5	15.1	15.1	17.7	15.5
5.0	10.4	17.8	17.3	8.4	17.3	15.1	14.0	12.7	15.4
6.0	9.9	17.6	16.9	7.6	11.5	15.1	9.0	11.0	15.1
6.5		16.7							
7.0			16.2	7.4		15.1	8.4	10.4	15.1
8.0			15.2			15.0			
9.0						12.0			
9.5						10.0			

Depth in m, Temperature in ^oC

Light

Depth	11 Jun 1996	22 Jul 1996	07 Sep 1996	09 Jun 1997	21 Jul 1997	08 Sep 1997
0.02	0.74	0.72	0.675	0.665	0.651	0.564
1.0	0.297	0.28	0.313	0.249	0.253	0.219
2.0	0.141	0.113	0.15	0.098	0.107	0.092
3.0	0.062	0.056	0.076	0.043	0.046	0.044
4.0	0.028	0.019	0.037	0.019	0.02	0.02
5.0	0.011	0.008	0.016	0.008	0.009	0.012
6.0	0.003		0.006			

Depth in m, Light in $\frac{I_{Depth}}{I_{Surface}}$

Appendix 2

1% and 0.1% Light Levels and Hypolimnion Depths Throughout Sampling Campaign (1996 – 98)

Lake	Year	Sampling dates for each sortie 1	2	3	1% Light Level Depth 1	2	3	AVG	0.1% Light Level Depth 1	2	3	AVG	Hypolimnion Depth 1	2	3	AVG
C2a	1996	13-Jun-96	24-Jul-96		2.43	1.72		2.08	2.47	1.75		2.11	4.5	5.5	6.5	5.50
C2a	1997	13-Jun-97	23-Jul-97	10-Sep-97	2.42	1.78	1.75	1.98	2.47	1.82	1.78	2.02	3.5	6.5	6.5	5.50
C2a	1998	26-May-98	14-Jul-98	16-Sep-98	2.46	2.43	1.79	2.23	2.50	2.48	1.82	2.27	4.5	4.5	7.5	5.50
C9b	1996	13-Jun-96	23-Jul-96		3.94	3.18		3.56	4.01	3.24		3.63	5.5	6.5	7.5	6.50
C9b	1997	13-Jun-97	23-Jul-97		2.55	2.52		2.54	2.60	2.57		2.59	4.5	5.5	7.0	5.67
C9b	1998	29-May-98	17-Jul-98	19-Sep-98	2.55	3.26	3.28	3.03	2.59	3.33	3.33	3.08	4.5	6.5	7.5	6.17
C23a	1996	11-Jun-96	22-Jul-96	07-Sep-96	2.35	1.69	1.68	1.91	2.39	1.72	1.72	1.94	4.5		2.5	3.50
C23a	1998	25-May-98	13-Jul-98	14-Sep-98	1.70	1.68	1.70	1.69	1.73	1.72	1.72	1.73	4.5	4.5		4.50
C24a	1996	11-Jun-96	22-Jul-96	07-Sep-96	2.37	1.69	1.68	1.91	2.41	1.72	1.71	1.95	3.5	4.5	5.5	4.50
C24a	1997	09-Jun-97	21-Jul-97	08-Sep-97	1.72	1.72	1.69	1.71	1.75	1.75	1.74	1.74	2.5	5.5	6.5	4.83
C24a	1998	25-May-98	13-Jul-98	14-Sep-98	1.71	1.71	1.70	1.71	1.74	1.75	1.73	1.74	3.5	3.5	6.5	4.50
C29a	1996	10-Jun-96	25-Jul-96	05-Sep-96	*6.22*	4.98	6.25	5.81	*6.32*	5.08	6.35	5.92	*5.5*	7.5	8.5	7.17
C29a	1998	27-May-98	15-Jul-98	17-Sep-98	4.83	4.79	4.22	4.61	4.93	4.88	4.28	4.70	6.5	6.5		6.50
C40a	1996	11-Jun-96	22-Jul-96	07-Sep-96	3.95	4.03	3.89	3.96	4.02	4.10	3.96	4.03	6.5	7.5	6.5	6.83
C40a	1997	09-Jun-97	21-Jul-97	08-Sep-97	*3.96*	3.90	3.31	3.72	*4.03*	3.97	3.37	3.79	*3.5*	5.5	6.5	5.17
C40a	1998	25-May-98	13-Jul-98	14-Sep-98	3.40	4.00	4.04	3.81	3.46	4.07	4.11	3.88	4.5	7.5	7.5	6.50
C44a	1996	13-Jun-96	23-Jul-96	06-Sep-96	6.17	4.74	4.67	5.20	6.29	4.83	4.76	5.29	7.5	6.5	7.5	7.17
C44a	1997	12-Jun-97	25-Jul-97		4.84	4.74		4.79	4.93	4.82		4.87	5.5	7.5	8.5	7.17
C44a	1998	29-May-98	17-Jul-98	19-Sep-98	4.16	3.39	4.07	3.87	4.23	3.45	4.14	3.94	5.5	7.5	9.5	7.50
C48b	1996	10-Jun-96	25-Jul-96	05-Sep-96	3.12	2.47	3.22	2.94	3.18	2.52	3.28	2.99	6.5	11.5	2.5	6.83
C48b	1997	22-Jul-97	09-Sep-97		2.50	2.43		2.46	2.55	2.48		2.52	5.5	6.5		6.00
FBP9b	1997	10-Jun-97	23-Jul-97	10-Sep-97	2.45	2.43	1.80	2.23	2.49	2.47	1.83	2.27	4.5	5.5	6.5	5.50
FBP9b	1998	26-May-98	14-Jul-98	16-Sep-98	2.42	1.76	1.75	1.98	2.48	1.79	1.78	2.02	6.5	5.5	10.5	7.50
FBP10a	1996	10-Jun-96	25-Jul-96		*6.99*	4.76		5.88	*7.10*	4.85		5.97	*6.5*	8.5	9.5	8.17
FBP10a	1997	23-Jul-97	09-Sep-97		4.74	4.20		4.47	4.82	4.30		4.56	5.5	6.5	9.5	7.17
FBP10a	1998	27-May-98	15-Jul-98	17-Sep-98	*5.54*	4.83	4.86	5.08	*5.64*	4.92	4.96	5.17	*5.5*	6.5	9.5	7.17
FP2a	1996	09-Jun-96	26-Jul-96	06-Sep-96	3.07	2.41	1.74	2.41	3.13	2.47	1.76	2.45	5.5	5.5	6.5	5.83
FP2a	1997	12-Jun-97	24-Jul-97	11-Sep-97	1.72	1.67	1.04	1.48	1.75	1.71	1.06	1.51	4.5	5.5	6.5	5.50
FP2a	1998	28-May-98	16-Jul-98	18-Sep-98	1.68	1.67	1.03	1.46	1.71	1.71	1.04	1.49	5.5	4.5	7.5	5.83
FP15b	1996	09-Jun-96	26-Jul-96	06-Sep-96	3.79	2.46	3.15	3.13	3.86	2.51	3.21	3.19	6.5	7.5	7.5	7.17
FP15b	1997	12-Jun-97	24-Jul-97		2.47	2.43		2.45	2.52	2.47		2.50	4.5	5.5	6.5	5.50
FP15b	1998	16-Jul-98	18-Sep-98		1.76	1.75		1.76	1.80	1.78		1.79	7.5	7.5		7.50
FP24a	1996	13-Jun-96	23-Jul-96	07-Sep-96	4.69	4.03	6.09	4.94	4.78	4.11	6.24	5.04	5.5	6.5	7.5	6.50
FP24a	1997	13-Jun-97	23-Jul-97		3.84	3.28		3.56	3.91	3.34		3.63	4.5	6.5	6.5	5.83
FP24a	1998	29-May-98	17-Jul-98	18-Sep-98	2.56	3.22	2.55	2.78	2.60	3.28	2.60	2.83	4.5	5.5	6.5	5.50
FP27a	1996	09-Jun-96	26-Jul-96	06-Sep-96	*5.57*	*7.80*	7.78	7.05	*5.64*	*7.93*	7.92	7.17	*5.5*	*7.5*	10.5	7.83
FP27a	1997	12-Jun-97	24-Jul-97		*6.39*	7.22		6.80	6.50	7.34		6.92	*5.5*	7.5	9.5	7.50
FP27a	1998	28-May-98	16-Jul-98	18-Sep-98	4.30	6.39	7.08	5.92	4.36	6.50	7.25	6.04	5.5	8.5	8.5	7.50
FP30a	1998	28-May-98	16-Jul-98	18-Sep-98	2.45	2.46	1.77	2.23	2.49	2.50	1.80	2.26	7.5	8.5	7.5	7.83
FP30a	1996	09-Jun-96	26-Jul-96	06-Sep-96	3.21	3.18	3.20	3.20	3.26	3.25	3.25	3.25	4.5	5.5	8.5	6.17
FP30a	1997	12-Jun-97	24-Jul-97		3.24	2.54		2.89	3.29	2.60		2.95	5.5	4.5	7.5	5.83

Italicized hypolimnetic depths indicate the instances where the hypolimnion depth is shallower than the 1% or 0.1% light depths

Continued on next page.

Lake	Year	Sampling dates for each sortie			1% Light Level Depth				0.1% Light Level Depth				Hypolimnion Depth			
		1	2	3	1	2	3	AVG	1	2	3	AVG	1	2	3	AVG
FP32a	1996	09-Jun-96	23-Jul-96		3.89	3.18		3.54	3.95	3.23		3.59	6.5	6.5	7.5	6.83
FP32a	1997	13-Jun-97	24-Jul-97		3.15	2.46		2.80	3.20	2.50		2.85	4.5	5.5	6.5	5.50
FP32a	1998	28-May-98	17-Jul-98	18-Sep-98	2.42	1.79	1.74	1.98	2.46	1.82	1.77	2.02	5.5	8.5	7.5	7.17
N5a	1996	13-Jun-96	23-Jul-96		3.22	2.47		2.85	3.29	2.51		2.90	5.5	6.5	6.5	6.17
N5a	1997	13-Jun-97	24-Jul-97		3.24	2.52		2.88	3.30	2.57		2.94	4.5	6.0	6.5	5.67
N5a	1998	29-May-98	17-Jul-98		2.58	2.55		2.57	2.62	2.59		2.61	4.5	6.5		5.50
N16a	1996	13-Jun-96	23-Jul-96		4.73	4.65		4.69	4.82	4.74		4.78	7.5	7.5	8.5	7.83
N16a	1997	13-Jun-97	25-Jul-97		*3.96*	2.62		3.29	*4.06*	2.69		3.37	*3.5*	7.5	7.0	6.00
N35a	1997	12-Jun-97	25-Jul-97		3.27	3.25		3.26	3.33	3.31		3.32	5.5	5.5	6.5	5.83
N43a	1996	10-Jun-96	25-Jul-96	05-Sep-96	3.07	2.40	2.43	2.64	3.13	2.44	2.48	2.68	4.5	8.5	6.5	6.50
N43a	1997	22-Jul-97	09-Sep-97		2.37	1.75		2.06	2.43	1.79		2.11	3.5	6.0	7.5	5.67
N43a	1998	27-May-98	15-Jul-98	17-Sep-98	2.43	1.81	1.78	2.00	2.47	1.84	1.80	2.04	5.5	4.5	6.5	5.50
N56a	1996	11-Jun-96	22-Jul-96	07-Sep-96	3.97	3.95	3.98	3.97	4.04	4.04	4.06	4.05	5.5	6.5	7.5	6.50
N59a	1996	09-Jun-96	26-Jul-96	06-Sep-96	5.50	4.72	4.68	4.97	5.60	4.81	4.78	5.06	6.5	6.5	7.5	6.83
N59a	1997	12-Jun-97	21-Jul-97	11-Sep-97	4.74	4.11	3.38	4.08	4.84	4.18	3.45	4.16	5.5	7.5	7.5	6.83
N59a	1998	28-May-98	16-Jul-98	18-Sep-98	*4.77*	4.78	4.87	4.81	*4.89*	4.86	4.96	4.90	*4.5*	7.5	7.5	6.50
N63a	1996	09-Jun-96	26-Jul-96	06-Sep-96	*4.79*	4.67	4.69	4.72	*4.87*	4.76	4.78	4.80	*4.5*	8.5	9.5	7.50
N63a	1997	12-Jun-97	24-Jul-97	11-Sep-97	3.24	2.56	4.37	3.39	3.30	2.63	4.45	3.46	3.5	6.0		4.75
N63a	1998	28-May-98	16-Jul-98	18-Sep-98	3.92	3.31	3.36	3.53	4.00	3.37	3.41	3.59	5.5	4.5		5.00
N70a	1996	11-Jun-96	22-Jul-96	07-Sep-96	5.02	4.61	4.71	4.78	5.19	4.70	4.79	4.89	9.5	7.5	8.5	8.50
N70a	1997	09-Jun-97	21-Jul-97	08-Sep-97	*3.96*	4.01	3.31	3.76	*4.03*	4.08	3.38	3.83	*3.5*	6.5	7.5	5.83
N70a	1998	25-May-98	13-Jul-98	14-Sep-98	3.28	3.32	3.99	3.53	3.34	3.39	4.07	3.60	6.5	6.5	9.5	7.50
N82a	1996	12-Jun-96	24-Jul-96		4.68	5.38		5.03	4.77	5.49		5.13	5.5	5.5	7.5	6.17
N82a	1997	10-Jun-97	23-Jul-97	10-Sep-97	*4.69*	4.08	4.12	4.30	*4.77*	4.15	4.20	4.37	*4.5*	6.5	7.5	6.17
N82a	1998	26-May-98	14-Jul-98	16-Sep-98	4.77	4.76	4.87	4.80	4.85	4.84	4.95	4.88	5.5	6.5	6.5	6.17
N84b	1997	10-Jun-97	23-Jul-97	10-Sep-97	*4.81*	4.82	5.53	5.05	*4.88*	4.90	5.64	5.14	*4.5*	6.5	8.5	6.50
N84b	1998	26-May-98	14-Jul-98	16-Sep-98	5.68	5.53	6.36	5.86	5.77	5.64	6.47	5.96	5.5	6.5	9.5	7.17
N88a	1996	12-Jun-96	25-Jul-96		3.94	4.01		3.98	4.01	4.08		4.05	5.5	6.5	6.5	6.17
N88a	1997	22-Jul-97	09-Sep-97		4.02	3.26		3.64	4.09	3.33		3.71	4.5	6.0	6.5	5.67
N88a	1998	27-May-98	15-Jul-98	17-Sep-98	3.95	3.26	3.24	3.48	4.03	3.31	3.31	3.55	5.5	5.5	7.5	6.17
N89a	1996	12-Jun-96	25-Jul-96	05-Sep-96	*5.53*	5.60	4.76	5.30	*5.63*	5.70	4.84	5.39	*4.5*	7.5	8.5	6.83
N89a	1997	22-Jul-97	09-Sep-97		*4.84*	4.74		4.79	*4.92*	4.82		4.87	*4.5*	6.0	8.5	6.33
N89a	1998	27-May-98	15-Jul-98	17-Sep-98	4.91	5.53	4.83	5.09	4.99	5.63	4.96	5.19	6.5	5.5	8.5	6.83
N106a	1996	12-Jun-96	24-Jul-96		3.94	3.93		3.94	4.02	4.02		4.02	4.5	7.5	8.5	6.83
N106a	1997	10-Jun-97	22-Jul-97	10-Sep-97	3.26	3.91	3.23	3.47	3.32	3.99	3.30	3.54	3.5	5.5	8.5	5.83
N106a	1998	26-May-98	14-Jul-98	16-Sep-98	3.25	3.24	3.29	3.26	3.31	3.30	3.36	3.33	5.5	4.5	8.5	6.17
N107a	1996	12-Jun-96	24-Jul-96		3.90	3.19		3.55	3.99	3.25		3.62	4.5	5.5	6.5	5.50
N107a	1997	10-Jun-97	22-Jul-97	10-Sep-97	3.87	3.24	2.55	3.22	3.94	3.30	2.60	3.28	4.5	5.5	6.5	5.50
N107a	1998	26-May-98	14-Jul-98	16-Sep-98	3.29	3.23	1.75	2.76	3.36	3.29	1.78	2.81	5.5	5.5	10.5	7.17
N120a	1996	10-Jun-96	25-Jul-96	05-Sep-96	*6.16*	6.30	6.31	6.26	*6.26*	6.46	6.42	6.38	*5.5*	8.5	8.5	7.50
N120a	1997	11-Jun-97	22-Jul-97	09-Sep-97	*4.72*	5.50	5.57	5.26	*4.82*	5.61	5.70	5.37	*4.5*	6.5	8.5	6.50

Italicized hypolimnetic depths indicate the instances where the hypolimnion depth is shallower than the 1% or 0.1% light depths

Continued on next page.

Lake	Year	Sampling dates for each sortie			1% Light Level Depth				0.1% Light Level Depth				Hypolimnion Depth			
		1	2	3	1	2	3	AVG	1	2	3	AVG	1	2	3	AVG
N120a	1998	27-May-98	15-Jul-98	17-Sep-98	5.59	4.90	5.04	5.18	5.74	5.00	5.12	5.29	6.5	6.5		6.50
N122a	1996	12-Jun-96	25-Jul-96	05-Sep-96	3.93	3.92	3.23	3.70	4.00	3.99	3.40	3.80	6.5	7.75	6.5	6.92
N122a	1998	27-May-98	15-Jul-98	17-Sep-98	3.94	3.94	3.28	3.72	4.01	4.01	3.35	3.79	5.5	6.5	7.5	6.50
P25a	1996	13-Jun-96	24-Jul-96		4.69	3.70		4.20	4.79	3.75		4.27	5.5	6.5	9.0	7.00
P25a	1997	13-Jun-97	23-Jul-97	10-Sep-97	3.28	4.04	3.99	3.77	3.34	4.10	4.07	3.84	3.5	5.5	6.5	5.17
P25a	1998	26-May-98	14-Jul-98	16-Sep-98	4.03	3.35	4.07	3.82	4.10	3.42	4.14	3.89	5.5	6.5	7.5	6.50
P109a	1996	11-Jun-96	22-Jul-96	07-Sep-96	*3.88*	3.19	3.95	3.67	*3.95*	3.25	4.03	3.74	*3.5*	6.5	7.5	5.83
P109a	1997	09-Jun-97	21-Jul-97	08-Sep-97	3.22	2.50	3.95	3.22	3.27	2.54	4.03	3.28	4.5	5.5	6.5	5.50
P109a	1998	25-May-98	13-Jul-98	14-Sep-98	3.23	3.24	3.94	3.47	3.29	3.30	4.01	3.53	5.5	6.5	6.5	6.17
P110a	1997	09-Jun-97	21-Jul-97	08-Sep-97	3.98	4.01	4.03	4.01	4.06	4.09	4.12	4.09	4.5	5.5	9.0	6.33
P110a	1998	25-May-98	13-Jul-98	14-Sep-98	2.61	4.81	3.97	3.80	2.66	4.89	4.03	3.86	5.5	5.5		5.50

Italicized hypolimnetic depths indicate the instances where the hypolimnion depth is shallower than the 1% or 0.1% light depths

Appendix 3

Structured Query Language (SQL) Queries

The following Structured Query Language (SQL) queries were used with the PostGreSQL relational database management system to work up all but the nutrient export data used in this project; This approach ensures that the actual steps taken to work up the data can be reviewed for accuracy in a logical, straightforward manner. Also, these techniques scale well to very large datasets – this code would work without modification on a dataset ten times as large.

Appendix 3: Data Preparation Code (SQL)

```
/* ***************************************************************
   *    MSC THESIS DATABASE - PETER DOUGLAS ST. ONGE - (c) 2000    *
   ***************************************************************
   TABLE w/ DESCRIPTION

/*

/* START with a crosstab with dissox_prof where boolIsHypol = true and */
/*  dissox >= 4,  create field type (character)                        */
/*   update type with treatment_type (cut, burned, reference)          */
/*   LY, depth, pivot sortie                                           */
/* Do it the hard way.                                                  */
/* Start by building the distinct table of lake-depths and LY-depths   */
/* Then create the temporary dissox, temp profile tables with said     */
/* oids then do the two queries (results and nulls) for each level     */
/* try to add julian dates as you go, saves 3 queries                  */

/* 1623 rows */
CREATE TABLE msc_key_dissox_strat AS
             SELECT DISTINCT lake_id, lakename, year, depth
             FROM dissox_prof
            WHERE lakename NOT LIKE 'NL-LTER%'
              AND lakename NOT LIKE 'ELA%'
;

/* 622 */
CREATE TABLE msc_key_dissox_year AS
             SELECT DISTINCT lake_id, lakename, depth
             FROM dissox_prof
            WHERE lakename NOT LIKE 'NL-LTER%'
              AND lakename NOT LIKE 'ELA%'
;

/* now create indexes for same                                          */
CREATE INDEX msc_key_dissox_strat_index
          ON msc_key_dissox_strat (lake_id, year, depth)
;

CREATE INDEX msc_key_dissox_year_index
          ON msc_key_dissox_year (lake_id, depth)
;

/* 1837 */
/* now create temporary dissox and temp tables and indexes             */
CREATE  TABLE ms:_temp_dissox_prof AS
       SELECT dissox_prof.lake_id,
              dissox_prof.lakename,
              dissox_prof.smpldate,
              dissox_prof.smpltime,
              dissox_prof.julianday,
              dissox_prof.year,
              dissox_prof.month,
              dissox_prof.sortie,
              dissox_prof.depth,
              dissox_prof.dissox,
              dissox_prof.boolishypol,
              msc_key_dissox_strat.oid AS lyd
        WHERE
              dissox_prof.sortie < 4
          AND
              int2(dissox_prof.boolishypol) = 1
          AND
              dissox_prof.lakename NOT LIKE 'NL-LTER%'
          AND
              dissox_prof.lakename NOT LIKE 'ELA%'
          AND
              dissox_prof.lake_id = msc_key_dissox_strat.lake_id
          AND
              dissox_prof.year = msc_key_dissox_strat.year
          AND
              dissox_prof.depth = msc_key_dissox_strat.depth
;

CREATE INDEX msc_temp_dissox_prof_index ON msc_temp_dissox_prof (lyd)
;

/* 1855 ... should this be kds_oid */
CREATE TABLE msc_temp_temp_prof AS
      SELECT temperature_prof.lake_id,
             temperature_prof.lakename,
             temperature_prof.smpldate,
             temperature_prof.smpltime,
             temperature_prof.julianday,
             temperature_prof.year,
             temperature_prof.month,
             temperature_prof.sortie,
             temperature_prof.depth,
             temperature_prof.temperature,
             temperature_prof.boolishypol,
             msc_key_dissox_strat.oid AS lyd
        FROM temperature_prof, msc_key_dissox_strat
       WHERE
             temperature_prof.sortie < 4
         AND
             int2(temperature_prof.boolishypol) = 1
         AND
             temperature_prof.lakename NOT LIKE 'NL-LTER%'
         AND
             temperature_prof.lakename NOT LIKE 'ELA%'
         AND
             temperature_prof.lake_id = msc_key_dissox_strat.lake_id
         AND
             temperature_prof.year = msc_key_dissox_strat.year
         AND
             temperature_prof.depth = msc_key_dissox_strat.depth
;

CREATE INDEX msc_temp_temp_prof_index ON msc_temp_temp_prof (lyd)
;


/* now is time to start with building columns                           */
/* 695 */
CREATE TABLE msc_key_dissox_prof_1 AS
      SELECT msc_key_dissox_strat.lake_id,
             msc_key_dissox_strat.lakename,
             msc_key_dissox_strat.year,
             msc_key_dissox_strat.depth,
             msc_key_dissox_strat.oid AS kds_oid,
             msc_temp_dissox_prof.dissox AS dissox1,
             msc_temp_dissox_prof.julianday AS julian1
        FROM msc_key_dissox_strat, msc_temp_dissox_prof
       WHERE
             msc_temp_dissox_prof.lyd = msc_key_dissox_strat.oid
```

```
        AND
            msc_temp_dissox_prof.sortie = 1
;

/* 631 */
CREATE TABLE msc_key_dissox_prof_2 AS
       SELECT msc_key_dissox_strat.lake_id,
              msc_key_dissox_strat.lakename,
              msc_key_dissox_strat.year,
              msc_key_dissox_strat.depth,
              msc_key_dissox_strat.oid AS kds_oid,
              msc_temp_dissox_prof.dissox AS dissox2,
              msc_temp_dissox_prof.julianday AS julian2
         FROM msc_key_dissox_strat, msc_temp_dissox_prof
        WHERE
              msc_temp_dissox_prof.lyd = msc_key_dissox_strat.oid
          AND
              msc_temp_dissox_prof.sortie = 2
;

/* 511 */
CREATE  TABLE msc_key_dissox_prof_3 AS
SELECT  msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth,
        msc_key_dissox_strat.oid AS kds_oid,
        msc_temp_dissox_prof.dissox AS dissox3,
        msc_temp_dissox_prof.julianday AS julian3
   FROM msc_key_dissox_strat, msc_temp_dissox_prof
  WHERE
        msc_temp_dissox_prof.lyd = msc_ke/_dissox_strat.oid
    AND
        msc_temp_dissox_prof.sortie = 3
;

/* get the missing records to fill the outer join                */
SELECT lake_id, lakename, year, depth, oid AS kds_oid
  INTO msc_temp_dissox_1
  FROM msc_key_dissox_strat
EXCEPT
SELECT lake_id, lakename, year, depth, kds_oid
  FROM msc_key_dissox_prof_1
;

SELECT lake_id, lakename, year, depth, oid AS kds_oid
  INTO msc_temp_dissox_2
  FROM msc_key_dissox_strat
EXCEPT
SELECT lake_id, lakename, year, depth, kds_oid
  FROM msc_key_dissox_prof_2
;

SELECT lake_id, lakename, year, depth, oid AS kds_oid
  INTO msc_temp_dissox_3
  FROM msc_key_dissox_strat
EXCEPT
SELECT lake_id, lakename, year, depth, kds_oid
  FROM msc_key_dissox_prof_3
;

/* now create the merged table                                   */
INSERT INTO msc_key_dissox_prof_1
SELECT lake_id, lakename, year, depth, kds_oid,
       NULL AS dissox1, NULL AS julian1
  FROM msc_temp_dissox_1
;

INSERT INTO msc_key_dissox_prof_2
SELECT lake_id, lakename, year, depth, kds_oid,
       NULL AS dissox2, NULL AS julian2
  FROM msc_temp_dissox_2
;

INSERT INTO msc_key_dissox_prof_3
SELECT lake_id, lakename, year, depth, kds_oid,
       NULL AS dissox3, NULL AS julian3
  FROM msc_temp_dissox_3
;

/* 1623 */
/* now we bring it together                                      */
CREATE  TABLE msc_oxygen_1 AS
SELECT  msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth,
        msc_key_dissox_strat.oid AS kds_oid,
        msc_key_dissox_strat.year AS cnts,
        msc_key_dissox_prof_1.dissox1,
        msc_key_dissox_prof_2.dissox2,
        msc_key_dissox_prof_3.dissox3,
        msc_key_dissox_prof_1.julian1,
        msc_key_dissox_prof_2.julian2,
        msc_key_dissox_prof_3.julian3
  FROM  msc_key_dissox_strat,  msc_key_dissox_prof_1,
        msc_key_dissox_prof_2, msc_key_dissox_prof_3
 WHERE
        msc_key_dissox_prof_1.kds_oid = msc_key_dissox_strat.oid
   AND
        msc_key_dissox_prof_2.kds_oid = msc_key_dissox_strat.oid
   AND
        msc_key_dissox_prof_3.kds_oid = msc_key_dissox_strat.oid
;

CREATE INDEX msc_oxygen_1_index
         ON msc_oxygen_1 (kds_oid)
;


/* 1623 */
/* next step, get the temperature stuff done */
CREATE  TABLE msc_key_temp_prof_1 AS
SELECT  msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth,
        msc_key_dissox_strat.oid AS kds_oid,
        msc_temp_temp_prof.temperature AS temperature1
   FROM msc_key_dissox_strat, msc_temp_temp_prof
  WHERE
        msc_temp_temp_prof.lyd = msc_key_dissox_strat.oid
    AND
        msc_temp_temp_prof.sortie = 1
;

CREATE INDEX msc_key_temp_prof_1_index
         ON msc_key_temp_prof_1 (kds_oid)
;

/* 1623 */
CREATE  TABLE msc_key_temp_prof_2 AS
```

```
SELECT  msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth,
        msc_key_dissox_strat.oid AS kds_oid,
        msc_temp_temp_prof.temperature AS temperature2
   FROM msc_key_dissox_strat, msc_temp_temp_prof
  WHERE
        msc_temp_temp_prof.lyd = msc_key_dissox_strat.oid
    AND
        msc_temp_temp_prof.sortie = 2
;

CREATE INDEX msc_key_temp_prof_2_index
          ON msc_key_temp_prof_2 (kds_oid)
;

/* 1623 */
CREATE  TABLE msc_key_temp_prof_3 AS
SELECT  msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth,
        msc_key_dissox_strat.oid AS kds_oid,
        msc_temp_temp_prof.temperature AS temperature3
   FROM msc_key_dissox_strat, msc_temp_temp_prof
  WHERE
        msc_temp_temp_prof.lyd = msc_key_dissox_strat.oid
    AND
        msc_temp_temp_prof.sortie = 3
;

CREATE INDEX msc_key_temp_prof_3_index
          ON msc_key_temp_prof_3 (kds_oid)
;

/* now get the unselected rows                                      */
/* this approach has to change ... it's too slow                    */
/* options: first do kds_oid only                                   */
/*          then join on kds_oid = oid and fill the rest of the table */
SELECT oid AS kds_oid
  INTO msc_temp_temp_1a
  FROM msc_key_dissox_strat
EXCEPT
SELECT kds_oid
  FROM msc_key_temp_prof_1
;

SELECT  oid AS kds_oid
  INTO msc_temp_temp_2a
  FROM msc_key_dissox_strat
EXCEPT
SELECT kds_oid
  FROM msc_key_temp_prof_2
;

SELECT oid AS kds_oid
  INTO msc_temp_temp_3a
  FROM msc_key_dissox_strat
EXCEPT
SELECT kds_oid
  FROM msc_key_temp_prof_3
;

/* alright. now we fill the list of unincluded kds_oids             */
SELECT msc_temp_temp_1a.kds_oid,
        msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth
  INTO msc_temp_temp_1
  FROM msc_key_dissox_strat, msc_temp_temp_1a
 WHERE msc_key_dissox_strat.oid = msc_temp_temp_1a.kds_oid
;

SELECT msc_temp_temp_2a.kds_oid,
        msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth
  INTO msc_temp_temp_2
  FROM msc_key_dissox_strat, msc_temp_temp_2a
 WHERE msc_key_dissox_strat.oid = msc_temp_temp_2a.kds_oid
;

SELECT msc_temp_temp_3a.kds_oid,
        msc_key_dissox_strat.lake_id,
        msc_key_dissox_strat.lakename,
        msc_key_dissox_strat.year,
        msc_key_dissox_strat.depth
  INTO msc_temp_temp_3
  FROM msc_key_dissox_strat, msc_temp_temp_3a
 WHERE msc_key_dissox_strat.oid = msc_temp_temp_3a.kds_oid
;

/* now create the merged table                                      */
INSERT INTO msc_key_temp_prof_1
     SELECT lake_id, lakename, year, depth,
            kds_oid, NULL AS temperature1
       FROM msc_temp_temp_1
;

DROP INDEX msc_key_temp_prof_1_index
;

CREATE INDEX msc_key_temp_prof_1_index
          ON msc_key_temp_prof_1 (kds_oid)
;

INSERT INTO msc_key_temp_prof_2
     SELECT lake_id, lakename, year, depth,
            kds_oid, NULL AS temperature2
       FROM msc_temp_temp_2
;

DROP INDEX msc_key_temp_prof_2_index
;

CREATE INDEX msc_key_temp_prof_2_index
          ON msc_key_temp_prof_2 (kds_oid)
;

INSERT INTO msc_key_temp_prof_3
     SELECT lake_id, lakename, year, depth,
            kds_oid, NULL AS temperature3
       FROM msc_temp_temp_3
;

DROP INDEX msc_key_temp_prof_3_index
;

CREATE INDEX msc_key_temp_prof_3_index
```

```
        ON msc_key_temp_prof_3 (kds_oid)
;

/* consolidation                                                  */
/* have to do this somewhat differently, do the joins separately, then */
/* bring everything together                                      */
CREATE TABLE msc_key_temp_prof_12 AS
      SELECT msc_key_temp_prof_1.kds_oid,
             msc_key_temp_prof_1.temperature1,
             msc_key_temp_prof_2.temperature2
        FROM msc_key_temp_prof_1, msc_key_temp_prof_2
       WHERE msc_key_temp_prof_1.kds_oid = msc_key_temp_prof_2.kds_oid
;

CREATE TABLE msc_key_temp_prof_123 AS
      SELECT msc_key_temp_prof_12.kds_oid,
             msc_key_temp_prof_12.temperature1,
             msc_key_temp_prof_12.temperature2,
             msc_key_temp_prof_3.temperature3
        FROM msc_key_temp_prof_12, msc_key_temp_prof_3
       WHERE msc_key_temp_prof_12.kds_oid = msc_key_temp_prof_3.kds_oid
;

CREATE TABLE msc_oxygen AS
SELECT  msc_oxygen_1.lake_id,
        msc_oxygen_1.lakename,
        msc_oxygen_1.year,
        msc_oxygen_1.depth,
        msc_oxygen_1.kds_oid,
        msc_oxygen_1.dissox1,
        msc_oxygen_1.dissox2,
        msc_oxygen_1.dissox3,
        msc_oxygen_1.julian1,
        msc_oxygen_1.julian2,
        msc_oxygen_1.julian3,
        msc_key_temp_prof_123.temperature1,
        msc_key_temp_prof_123.temperature2,
        msc_key_temp_prof_123.temperature3,
        msc_oxygen_1.year AS cnts
   FROM msc_oxygen_1, msc_key_temp_prof_123
  WHERE
        msc_key_temp_prof_123.kds_oid = msc_oxygen_1.kds_oid
;

CREATE INDEX msc_oxygen_index
        ON msc_oxygen (kds_oid)
;

/* make a copy of the main table                                  */
CREATE TABLE msc_oxygen_backup AS
      SELECT *
        FROM msc_oxygen
;

/* now drop all temporary tables                                  */
DROP TABLE msc_key_dissox_strat;
DROP TABLE msc_key_dissox_year;
DROP TABLE msc_key_temp_prof_1;
DROP TABLE msc_key_temp_prof_123;
DROP TABLE msc_key_temp_prof_12;
DROP TABLE msc_key_temp_prof_2;
DROP TABLE msc_key_temp_prof_3;
DROP TABLE msc_oxygen_1;
DROP TABLE msc_temp_dissox_prof;
DROP TABLE msc_temp_temp_1;
DROP TABLE msc_temp_temp_1a;
DROP TABLE msc_temp_temp_2;
DROP TABLE msc_temp_temp_2a;
DROP TABLE msc_temp_temp_3;
DROP TABLE msc_temp_temp_3a;
DROP TABLE msc_temp_temp_prof;
DROP TABLE msc_key_dissox_prof_1 ;
DROP TABLE msc_key_dissox_prof_2 ;
DROP TABLE msc_key_dissox_prof_3 ;
DROP TABLE msc_temp_dissox_1 ;
DROP TABLE msc_temp_dissox_2 ;
DROP TABLE msc_temp_dissox_3 ;


/* **********        SECTION TWO STARTS HERE  (LINE 462)       ********** */
/* Now that the basic data have been entered into the table, we can    */
/* now do the following:                                               */
/*    0) add the count column - done previously                        */
/*    1) do the three count (UPDATE) queries                           */
/*    2) clean up table based on count > 1                             */
/*    3) do the remainder of the calculations on the remaining records */

/* ZERO the CNTS column                                                */
UPDATE msc_oxygen
   SET cnts = 0
;

/*    1) do the three count (UPDATE) queries                           */
UPDATE msc_oxygen
   SET cnts = cnts + 1
 WHERE dissox1 > 0
;

UPDATE msc_oxygen
   SET cnts = cnts + 1
 WHERE dissox2 > 0
;

UPDATE msc_oxygen
   SET cnts = cnts + 1
 WHERE dissox3 > 0
;

/*    2) clean up table based on counts > 1                            */
CREATE TABLE msc_oxygen_1 AS
      SELECT *
        FROM msc_oxygen
       WHERE
             msc_oxygen.cnts > 1
;

/*    3) do the remainder of the calculations on the remaining records */
/*       - set up table for new fields                                 */
ALTER TABLE msc_oxygen_1
        ADD (dissox_1 float4)
;

ALTER TABLE msc_oxygen_1
        ADD (dissox_L float4)
;

ALTER TABLE msc_oxygen_1
        ADD (delta_dissox float4)
;

ALTER TABLE msc_oxygen_1
        ADD (sum_temp float4)
```

```
;

ALTER TABLE msc_oxygen_1
        ADD (avg_temp float4)
;

ALTER TABLE msc_oxygen_1
        ADD (julian_1 int4)
;

ALTER TABLE msc_oxygen_1
        ADD (julian_L int4)
;

ALTER TABLE msc_oxygen_1
        ADD (delta_days int4)
;

ALTER TABLE msc_oxygen_1
        ADD (ddodt float4)
;

/*      - run calculations, remembering that there are four cases:      */
/*        - counts = 3, take first, last and sum of temp                */
/*        - counts = 2 and dissox1 is null; second and last             */
/*        - counts = 2 and dissox2 is null; first and last              */
/*        - counts = 2 and dissox3 is null; first and second            */

/* dealing with counts = 3                                              */
UPDATE msc_oxygen_1
   SET dissox_1 = dissox1,
       dissox_L = dissox3,
       sum_temp = temperature1 + temperature2 + temperature3,
       julian_1 = julian1,
       julian_L = julian3
 WHERE cnts = 3
;

/* dealing with counts = 2, dissox1 is null                             */
UPDATE msc_oxygen_1
   SET dissox_1 = dissox2,
       dissox_L = dissox3,
       sum_temp = temperature2 + temperature3,
       julian_1 = julian2,
       julian_L = julian3
 WHERE
       cnts = 2
   AND
       dissox1 = NULL
;

/* dealing with counts = 2, dissox2 is null                             */
UPDATE msc_oxygen_1
   SET dissox_1 = dissox1,
       dissox_L = dissox3,
       sum_temp = temperature1 + temperature3,
       julian_1 = julian1,
       julian_L = julian3
 WHERE
       cnts = 2
   AND
       dissox2 = NULL
;
/* dealing with counts = 2, dissox3 is null                             */
UPDATE msc_oxygen_1
   SET dissox_1 = dissox1,
       dissox_L = dissox2,
       sum_temp = temperature1 + temperature2,
       julian_1 = julian1,
       julian_L = julian2
 WHERE
       cnts = 2
   AND
       dissox3 = NULL
;

/* Now the calc updates can be done                                     */
UPDATE msc_oxygen_1
   SET delta_dissox = dissox_1 - dissox_L,
       avg_temp = sum_temp / cnts,
       delta_days = julian_L - julian_1
;

/* linear concentration change with time                                */
UPDATE msc_oxygen_1
   SET ddodt = delta_dissox / delta_days
;

DROP TABLE msc_oxygen
;

SELECT *
  INTO msc_oxygen
  FROM msc_oxygen_1
;

DROP TABLE msc_oxygen_1
;

/* ********** SECTION THREE (MORPH) STARTS HERE  (LINE 614) ********** */
/* at this point, change in oxygen has been calculated. in order for   */
/*   this to work, I now need the morphometric info worked up, and     */
/*   then water chemistry info AS well.                                */

/* integerize the depths and use distinct predicate to remove odd z    */
CREATE TABLE msc_morph_1 AS
         SELECT DISTINCT lake_id, lakename, int2(depth) AS depth
                FROM morphconv
               WHERE
                    lakename NOT LIKE 'NL-LTER%'
                 AND
                    lakename NOT LIKE 'ELA%'
;

/* now alter the table for initial info                                */
ALTER TABLE msc_morph_1
        ADD (upper_depth float4)
;

ALTER TABLE msc_morph_1
        ADD (lower_depth float4)
;

/* and add said info in four? steps...                                 */
/*          1- set for 0                                               */
UPDATE msc_morph_1
   SET upper_depth = 0
 WHERE
       depth = 0
;

/*          2- set for max                                             */
```

```
UPDATE msc_morph_1
   SET lower_depth = depth
 WHERE
       depth = (SELECT MAX(depth) FROM msc_morph_1 AS P1
                   WHERE msc_morph_1.lake_id = P1.lake_id
                 )
;

/*          3- set upper AS depth - 0.5, except where 0              */
UPDATE msc_morph_1
   SET upper_depth = depth - 0.5
 WHERE
       upper_depth = NULL
;

/*          4- set lower AS depth + 0.5, except where max            */
UPDATE msc_morph_1
   SET lower_depth = depth + 0.5
 WHERE
       lower_depth = NULL
;

/* now we create a new table for the upper vol and psa              */
CREATE TABLE msc_morph_1_a AS
      SELECT msc_morph_1.*,
             morphconv.volbelow AS upper_vol,
             morphconv.psa AS upper_psa
       WHERE
             morphconv.lake_id = msc_morph_1.lake_id
         AND
             morphconv.depth = msc_morph_1.upper_depth
;

/* now the lower vol and psa                                        */
CREATE TABLE msc_morph AS
      SELECT msc_morph_1_a.*,
             morphconv.volbelow AS lower_vol,
             morphconv.psa AS lower_psa
       WHERE
             morphconv.lake_id = msc_morph_1_a.lake_id
         AND
             morphconv.depth = msc_morph_1_a.lower_depth
;

ALTER TABLE msc_morph
       ADD (delta_vol float4)
;

ALTER TABLE msc_morph
       ADD (delta_psa float4)
;

ALTER TABLE msc_morph
       ADD (vsa float4)
;

UPDATE msc_morph
   SET delta_vol = upper_vol - lower_vol,
       delta_psa = upper_psa - lower_psa
;

UPDATE msc_morph
   SET vsa = delta_vol / delta_psa
;

DROP TABLE msc_morph_1
;

DROP TABLE msc_morph_1_a
;

/* MORPH SECTION ENDS HERE :)                                        */
/* START SECTION 3 HERE: LINE 719                                    */
/* do merge of morph info and oxygen info here;                      */
/*      morph info required for summary oxygen calcs                 */
/*      BUT!!! need to do it in two steps:                           */
/*           first do the odd (0.02, .5 etc) strata                  */
/*           then do the even strata                                 */
CREATE TABLE msc_oxymorph AS
      SELECT msc_oxygen.*,
             msc_morph.upper_depth,
             msc_morph.lower_depth,
             msc_morph.upper_psa,
             msc_morph.lower_psa,
             msc_morph.upper_vol,
             msc_morph.lower_vol,
             msc_morph.delta_psa,
             msc_morph.delta_vol,
             msc_morph.vsa
        FROM msc_oxygen, msc_morph
       WHERE
             msc_morph.lake_id = msc_oxygen.lake_id
         AND
             msc_oxygen.depth >= msc_morph.upper_depth
         AND
             msc_oxygen.depth <= msc_morph.lower_depth
;

/* add the stratum oxygen mass depletion calculations               */
ALTER TABLE msc_oxymorph
       ADD (oxy_mass float4)
;

/* now do the actual stratum oxygen mass depletion calc             */
UPDATE msc_oxymorph
   SET oxy_mass = delta_vol * delta_dissox
;

/* SECTION 5 - prepping chem and watershed info starts HERE (LINE 745) */
/* this works too                                                    */
/* chemistry data from watchemseasonal                               */
CREATE TABLE msc_chem_1 AS
      SELECT waterchemseasonal.*
        FROM waterchemseasonal
       WHERE
             waterchemseasonal.lakename NOT LIKE 'NL-LTER%'
         AND
             waterchemseasonal.lakename NOT LIKE 'ELA%'
;


/* SECTION 6: THIS WORKS JUST FINE                                   */
/* watershed info from main                                          */
CREATE TABLE msc_wshed_1 AS
      SELECT main.oid AS lake_id,
             main.lakename,
             main.deg_lat,
             main.deg_long,
             main.dsa_km2 * 100 AS dsa_ha,
             main.lsa_km2 * 100 AS lsa_ha,
             main.wsa_km2 * 100 AS wsa_ha,
             main.dsalsa AS cala,
```

```
            main.ws AS w_slope,
            main.pct_aff,
            main.pct_marsh
        FROM main
       WHERE
            main.lakename NOT LIKE 'NL-LTER%'
         AND
            main.lakename NOT LIKE 'ELA%'
         AND
            main.deg_lat > 0
;


/* Need info on Zamax, Zavg, Vtotal                                    */
/*     (Vhypo can come from another table                              */
CREATE TABLE msc_vols_1 AS
      SELECT morphconv.lake_id,
             max(morphconv.depth) AS max_depth,
             max(morphconv.psa) AS max_psa,
             max(morphconv.volbelow) AS max_vol
        FROM morphconv
       WHERE
             lakename NOT LIKE 'NL-LTER%'
         AND
             lakename NOT LIKE 'ELA%'
    GROUP BY
             lake_id
;

ALTER TABLE msc_vols_1
        ADD (mean_depth float4)
;

UPDATE msc_vols_1
   SET mean_depth = float4(max_vol) / float4(max_psa)
;


/* Next step  is to join vols and watershed tables into one            */
CREATE TABLE msc_physical AS
      SELECT msc_wshed_1.lake_id,
             msc_wshed_1.lakename,
             msc_wshed_1.deg_lat,
             msc_wshed_1.deg_long,
             msc_wshed_1.dsa_ha,
             msc_wshed_1.lsa_ha ,
             msc_wshed_1.wsa_ha,
             msc_wshed_1.w_slope,
             msc_wshed_1.cala,
             msc_wshed_1.pct_aff,
             msc_wshed_1.pct_marsh,
             msc_vols_1.max_depth,
             msc_vols_1.max_psa,
             msc_vols_1.max_vol
        FROM msc_wshed_1, msc_vols_1
       WHERE
             msc_vols_1.lake_id = msc_wshed_1.lake_id
;

/* DROP TEMPORARY TABLES                                               */
/*
DROP TABLE msc_vols_1;
*/

/* CONSIDER ABOVE THIS MARKER BEING CODE THAT WORKS                    */
```

```
/*
 what's left to do?
    1) calc mean temp for summary hypo depletion
       - temp * vol, vol total
         add field vol_temp to msc_oxymorph
         update vol_temp to avg temp * vol
*/

/* add the vol weighted temp field                                     */
ALTER TABLE msc_oxymorph
        ADD (vol_temp float4)
;

/* now do the update                                                   */
UPDATE msc_oxymorph
   SET vol_temp = avg_temp * delta_vol
;


/* create a summary table, to be combined with other tables as needed  */
CREATE TABLE msc_summary_temp AS
SELECT lake_id,
       lakename,
       year,
       count(depth) AS num_strat,      -- let's see hhow many
       min(upper_depth) AS hypo_depth, -- need for hypothickness
       max(upper_psa) AS hypo_area,    -- need for AHOD determination
       max(upper_vol) AS hypo_vol,     -- need for VOD, CA:VH det
       sum(delta_vol) AS oxy_vol,   -- need for temp, optional for VOD det
       sum(vol_temp) AS vol_heat,   -- need for vol weighted temp det
       sum(oxy_mass) AS do_depleted  -- need for AHOD, VOD
  FROM msc_oxymorph
GROUP BY lake_id, lakename, year
;

ALTER TABLE msc_summary_temp
        ADD (vw_avg_temp float4)
;

UPDATE msc_summary_temp
   SET vw_avg_temp = vol_heat / oxy_vol
;

/* line 893 - this works too, and tested all the way                   */

/* calc AHOD                                                           */
ALTER TABLE msc_summary_temp
        ADD (ahod float4)
;

UPDATE msc_summary_temp
   SET ahod = do_depleted / hypo_area
;

/* calc VOD                                                            */
ALTER TABLE msc_summary_temp
        ADD (vod float4)
;

UPDATE msc_summary_temp
   SET vod = do_depleted / hypo_vol
;

/* now calculate average hypo temperatures                             */

ALTER TABLE msc_summary_temp
```

```
       ADD (avg_hypo_temp float4)
;

UPDATE msc_summary_temp
   SET avg_hypo_temp = vol_heat / oxy_vol
;

/* everything should work up to here  (LINE 924)                  */


/* get study period length from oxyphys, rename and recreate summary  */
/* once this is run, delete the msc_summary_temp table, and replace   */
/* it with msc_summary_temp_back                                       */
ALTER TABLE msc_summary_temp
  RENAME TO msc_summary_temp_1;

SELECT    lakename,
          lake_id,
          year,
          max(delta_days) AS study_period
     INTO msc_study_period
     FROM msc_oxymorph
 GROUP BY lakename, lake_id, year
;

/* put delta time into msc_summary temp                            */
SELECT msc_summary_temp_1.*,
       msc_study_period.study_period
  INTO msc_summary_temp
  FROM msc_summary_temp_1, msc_study_period
 WHERE
       msc_summary_temp_1.lake_id = msc_study_period.lake_id
   AND
       msc_summary_temp_1.year =  msc_study_period.year
;

ALTER TABLE  msc_summary_temp
       ADD (ahodr float4);

UPDATE msc_summary_temp
   SET ahodr = ahod / study_period
;

ALTER TABLE  msc_summary_temp
       ADD (vodr float4);

UPDATE msc_summary_temp
   SET vodr = vod / study_period
;


/* create penultimate data table                                   */
SELECT msc_physical.*,
       msc_chem_1.year,
       msc_chem_1.udmdoc,
       msc_chem_1.mcgilltp,
       msc_chem_1.udmtp,
       msc_chem_1.mcgilltn,
       msc_chem_1.mcgillchla,
       msc_chem_1.uqamchla
  INTO msc_chem_phys
  FROM msc_chem_1, msc_physical
 WHERE
       msc_chem_1.lake_id = msc_physical.lake_id
;
```

```
/* NOW START FINAL TABLE MERGES                                        */

CREATE TABLE msc_summary_final
          AS SELECT msc_summary_temp.*,
                    msc_chem_phys.deg_lat,
                    msc_chem_phys.deg_long,
                    msc_chem_phys.dsa_ha,
                    msc_chem_phys.lsa_ha,
                    msc_chem_phys.wsa_ha,
                    msc_chem_phys.w_slope,
                    msc_chem_phys.cala,
                    msc_chem_phys.pct_aff,
                    msc_chem_phys.pct_marsh,
                    msc_chem_phys.max_depth,
                    msc_chem_phys.max_psa,
                    msc_chem_phys.max_vol,
                    msc_chem_phys.udmdoc,
                    msc_chem_phys.mcgilltp,
                    msc_chem_phys.udmtp,
                    msc_chem_phys.mcgilltn,
                    msc_chem_phys.mcgillchla,
                    msc_chem_phys.uqamchla,
                    msc_chem_phys.lakename as colour
               FROM msc_summary_temp, msc_chem_phys
              WHERE
                    msc_summary_temp.lake_id =  msc_chem_phys.lake_id
                AND
                    msc_summary_temp.year =  msc_chem_phys.year
;

/* should be good to here (line 1013)                                  */
ALTER TABLE msc_summary_final
        ADD (wrt float4)
;

/* WRT = time to recharge                                              */
/*     = 1/ (number of recharges in a year)                            */
/*     = */
UPDATE msc_summary_final
   SET wrt = 1/((wsa_ha * 10000 * 0.55) / max_vol)
;

/* CAHT and CAHV - catchment area to total and hypo volume, resp.     */
ALTER TABLE msc_summary_final
        ADD (caht float4)
;

ALTER TABLE msc_summary_final
        ADD (cahv float4)
;

UPDATE msc_summary_final
   SET caht = (dsa_ha * 10000) / max_vol
;

UPDATE msc_summary_final
   SET cahv = (dsa_ha * 10000) / hypo_vol
;


/* now create final stratum table                                      */
CREATE TABLE msc_strata_final
   AS SELECT msc_oxymorph.*,
             msc_summary_final.hypo_depth,
             msc_summary_final.hypo_area,
             msc_summary_final.hypo_vol,
```

```
            msc_summary_final.deg_lat,
            msc_summary_final.deg_long,
            msc_summary_final.dsa_ha,
            msc_summary_final.lsa_ha,
            msc_summary_final.wsa_ha,
            msc_summary_final.w_slope,
            msc_summary_final.cala,
            msc_summary_final.pct_aff,
            msc_summary_final.pct_marsh,
            msc_summary_final.max_depth,
            msc_summary_final.max_psa,
            msc_summary_final.max_vol,
            msc_summary_final.udmdoc,
            msc_summary_final.mcgilltp,
            msc_summary_final.udmtp,
            msc_summary_final.mcgilltn,
            msc_summary_final.mcgillchla,
            msc_summary_final.uqamchla,
            msc_summary_final.wrt,
            msc_summary_final.caht,
            msc_summary_final.cahv,
            msc_summary_final.lakename AS colour
      WHERE
            msc_oxymorph.lake_id =  msc_summary_final.lake_id
        AND
            msc_oxymorph.year =  msc_summary_final.year
;


UPDATE msc_summary_final
   SET colour = 'green'
;

UPDATE msc_summary_final
   SET colour = 'yellow'
 WHERE
       lakename like 'C%'
;

UPDATE msc_summary_final
   SET colour = 'red'
 WHERE
       lakename like 'F%'
;

-- ALTER TABLE msc_strata_final
--        ADD (colour varchar(10))
-- ;

UPDATE msc_strata_final
   SET colour = 'green'
;

UPDATE msc_strata_final
   SET colour = 'yellow'
 WHERE
       lakename like 'C%'
;

UPDATE msc_strata_final
   SET colour = 'red'
 WHERE
       lakename like 'F%'
;

ALTER TABLE msc_strata_final
        ADD (vhvt float4)
;

UPDATE msc_strata_final
   SET vhvt = float4(hypo_vol) / float4(max_vol)
;


ALTER TABLE msc_summary_final
        ADD (vhvt float4)
;

UPDATE msc_summary_final
   SET vhvt = float4(hypo_vol) / float4(max_vol)
;

ALTER TABLE msc_summary_final
        ADD (q10 float4)
;

UPDATE msc_summary_final
   SET q10 = 2 ^ ((vw_avg_temp - 4)/10)
;

/* now add the standardized results                                  */
ALTER TABLE msc_summary_final
        ADD (ahod4c float4)
;

UPDATE msc_summary_final
   SET ahod4c = ahod / q10
;

ALTER TABLE msc_summary_final
        ADD (ahodr4c float4)
;

UPDATE msc_summary_final
   SET ahodr4c = ahodr / q10
;

ALTER TABLE msc_summary_final
        ADD (vod4c float4)
;

UPDATE msc_summary_final
   SET vod4c = vod / q10
;

ALTER TABLE msc_summary_final
        ADD (vodr4c float4)
;

UPDATE msc_summary_final
   SET vodr4c = vodr / q10
;

/* now the same for the strata table                                 */
ALTER TABLE msc_strata_final
        ADD (q10 float4)
;

UPDATE msc_strata_final
   SET q10 = 2 ^ ((avg_temp - 4)/10)
```

```
;

ALTER TABLE msc_strata_final
        ADD (ddodt4c float4)
;

UPDATE msc_strata_final
   SET ddodt4c = ddodt / q10
;
```

```
ALTER TABLE msc_strata_final
        ADD (ddo4c float4)
;

UPDATE msc_strata_final
   SET ddo4c = delta_dissox / q10
;


/* everything should work up to here  (LINE 1200)                    */
```