Section 7 Appendices

7.1 Appendix A Curricula Vitarum of Investigators

Curriculum Vitae

Name: John Malcolm Casselman (Principal Investigator, Fish, Fisheries, and Adaptation – PI)

Institutional Address: Adjunct Professor, Department of Biology, 2406 Biosciences Complex, 116 Barrie Street, Queen's University, Kingston, Ontario K7L 3N6; e-mail: john.casselman@biology.queensu.ca; Phone: 613-533-6000 ext. 75371; Fax: 613-533-6617

Academic Background:

B.S.A.	1964	Biology (fisheries management)	University of Toronto
M.Sc.	1968	Zoology (fish ecology)	University of Guelph
Ph.D.	1978	Zoology (fisheries science)	University of Toronto

Employment Background:

1974-1976	Senior Aquatic Scientist, J.F. MacLaren, Engineers and Environmental Scientists
1976-2005	Senior Scientist, Scientist Emeritus, Ontario Ministry of Natural Resources, Age-Growth and Environmental Studies Unit, and Lake Ontario Research Unit
1985-present	Adjunct Professor, Department of Biology, Queen's University, Kingston, ON

Areas of Expertise: Climate, fish and fisheries; population and community structure and dynamics; environmental requirements; growth and production; global warming, invasions and exotic fish; calcified structures; age determination; calcified structure analysis; eels and oceanic effect.

Research Related to Present Proposal: Research into age, growth, and production of fish, as well as long-term community indexing in Lake Ontario (5 decades), has demonstrated the significant overriding effects of climate change on fish populations and communities. Studies have involved structure and dynamics, abundance, predator-prey interaction, and invasive species, producing a series of publications that have quantified the impacts of global climate change on fish and fisheries. I have been invited to make numerous presentations: university lectures, public seminars, science forums, workshops, and keynote addresses for sport (OFAH) and commercial (OCFA) fishing groups and to senior governmental personnel, managers, deputies, and ministers. I have published by invitation in American Fisheries Society and peer-reviewed symposia and have used long-term temperature data to confirm that warming of a broad range of aquatic habitats matches global climate change. I am working on global climate change in Tibet by invitation of the Chinese Academy of Sciences and in the Arctic for the U.S. National Science Foundation. Primary publications involve all thermal fish assemblages: warm-water (e.g., basses), cool-water (walleye and pike), and cold-water (lake trout and whitefish). I am extending my research on climate change to emphasize and understand adaptation and adaptive capacity at the species (e.g., pike) and resource-use levels to support decision making (fisheries policy, management, and assessment) in considering rapidly changing environmental factors. Received the 2008 AFS Award of Excellence, the most prestigious award of the 138-year-old society, given annually in recognition of original and outstanding contributions to fisheries science and aquatic biology for lifetime achievements as a researcher, mentor, and leader.

Selected Published Articles on Climate Change (Lifetime Primary Scientific Publications 110):

Casselman, J.M., and C.A. Lewis. 1996. Habitat requirements of northern pike Esox lucius. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1): 161-174.

Casselman, J.M. 2006. Long-term pike recruitment: Effects of water level, impoundment, and climate change; evidence of adaptation. Presented at American Fisheries Society Annual Meeting, International Pike Symposium, September 2006, Lake Placid, NY.

Casselman, J.M. 2008. Effects of climate and climate change on lake trout populations and fisheries. Second North American Lake Trout Symposium, Yellowknife, NT. 16-19 August 2005.

Curriculum Vitae

Name: Sobhalatha Kunjikutty (Co-Principal Investigator, Water Management and Modelling – Co-PI)

Institutional Address: Water Resources Engineer, Mississippi Valley Conservation, 4175 Hwy 511, Lanark, Ontario K0G 1K0; E-mail: skunjikutty@mvc.on.ca; Phone: 613-259-2421 Ext: 245; Fax: 613-259-3468

Academic Background:

B.Tech.	1993	Bioresources Engineering	Kerala University, India
M.E.	1995	Soil and Water Conservation Engineering	Tamilnadu University, India
Ph.D	2006	Bioresources Engineering (Env. Eng. Research)	McGill University, Montreal

Employment Background:

1995-1996	Graduate Research Assistant, Central Water Research Institute, India
1996-1997	Research Associate, Kerala University, India
1997-2002	Assistant and Associate Engineer, Provincial Government of Kerala, India
2002-2005	Doctoral Research Fellow/Research Assistant, McGill University, Montreal
2005-Present	Water Resources Engineer, Mississippi Valley Conservation, Lanark, Ontario

Areas of Expertise: Engineering expertise in water resources, hydrologic, hydraulic, land and water conservation, and bioresources; modelling expertise in surface water, ground water, hydrologic, hydrodynamic, watershed, and contaminant transport models; provincial and federal environmental regulations/policies on source water protection and drinking water strategies; environmental risk assessment and management; current/emerging computer modeling techniques/software and programming languages

Research/Projects Related to Present Proposal: Conducted studies on hydrological response in water resources development and management of low-and up-lands of Kerala, India; impacts of water conservation structures on ground water; water quality improvement using floodplain filtration system; evaluation of environmental and socioeconomic impacts of soil-water conservation and watershed management projects; wastewater land application; and performance, conveyance loss, and cost benefit assessment of a large irrigation project in Kuttiady, India, etc. Designed, supervised, and evaluated construction of various structures for water resources development and management, hydrological monitoring, and erosion control. Conducted modelling studies on fate and transport of pollutants (nutrients, pesticides, etc.) through soil-water-plant system; watershed based surface water, groundwater, hydraulic, hydrologic, and hydrodynamic models; artificial neural network models; numerical method of lines etc. Specific to the proposed study, conducted for Mississippi Valley Conservation a preliminary study of effects of long-term climate change on stream flow, using gauge data from Appleton station

Selected Articles on Climate Change (Scientific Publications, refereed and non-refereed: 33):

Kunjikutty, S., P. Lehman, and A. Broadbend. 2006. Preliminary long term climate change study in watershed area of Mississippi Valley Conservation, St. Lawrence River Conference-Source Water Protection, Cornwall, May 16-19, 2006.

Curriculum Vitae

Name: Paul Lehman (Co-Principal Investigator, Water Resources Management and Planning – Co-PI)

Institutional Address: Mississippi Valley Conservation, 4175 Highway 511, Lanark, Ontario K0G 1K0;
e-mail: plehman@mvc.on.ca; Phone: 613-259-5307 ext. 223
Fax: 613-259-3468

Academic Background:

B.A.Sc.	1981	Civil Engineering	University of Waterloo

Employment Background:

1981 - 1983	Project Engineer – Ontario Ministry of Natural Resources, Kemptville, Ontario
1984 - 1989	Water Resources Engineer – Mississippi Valley Conservation Authority
1989 - present	General Manager – Mississippi Valley Conservation Authority

Areas of Expertise: Water resources engineering, floodplain management, dam safety, hydrology and hydraulic modeling, project management

Research Related to Present Proposal: Chair of Mississippi River Water Management Plan planning team and principle technical director.

Selected Published Articles on Climate Change:

Mississippi River Water Management Plan Steering Committee. 2006. Mississippi River Water Management Plan. Mississippi Valley Conservation, Lanark, Ontario. 1,237 p. + appendices.

Curriculum Vitae

Name: Lucian Anthony Marcogliese (Co-Principal Investigator, Economics and Adaptation – Co-PI)

Address: 30 Salem Road, R.R. 1, Ameliasburgh, Ontario K0K 1A0; e-mail: marcogliese@sympatico.ca; Telephone: 613-961-1529; Fax: 613-961-1529

Academic Background:

B.E.S	1990	Environment and Resource Studies	University of Waterloo
M.Sc.	1995	Watershed Ecosystems	Trent University

Employment Background:

1991-1995	Fisheries Biologist, Ontario Ministry of Natural Resources (OMNR), Lake Ontario Research Unit
1995	Resource Technician, OMNR, Lake Ontario Management Unit
1995-present	Consulting Research Biologist, working on a broad range of projects, involving climate change, fish and fisheries for OMNR, Department Fisheries and Oceans (DFO), Great Lakes Fishery Commission, Trent and Queen's universities, etc.

Areas of Expertise: Climate change; fish and fisheries; resource planning and management; fish commercial harvest, interrelationship between fish value, price, harvest, and abundance; stock identification and fish stocking success; assessing fish age, growth, and production in changing climatic conditions; effects of environmental factors, particularly temperature

Research Related to Present Proposal: Early training in resource planning and management involving problem identification and solving by identifying user groups and concerns, public participation, and economical, social, cultural, biological, and political aspects in decision making while adhering to mandates and objectives of different agencies; knowledge of basic economic principles through accredited courses. Designed surveys and surveyed students at University of Waterloo to develop policy and implement recommendations concerning human health and safety standards. Analyzed catch, effort, and gear data (CPUE) collected from First Nations fishers; assessed subsistence fishery in northwestern Ontario; proposed management options and implications while acknowledging traditional and cultural importance of fishery. Have experience with survey designed and conducted in 1970s (Marcogliese 1977) and will resurvey to measure changes in anglers' attitudes toward fish resources and economic value in Ontario in a changing climate. Contributed to management strategies for sustainable use of fish resources and associated social and economic benefits as part of Strategic Fisheries Management Framework for Ottawa River; examined relationship between temperature and global warming on fish production and recommended promoting use of the resource. Conducting North American-wide study for DFO-OMNR of commercial harvest and value of American eels and their interrelationships for a 5-decade period, considering regulatory changes and fishing effort.

Selected Articles on Climate Change, Fisheries, Resource Value (Total Scientific Publications 8):

Michalenko, G., L.A. Marcogliese, and Muskrat Dam Band. 1989. (Abstract) The subsistence lake sturgeon (*Acipenser fulvescens*) fishery of the Indian village of Muskrat Dam in Northwestern Ontario, Canada. Acipenser, 1st International Symposium on the Sturgeon, October 1989, Bordeaux, France.

Casselman, J.M, L.A. Marcogliese, and T. Haxton. 2003. Preparation and interpretation of pectoral spines for validated age and growth estimates of slow-growing, long-lived northern fish. Presented at American Fisheries Society 133rd Annual Meeting, August 10-14, 2003, Quebec City.

Casselman, J.M., and L.A. Marcogliese. (In preparation.) Long-term changes in American eel harvest and value, interrelationships and declining abundance. Conducted for OMNR and DFO.

7.2 Appendix A1 Fish and Fisheries: Adapting to a Changing Climate

This appendix contains environmental data that were used in, and illustrate, the conditions that were part of the analysis of Changing Climate, Fish and Fisheries, Subproject 1. The data provide many decades of temperature, precipitation, and discharge conditions in the Bay of Quinte and inshore waters of Lake Ontario, as well as Ontario's Mississippi River and watershed. Detailed information concerning source, etc., is indicated in the specific table and figures. Selected graphs are provided that illustrate water and air temperature, precipitation, and discharge that are used in the analysis.

Actual mean monthly water temperatures for a 70-year period, from 1940 to 2009, are provided and formed the basis for water temperature analysis associated with the Great Lakes Basin.

Air temperature data for the Mississippi River watershed are presented, illustrating specific selected conditions, indicating mean annual values and, where present, significant long-term trends.

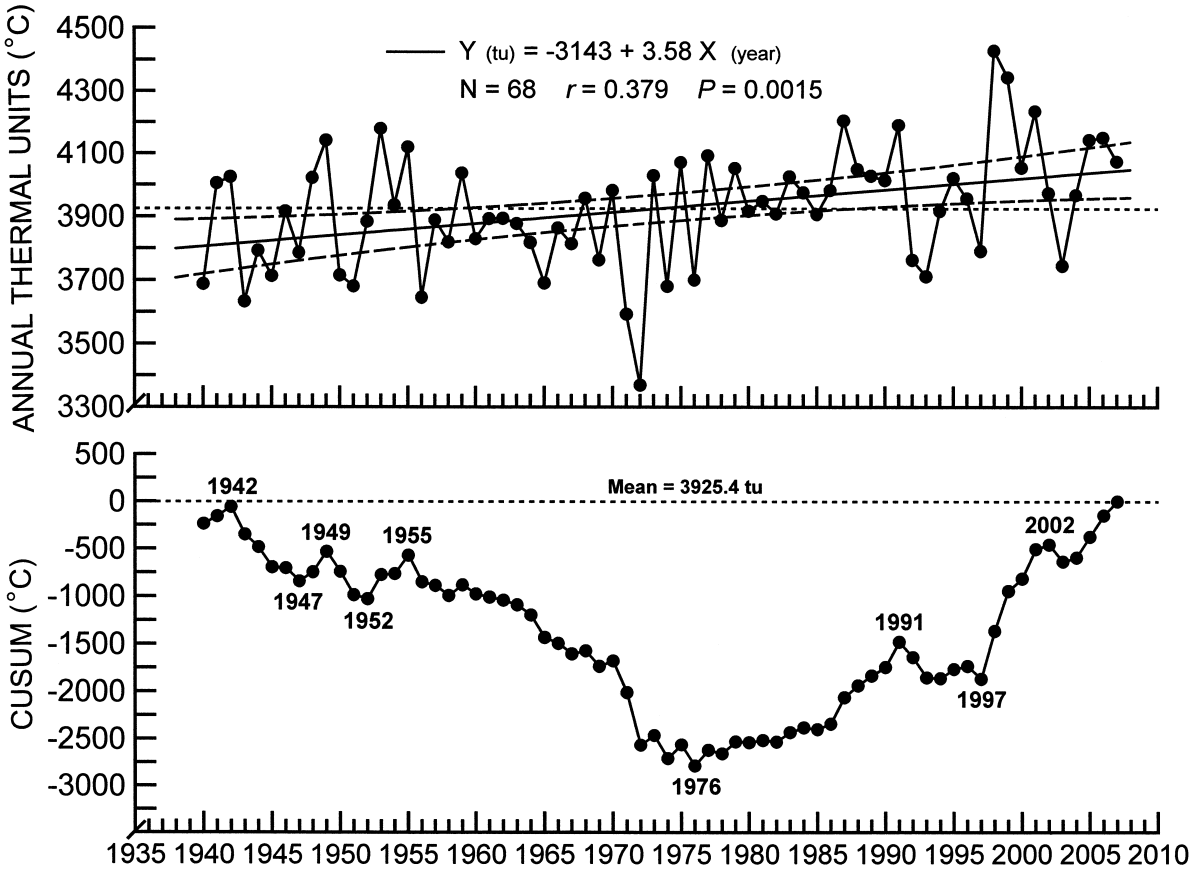
Precipitation, in the form of both rain and snow, for the Mississippi River watershed are presented, illustrating specific selected conditions, indicating mean annual values and, where present, significant long-term trends.

Discharge for the Mississippi River at Appleton are presented, illustrating specific selected conditions, indicating mean annual values and, where present, significant long-term trends.

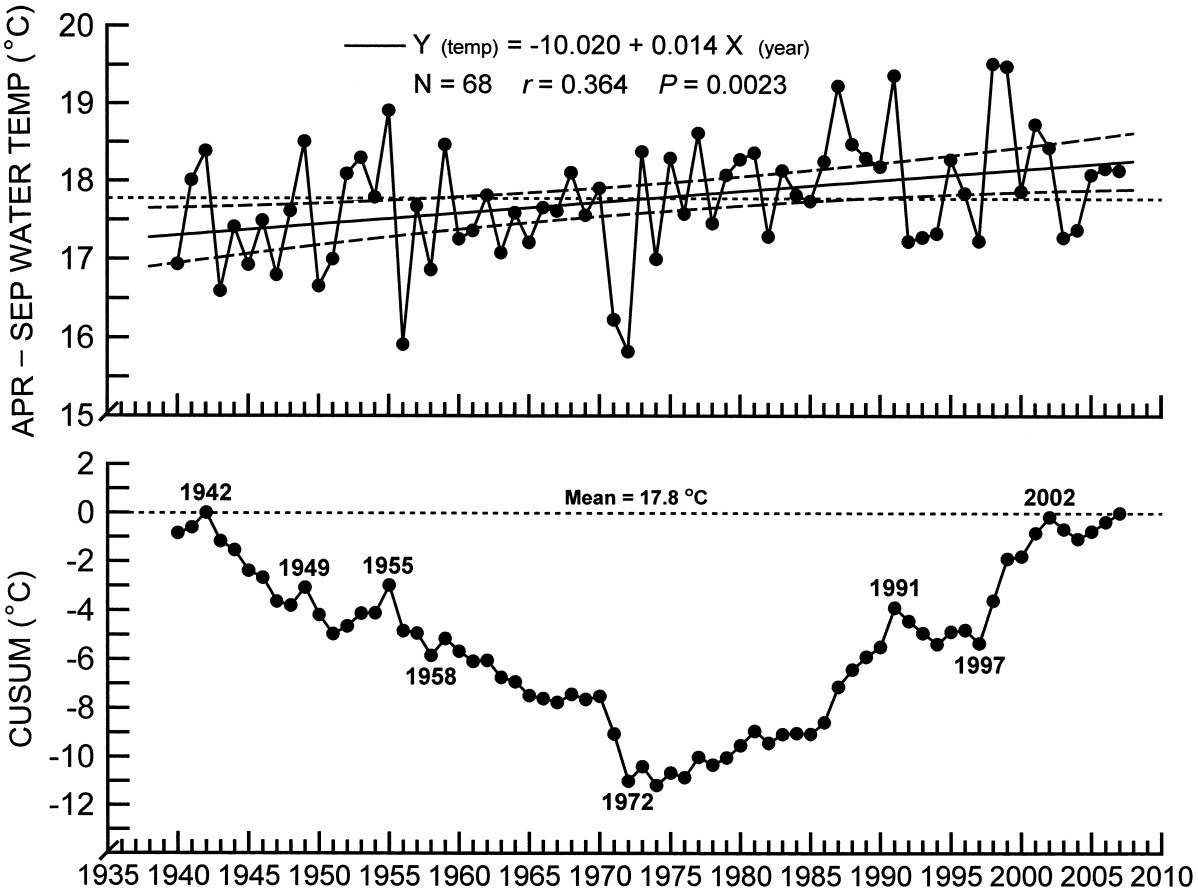
Appendix A1.1. Mean monthly water temperature for upper Bay of Quinte for a 70-yr period, 1940-2009. Water temperatures were measured in the upper Bay of Quinte at the Belleville municipal pumping station for water drawn at approximately 3.2 m. Bay of Quinte water temperatures at this location are homothermous. During several periods of time during the dataset, temperatures have been corrected for various anomalies (Casselman, unpublished data). These corrections are not numerous and have been made by using air-temperature data and water-temperature data measured specifically at the intake in the Bay of Quinte. Air-temperature data come from Belleville and Trenton, averaged, and Kingston airport, Kingston municipal pumping station, and Kingston hydro, as well as long-term data from Queen's University. Assembled by and source, refer to J.M. Casselman, Queen's University, 2009 unpublished data.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1940	0.56	0.56	0.56	2.92	14.77	20.67	21.79	23.53	17.94	11.47	4.63	1.11	10.04
1941	1.11	1.11	1.11	6.03	15.82	20.86	23.94	22.13	19.29	12.74	5.26	1.57	10.91
1942	1.11	1.11	1.29	8.03	16.09	20.67	23.26	22.70	19.56	12.25	4.46	1.11	10.97
1943	1.10	1.10	1.10	2.95	11.60	21.41	23.16	22.25	18.22	10.80	4.42	0.73	9.90
1944	0.60	0.60	0.86	3.28	14.84	20.36	23.93	23.36	18.68	11.60	5.14	0.65	10.33
1945	0.60	0.65	2.25	8.62	11.21	18.01	22.26	22.38	19.09	10.46	5.35	0.60	10.12
1946	0.60	0.60	1.98	7.61	13.35	19.16	24.55	22.12	18.16	12.22	6.87	0.85	10.67
1947	0.60	0.60	0.60	3.53	11.06	18.18	22.61	24.37	21.03	13.90	6.17	1.10	10.31
1948	1.10	1.10	1.10	7.07	12.81	19.52	23.36	22.40	20.52	12.25	8.02	2.34	10.97
1949	0.50	0.50	0.64	7.37	15.29	21.80	24.60	24.10	17.88	14.73	5.84	2.08	11.28
1950	0.75	0.65	0.69	4.56	13.57	19.82	22.23	22.14	17.61	12.84	5.89	0.70	10.12
1951	0.50	0.50	0.76	5.68	12.94	19.42	22.68	22.85	18.44	10.14	5.88	0.60	10.03
1952	1.02	1.10	1.17	7.35	14.17	20.10	24.65	22.83	19.45	9.95	4.26	0.95	10.58
1953	0.95	1.22	2.72	7.86	14.79	20.38	23.67	22.93	20.16	12.95	6.97	2.11	11.39
1954	0.48	0.53	0.70	6.76	14.61	20.77	23.11	22.79	18.70	13.36	5.53	1.35	10.72
1955	0.79	0.50	0.52	6.74	15.68	21.42	25.28	25.02	19.31	13.42	5.10	0.85	11.22
1956	1.10	1.10	1.10	2.96	11.36	20.03	21.44	22.01	17.68	12.15	7.22	1.06	9.93
1957	0.50	0.50	1.13	7.26	14.02	21.23	22.68	22.10	18.77	12.30	5.53	1.16	10.60
1958	0.52	0.50	0.85	7.78	12.54	17.74	22.29	22.19	18.64	12.95	7.53	1.39	10.41
1959	0.50	0.50	0.50	4.33	14.66	20.86	24.17	25.23	21.55	13.28	4.61	1.75	10.99
1960	0.50	0.50	0.50	4.15	14.68	20.47	22.20	22.56	19.47	12.79	6.00	1.35	10.43
1961	0.50	0.50	0.85	4.92	12.87	17.85	22.21	23.40	22.93	14.10	6.47	0.71	10.61
1962	0.50	0.50	0.62	5.36	16.39	21.44	22.76	21.90	19.05	12.62	4.35	1.80	10.61
1963	0.56	0.50	0.60	6.35	13.45	20.53	22.82	21.43	17.91	13.63	7.80	1.25	10.57
1964	0.53	0.50	0.75	6.25	15.83	19.57	24.38	20.64	18.90	10.44	5.94	1.10	10.40
1965	0.69	0.50	0.50	3.06	16.02	19.90	23.06	22.23	19.01	10.65	4.22	0.76	10.05
1966	0.50	0.50	1.19	6.60	11.95	20.15	25.07	23.10	19.08	11.50	5.47	1.23	10.53
1967	0.50	0.50	0.71	5.68	11.85	21.60	23.44	23.66	19.45	12.15	4.13	1.04	10.39
1968	0.50	0.50	0.68	9.31	14.14	19.31	23.27	22.44	20.17	14.13	4.45	0.52	10.78
1969	0.50	0.50	0.76	6.40	13.56	19.03	23.46	23.66	19.25	10.65	4.13	1.10	10.25
1970	0.58	0.50	0.50	5.27	15.46	20.72	22.69	24.47	18.83	13.79	6.55	0.82	10.85
1971	0.50	0.50	0.50	3.15	12.12	19.59	22.26	21.72	18.53	13.25	4.81	0.50	9.79
1972	0.50	0.50	0.50	2.34	13.01	17.93	22.06	20.77	18.83	9.88	3.23	0.52	9.17
1973	0.50	0.50	1.82	8.09	12.97	20.85	24.53	24.64	19.17	13.25	4.22	1.17	10.98
1974	0.50	0.50	0.76	5.68	12.94	19.42	22.68	22.85	18.44	10.14	5.88	0.60	10.03
1975	0.56	0.50	0.73	4.93	16.63	22.07	25.15	23.64	17.33	12.86	7.89	0.75	11.09
1976	0.50	0.50	0.50	8.35	12.61	21.52	22.45	22.02	18.53	10.69	2.89	0.50	10.09
1977	0.50	0.50	0.87	8.61	16.29	20.67	23.89	22.58	19.67	11.97	7.83	0.53	11.16
1978	1.00	1.00	1.00	3.33	13.85	21.13	23.98	23.61	18.82	12.26	6.57	0.56	10.59
1979	1.00	1.00	1.32	6.97	15.60	20.30	23.27	22.73	19.58	12.74	6.90	1.15	11.05
1980	0.64	0.69	0.38	7.32	15.32	18.80	23.45	24.76	20.02	11.89	4.18	0.59	10.67
1981	0.24	0.19	1.19	9.27	14.18	20.83	24.27	22.87	18.75	10.10	6.12	1.15	10.76
1982	0.88	0.69	0.37	4.52	15.69	20.08	23.65	21.69	18.10	13.48	6.85	1.75	10.65
1983	0.24	0.79	2.09	6.40	13.42	19.62	24.13	23.94	21.30	13.26	5.68	0.80	10.97
1984	0.91	0.77	0.06	6.92	13.34	20.60	23.08	24.06	18.90	13.90	6.47	0.99	10.83
1985	0.64	0.22	0.40	6.90	15.97	18.80	22.76	22.90	19.12	13.60	5.82	0.57	10.64
1986	0.48	0.45	0.40	8.87	16.37	20.25	23.23	23.08	17.72	12.85	5.58	0.94	10.85
1987	0.96	0.69	1.32	10.60	15.84	21.97	24.95	23.16	18.87	12.08	6.10	1.04	11.46
1988	1.01	0.77	1.11	8.08	15.15	20.52	23.29	24.98	18.83	11.63	5.83	1.20	11.03
1989	1.17	1.20	1.56	6.38	14.45	20.93	24.53	23.60	19.90	11.31	5.87	0.88	10.98
1990	0.96	0.53	1.03	7.05	14.68	20.57	23.21	24.06	19.55	12.37	5.85	1.43	10.94
1991	0.24	0.62	1.29	8.18	16.73	22.82	24.52	23.31	20.67	12.37	5.43	0.94	11.42
1992	1.14	0.79	0.25	5.80	15.34	20.07	21.66	21.27	19.23	11.65	4.70	1.15	10.25
1993	0.32	0.19	0.01	4.50	13.92	18.83	23.63	23.63	19.18	10.91	5.03	1.16	10.11
1994	0.72	0.53	0.29	5.79	13.18	20.03	23.98	22.38	18.62	13.12	7.85	1.63	10.68
1995	0.86	0.54	2.22	7.11	14.24	21.36	24.08	24.55	18.34	13.11	4.24	0.80	10.95
1996	0.79	0.61	0.78	6.26	13.16	20.76	23.02	23.47	20.39	12.76	5.49	1.91	10.78
1997	0.56	0.50	0.63	5.27	11.94	20.33	23.98	22.87	19.00	13.11	4.60	1.15	10.33
1998	1.10	0.89	2.21	9.43	18.02	20.53	24.24	24.19	20.72	13.61	6.49	3.38	12.07
1999	1.14	1.04	1.71	8.57	17.10	22.64	25.03	23.03	20.56	12.53	6.40	2.37	11.84
2000	1.10	0.89	2.98	7.39	15.07	19.27	22.37	23.38	19.73	12.77	6.33	1.26	11.05
2001	0.81	0.41	0.56	6.70	16.82	20.87	23.08	24.79	20.15	12.58	7.37	4.31	11.54
2002	0.70	1.13	1.00	7.50	11.80	19.60	24.80	24.80	22.10	11.30	4.20	1.10	10.84
2003	0.79	0.80	0.75	4.78	13.55	18.40	22.84	23.98	20.11	10.96	4.69	0.80	10.20
2004	0.95	0.59	0.71	6.53	14.63	19.30	22.08	21.77	19.94	12.95	7.23	3.07	10.81
2005	0.75	1.85	1.84	6.82	12.74	21.19	24.50	23.07	20.19	12.73	6.54	3.35	11.30
2006	2.09	1.69	2.49	8.53	13.85	19.07	24.78	24.05	18.70	11.85	6.19	2.44	11.31
2007	1.65	0.34	1.00	5.46	15.65	22.35	21.20	23.60	20.58	15.87	6.38	1.34	11.28
2008	0.42	0.16	1.07	8.54	15.02	23.17	25.03	23.78	21.26	13.25	5.43	1.10	11.52
2009	2.29	0.58	2.56	8.29	15.53	19.73	22.63	24.32	20.45	11.29	7.48	2.10	11.44
Mean	0.76	0.67	1.02	6.39	14.29	20.28	23.42	23.13	19.35	12.35	5.73	1.27	10.73

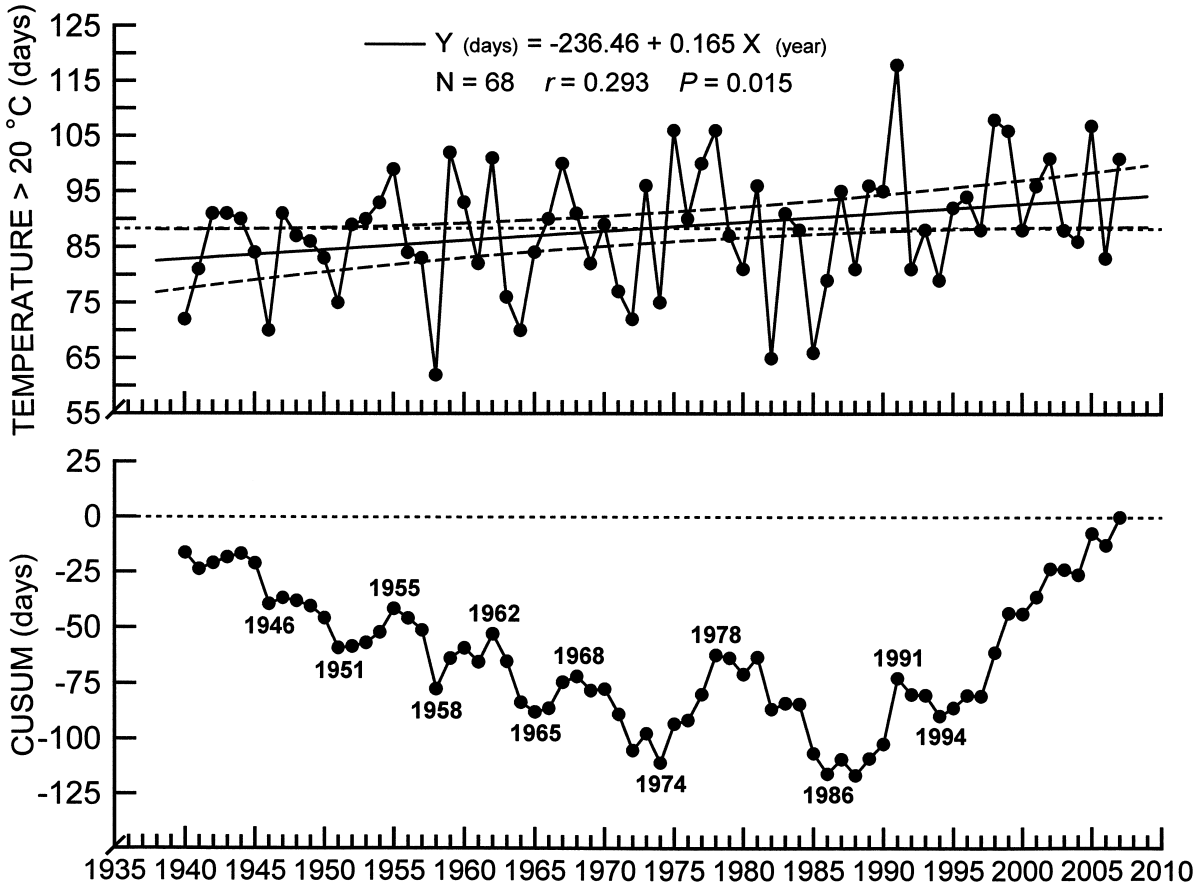
Appendix A1.2. Mean annual thermal units (degree days – C) for surface water temperature for the upper Bay of Quinte for a 68-year period, 1940-2007. The accumulated sum of the residuals (CUSUM, ^{o}C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided. Water temperature was measured in upper bay at the Belleville municipal pumping station for water drawn at approximately 3.2 m. Bay of Quinte water temperatures at this location are homothermous.



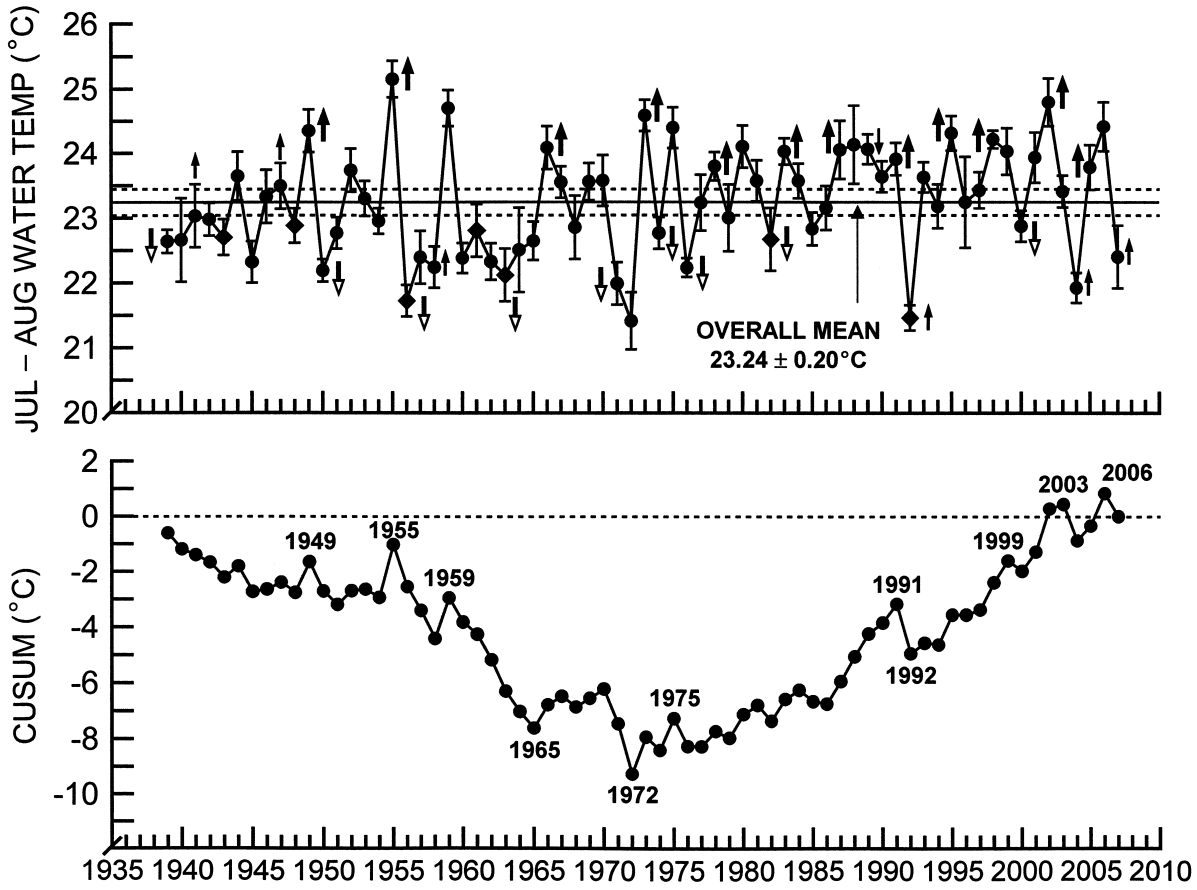
Appendix A1.3. Mean monthly surface water temperature for the open-water period (Apr-Sep) for the upper Bay of Quinte for a 68-year period, 1940-2007. The accumulated sum of the residuals (CUSUM, ^{o}C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided. Water temperature measured in upper bay at the Belleville municipal pumping station for water drawn at approximately 3.2 m. Bay of Quinte water temperatures at this location are homothermous.



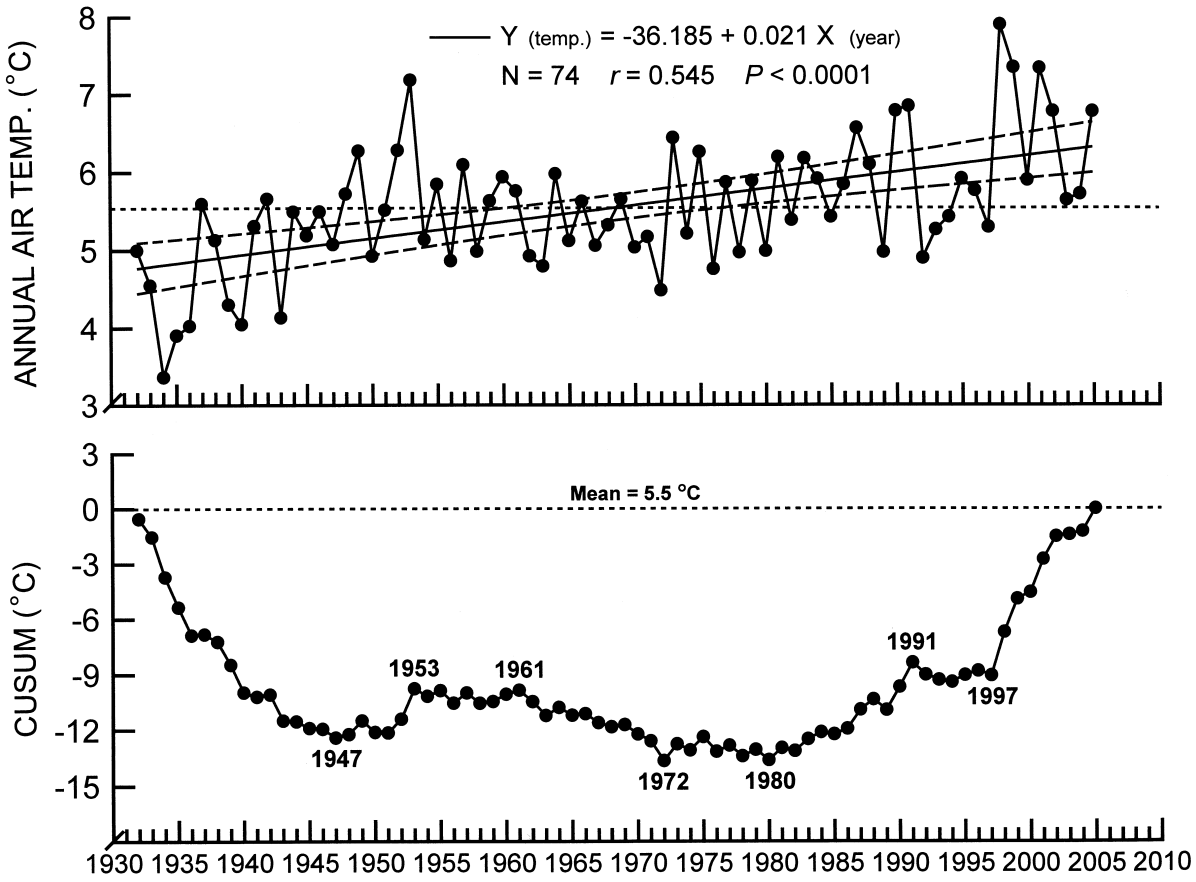
Appendix A1.4. Duration of high temperature period (>20°C) for surface water temperatures for the upper Bay of Quinte for a 68-year period, 1940-2007. The accumulated sum of the residuals (CUSUM, °C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided. Water temperature measured in upper bay at the Belleville municipal pumping station for water drawn at approximately 3.2 m. Bay of Quinte water temperatures at this location are homothermous.



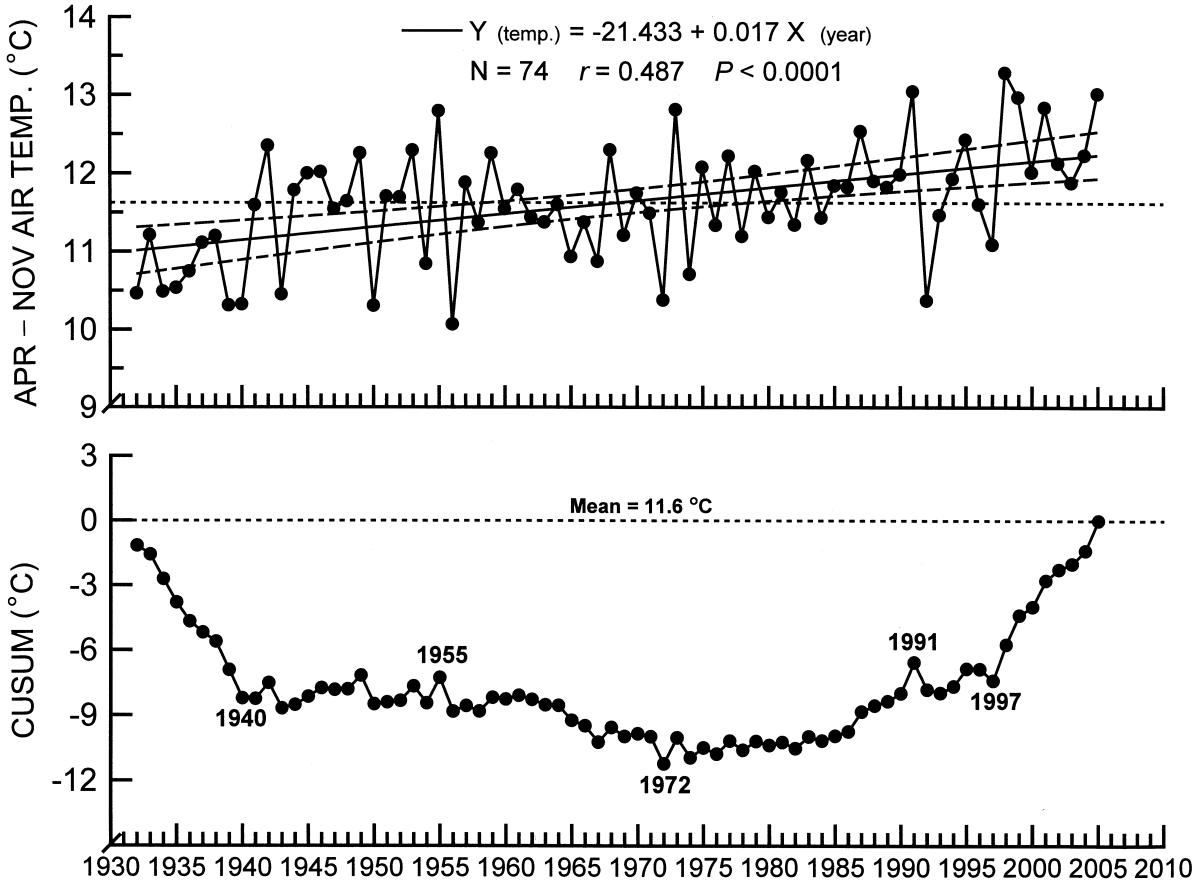
Appendix A1.5. Mean monthly midsummer surface water temperature (Jul-Aug) for the upper Bay of Quinte for a 69-year period, 1939-2007. The accumulated sum of the residuals (CUSUM, °C) about the mean is also provided, indicating the years when dynamic change occurred. Means and 95% confidence intervals are provided. Means with large closed up arrow indicate a high temperature extreme (>95% confidence limit for the period) and correspond to and indicate the expression of an El Niño event that year in the tropical Pacific. Small closed up arrows indicate El Niño events in the tropical Pacific that were not expressed by significantly increased midsummer water temperatures in the Bay of Quinte. Large open down arrows indicate low temperature extremes (>95% confidence limit for the period) and correspond to and indicate the expression of a La Niña event that year in the tropical Pacific. Small closed down arrows indicate El Niño events in the tropical Pacific that were not expressed by significantly increased midsummer water temperatures in the Bay of Quinte. Water temperature was measured in upper bay at the Belleville municipal pumping station for water drawn at approximately 3.2 m. Bay of Quinte water temperatures at this location are homothermous.



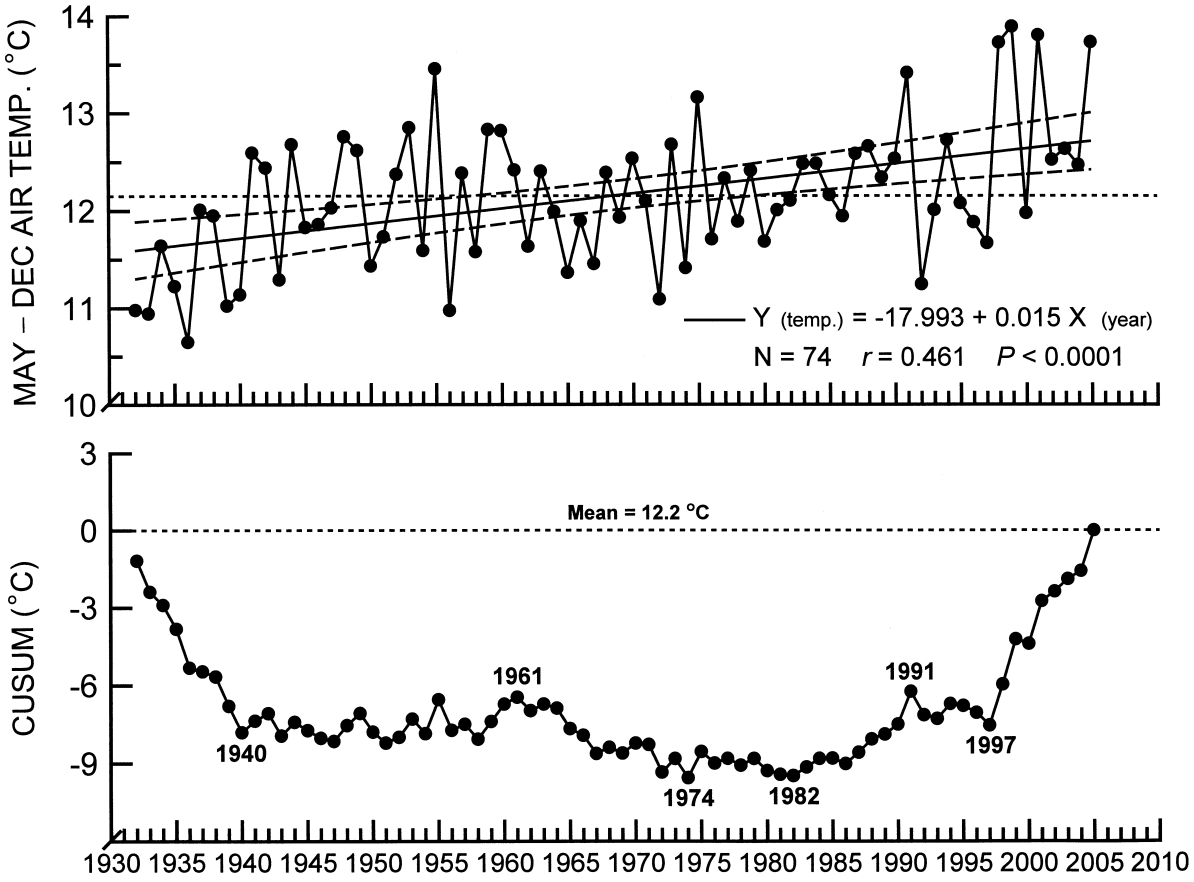
Appendix A1.6. Mean monthly summer air temperature for the Mississippi River and watershed for a 74-year period, 1932-2005, as estimated from air temperature at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, ^{o}C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



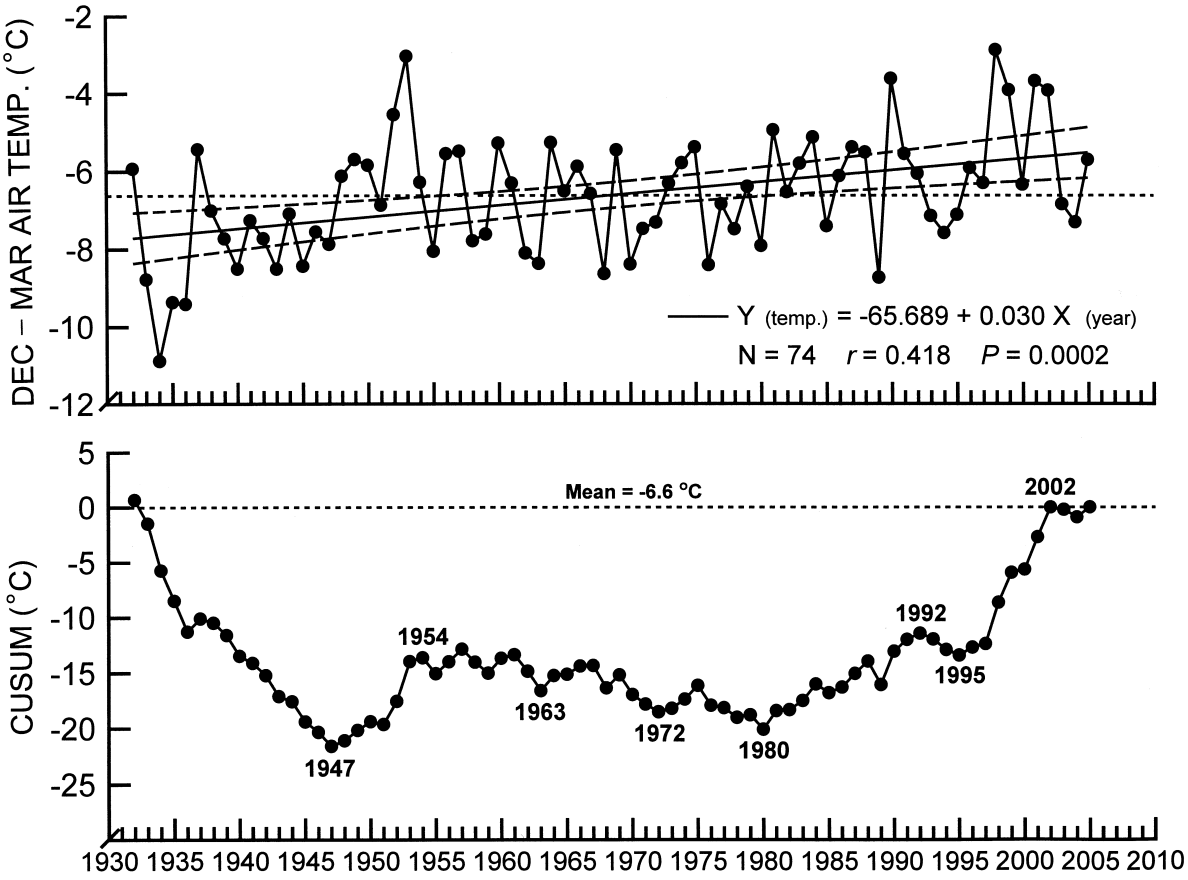
Appendix A1.7. Mean monthly air temperature for the open-water period (Apr-Nov) for the Mississippi River and watershed for a 74-year period, 1932-2005, as estimated from air temperature at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, °C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



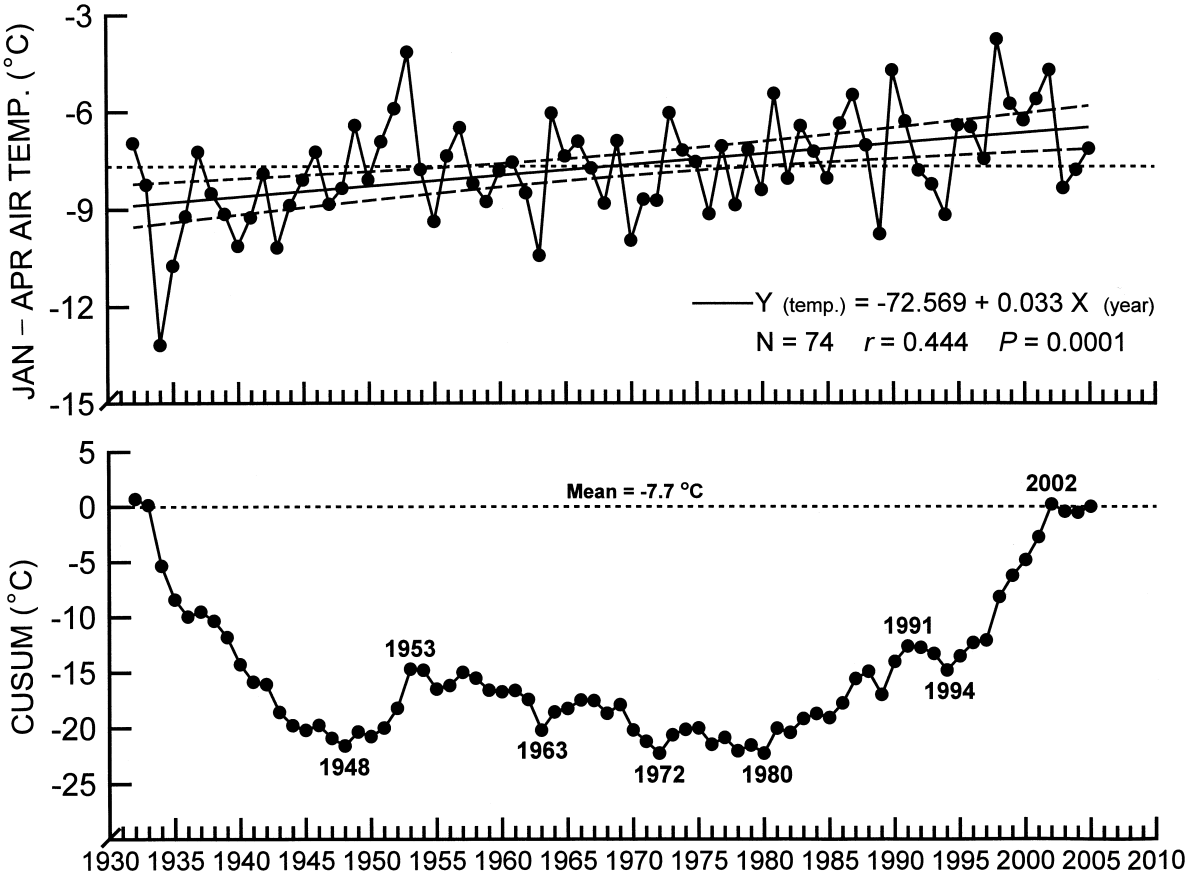
Appendix A1.8. Mean monthly air temperature for the open-water period (May-Dec) for the Mississippi River and watershed for a 74-year period, 1932-2005, as estimated from air temperature at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, °C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



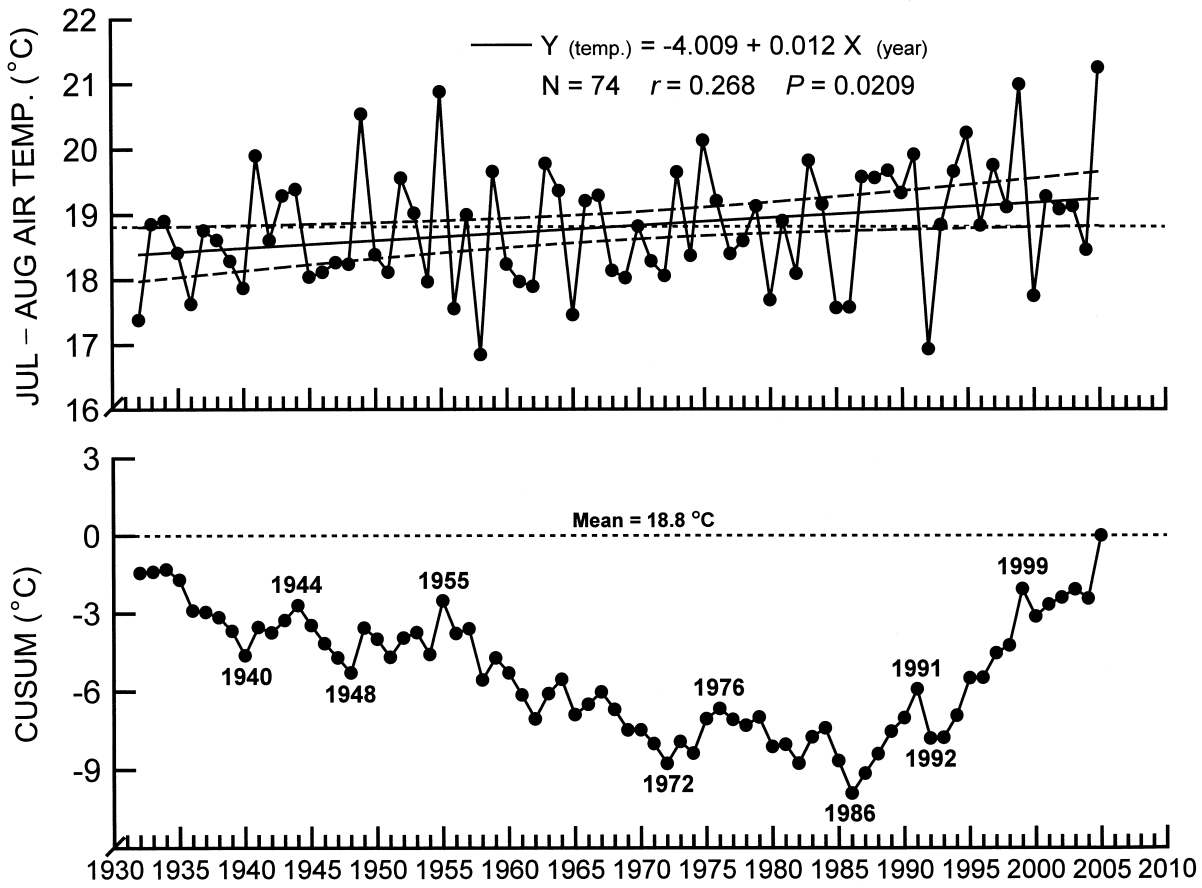
Appendix A1.9. Mean monthly air temperature for the closed-water period (Dec-Mar) for the Mississippi River and watershed for a 74-year period, 1932-2005, as estimated from air temperature at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, °C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



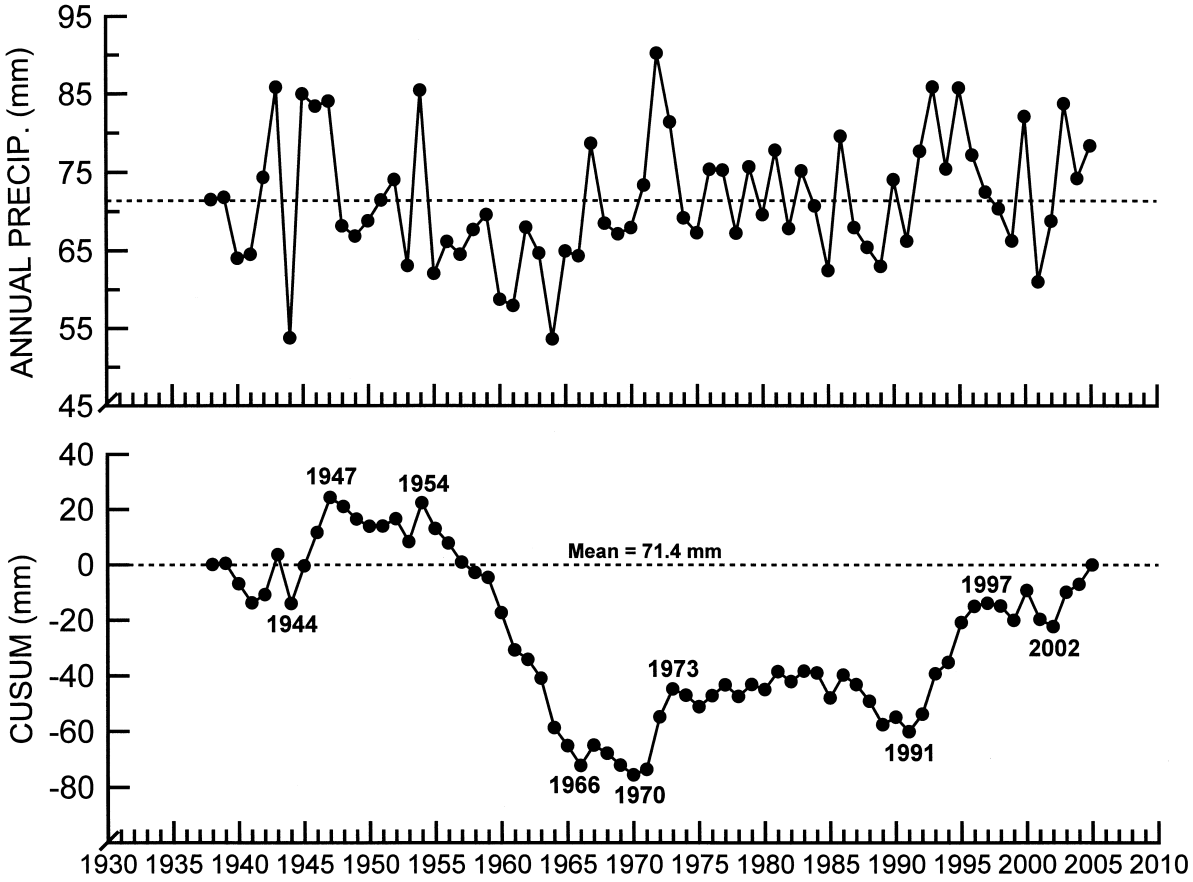
Appendix A1.10. Mean monthly air temperature for the closed-water period (Jan-Apr) for the Mississippi River and watershed for a 74-year period, 1932-2005, as estimated from air temperature at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, °C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



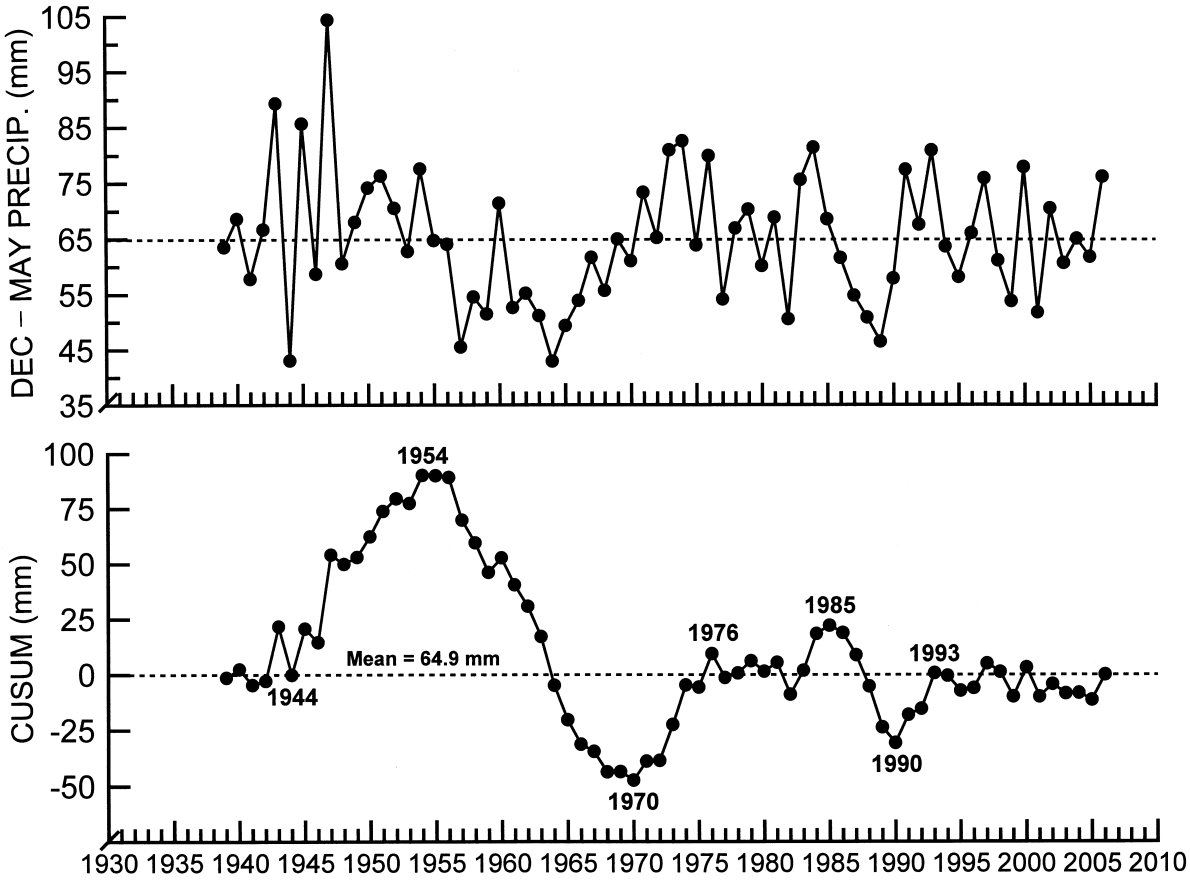
Appendix A1.11. Mean monthly midsummer air temperature for the Mississippi River and watershed for a 74-year period, 1932-2005, as estimated from air temperature at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, ^{o}C) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



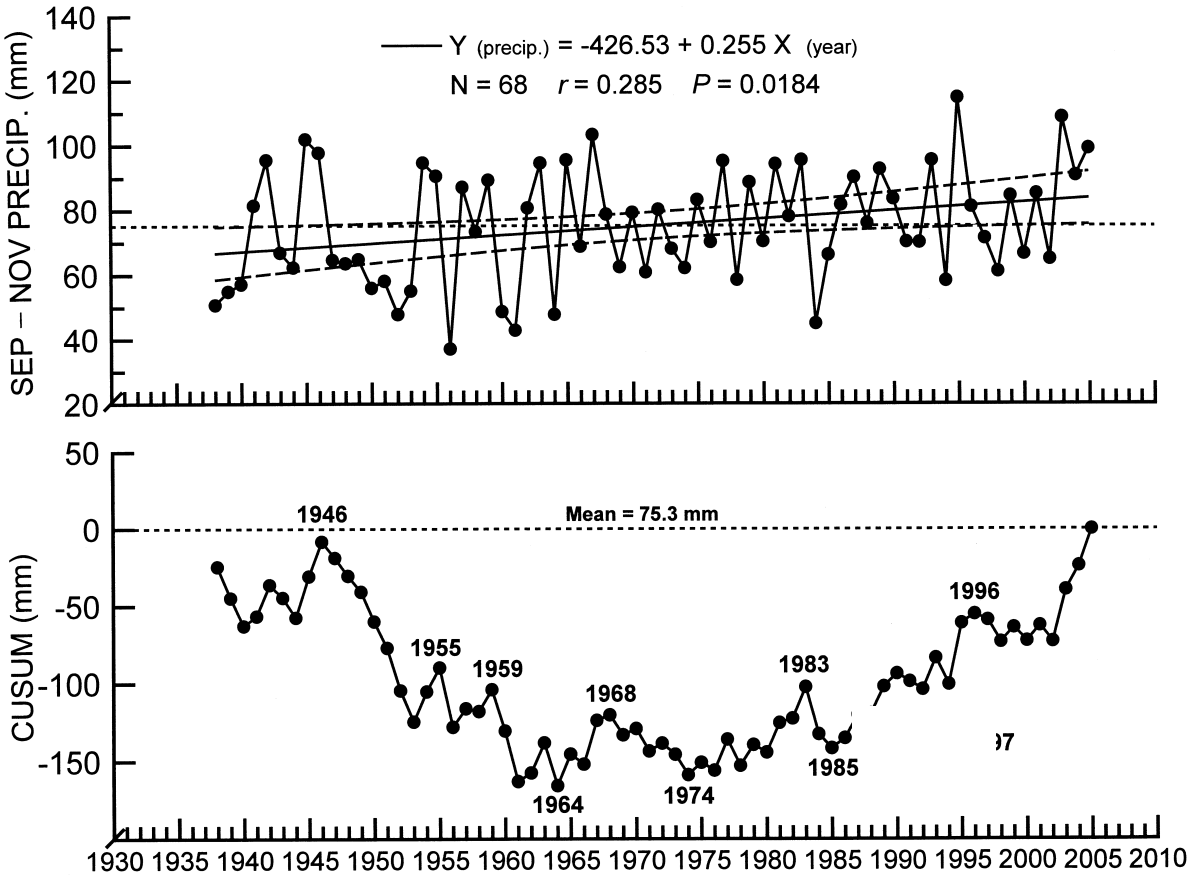
Appendix A1.12. Mean monthly precipitation (rain and snow) for the Mississippi River and watershed for a 68-year period, 1938-2005, as estimated from precipitation measured at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, oC) about the mean is also provided, indicating the years when dynamic change occurred.



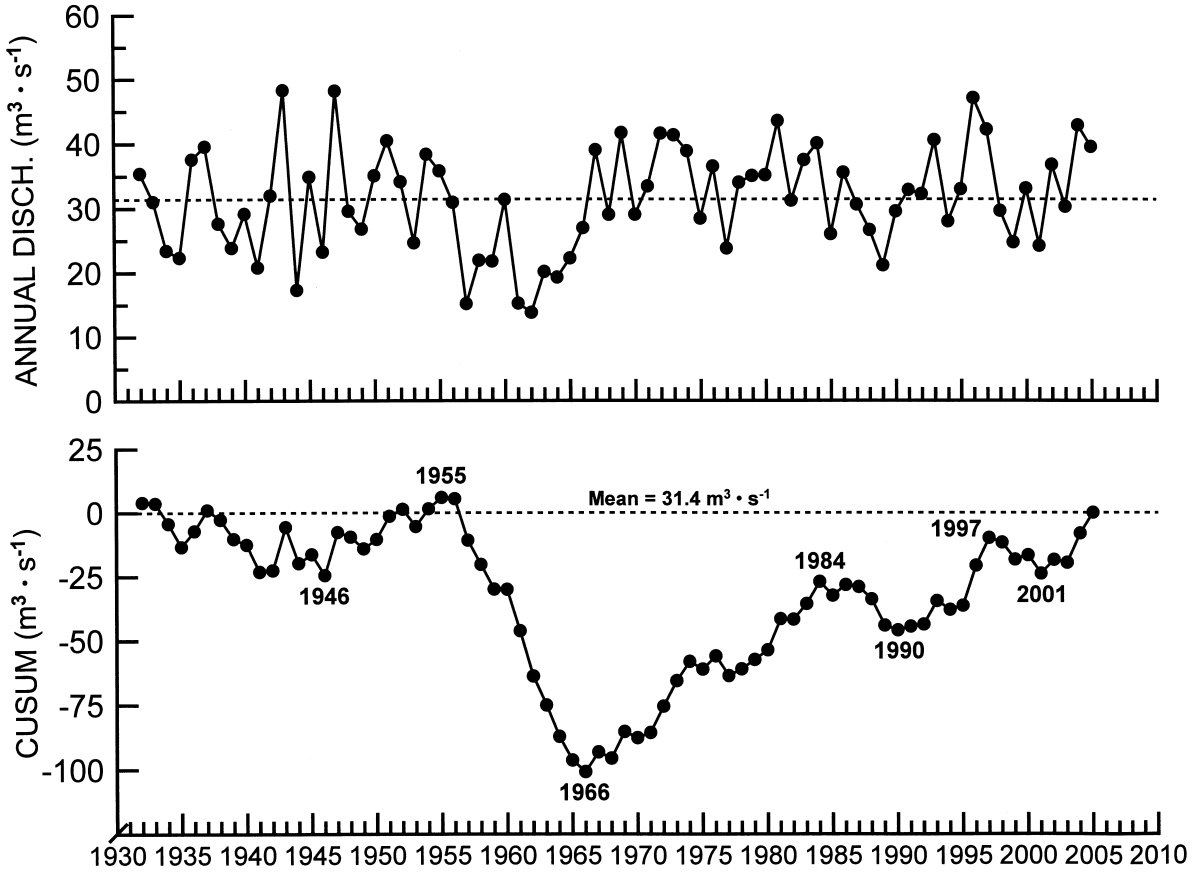
Appendix A1.13. Mean monthly winter and spring precipitation (rain and snow) (Dec-May) for the Mississippi River and watershed for a 68-year period, 1938-2005, as estimated from precipitation measured at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, ^{o}C) about the mean is also provided, indicating the years when dynamic change occurred.



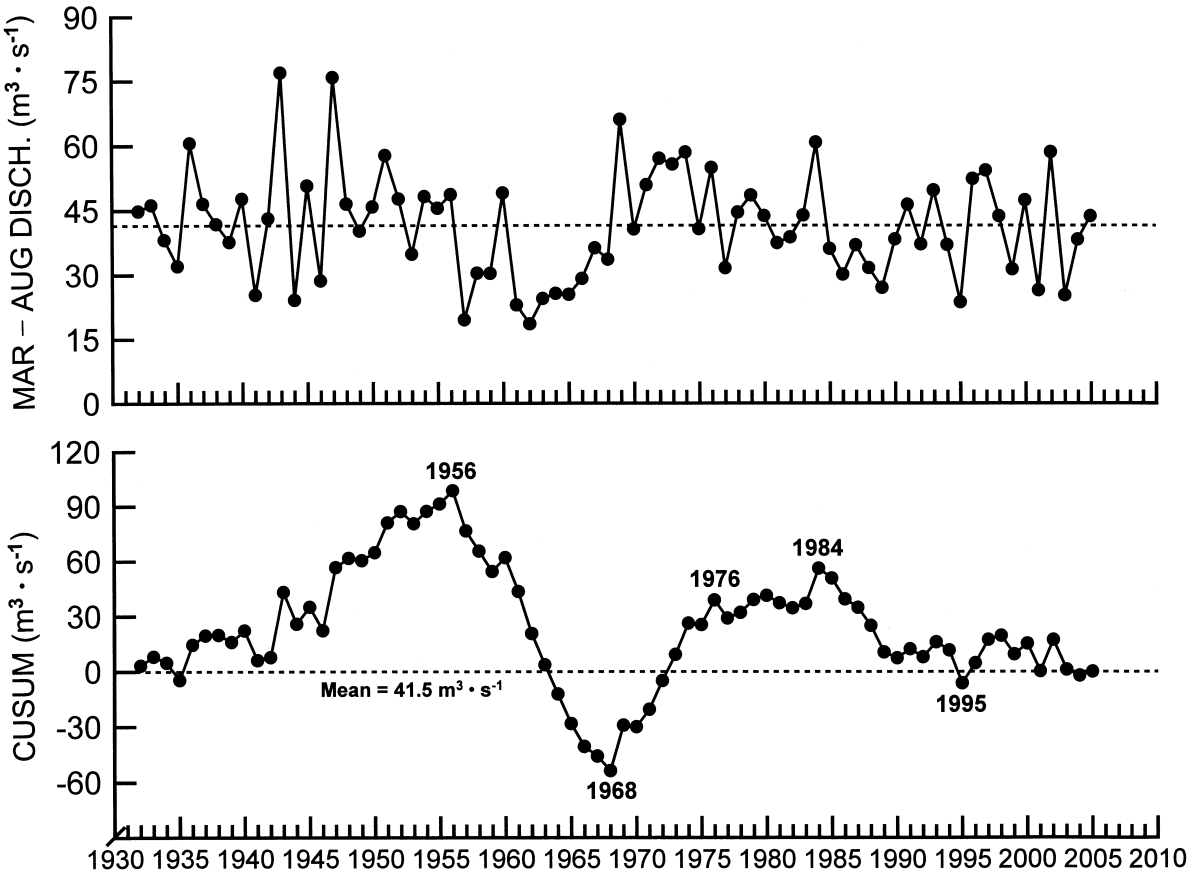
Appendix A1.14. Mean monthly fall precipitation (rain and snow) (Sep-Nov) for the Mississippi River and watershed for a 68-year period, 1938-2005, as estimated from precipitation measured at seven Environment Canada stations in the watershed and vicinity of Appleton. The accumulated sum of the residuals (CUSUM, ^{o}C) about the mean is also provided, indicating the years when dynamic change occurred. Means and 95% confidence intervals are provided, including the regression line, curved 95% confidence limits, equation, and associated statistics.



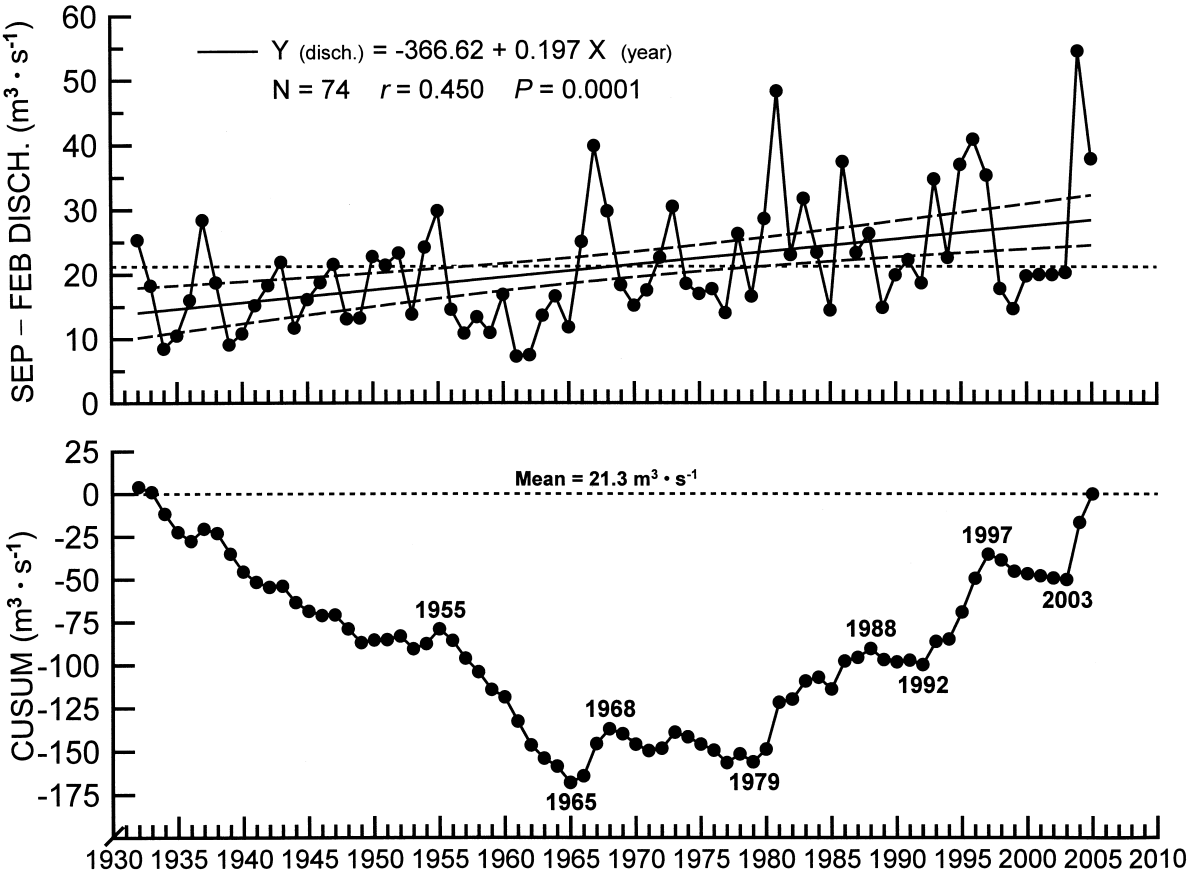
Appendix A1.15. Mean monthly discharge ($m^3 \cdot s^{-1}$) of the Mississippi River as measured at the Appleton gauge just upstream from the Appleton control dam and hydroelectric facility of Canadian Hydro Developers for a 74-year period, 1932-2005. The accumulated sum of the residuals (CUSUM, ^oC) about the mean is also provided, indicating the years when dynamic change occurred. Dotted line indicates mean.



Appendix A1.16. Mean monthly spring and summer discharge (Mar-Aug) ($m^3 \cdot s^{-1}$) of the Mississippi River as measured at the Appleton gauge just upstream from the Appleton control dam and hydroelectric facility of Canadian Hydro Developers for a 74-year period, 1932-2005. The accumulated sum of the residuals (CUSUM, ^oC) about the mean is also provided, indicating the years when dynamic change occurred. Dotted line indicates mean.



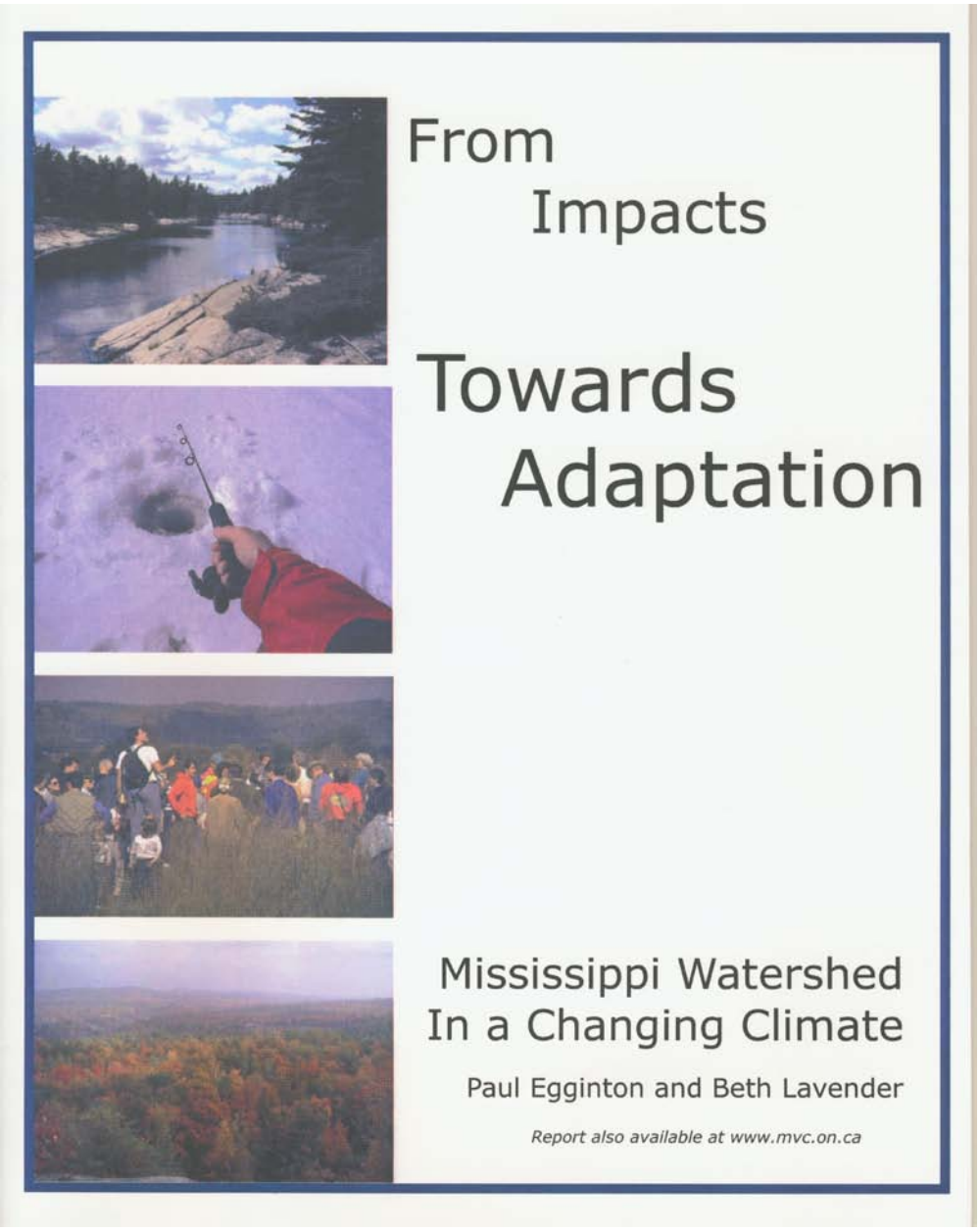
Appendix A1.17. Mean monthly fall and winter discharge (Sep-Feb) ($m^3 \cdot s^{-1}$) of the Mississippi River as measured at the Appleton gauge just upstream from the Appleton control dam and hydroelectric facility of Canadian Hydro Developers for a 74-year period, 1932-2005. The accumulated sum of the residuals (CUSUM, ^oC) about the mean is also provided, indicating the years when dynamic change occurred. The regression line, curved 95% confidence limits, equation, and associated statistics are provided.



7.2 Appendix A2 Weathering Climate Change – Stakeholders Outreach and Science Transfer Workshop

Egginton, P., and B. Lavender. [2009, manuscript report]. From impacts towards adaptation: Mississippi watershed in a changing climate. A summary of stakeholder workshops held in Almonte, Ontario, 2007. Sponsored by Mississippi Valley Conservation and Mississippi Valley Field Naturalists. 50 pages. See www.mvc.on.ca, 2009.

Cover page



7.2 Appendix A3 Impacts, Adaptive Capacity, and Socio-economic Consequences of Climate Change on Fish Resource Use and Management in Ontario: A Survey of Resource Users, Businesses, and Professionals

A copy of the survey follows this page and should be referenced as:

Marcogliese, L.A. 2008. Questionnaire and survey used to determine economics, consequences, and adaptation to climate change, conducted with fish resource users (anglers, businesses, professionals). Survey, unpublished research form, Ameliasburg, Ontario. 25 pages.

All respondents who completed and returned questionnaires were eligible, at the participant's request, to participate in a random draw to win a stay for four, graciously donated by Tumblehome Lodge, Crotch Lake, Mississippi Valley Watershed. Draw was held on February 20, 2008.

The announcement of the draw was illustrated with the following graphics:

Jerry Mitrovich from St. Catharines, Ontario, was the winner of the prize package that included a two-night stay for four and the use of a pontoon boat for a day at Tumblehome Lodge, located on Crotch Lake in the Mississippi Valley Watershed. Jerry obtained his copy of the survey from the website of the Ontario Federation of Anglers and Hunters. Over 200 people submitted a survey, and Jerry's name was randomly drawn from these submissions.

*** *Survey* ***

We solicit your assistance in a survey of adaptation and climate change in relation to fish, fisheries, and water-resource use

Participant: We are soliciting your assistance with an anonymous survey we are conducting on climate change, fisheries, and water-resource use. This study is sponsored by Natural Resources Canada and is part of a more extensive study of "Fish, Fisheries, and Water Resources: Adapting to Ontario's Changing Climate." The component with which we request your assistance involves evaluating your opinions, perceptions, and adaptations to changing aquatic resources: "Examining Impacts and Economic Consequences of Global Climate Change on Fish Resources and Resource Use". The survey is being conducted through Queen's University at Kingston, with the cooperation of several agencies, including Mississippi Valley Conservation and Mississippi Valley Field Naturalists.

We would appreciate your participation in completing the accompanying questionnaire. Participation is voluntary. The questions deal specifically with fisheries use and experiences, past and present, and include issues or concerns you have for the future of the resource and its use. When you have completed the questionnaire, please return it by e-mail to Lucian Marcogliese or by ground-mail to Lucian A. Marcogliese, 30 Salem Road, R.R.1, Ameliasburgh, Ontario K0K 1A0. We hope to have them returned by February 11, 2008. All completed and returned questionnaires will be eligible, at the participants request, to participate in a random draw to win a stay for four, graciously donated by Tumblehome Lodge, Crotch Lake, Mississippi Valley Watershed. Draw will be held on February 20, 2008.

This research will allow us to gauge past, present, and future resource use and make recommendations that will take into consideration social and economic concerns of resource users in relation to global climate change and adaptation. Working with resource users and understanding their willingness to adapt will provide the cornerstone for sound scientific recommendations and management.

For quality control purposes and in the event you win the draw, you will be asked to provide your name and contact information, which only this researcher will have access to. All questionnaires, however, are anonymous and confidential as each respondent will be given a random number for all subsequent data entry and analyses. All answers will be compiled and used only through a statistical analysis, presenting average results for the survey, which we hope will consist of some 500 questionnaires. Your decision to complete and return this questionnaire will be interpreted as an indication of your consent to participate. If you are interested in the results of the survey, we expect to post them in the spring, 2008, on the websites of Mississippi Valley Conservation (http://www.mvc.on.ca/), and the OFAH (http://www.ofah.org/). After completion of the study, all personal information will be destroyed. The personal information on this form is collected under the authority of the Queen's Royal Charter of 1841, as amended.

We look forward to your response and greatly appreciate your time and effort.
If you have any questions or concerns please contact:

Lucian A. Marcogliese, M.Sc., Consulting Research Biologist, 30 Salem Road, R.R. 1, Ameliasburgh, Ontario K0K 1A0, Phone: 613-961-1529, e-mail: ccfsurvey@sympatico.ca

John M. Casselman, Ph.D , Adjunct Professor, Queen's University, Department of Biology, 116 Barrie Street Kingston, Ontario K7L 3N6, Phone: 613-533-6000 ext. 75371, e-mail: casselmj@queensu.ca

General Research Ethics Board, Queen's University, Kingston, Ontario, K7L 3N6, Phone: 613-533-6081, e-mail: greb.chair@queensu.ca

Natural Resources Canada Ressources naturelles Canada Queen's University Mississippi Valley Conservation

All participants who return a completed questionnaire are eligible to win a two night stay for four at Tumblehome Lodge, Crotch Lake, in the Mississippi Valley Watershed

- Two nights accommodations valid May10–June 28, or August 24 to closing, 2008, (subject to availability)
- Use of a pontoon boat for a day
- Visit the Tumblehome Lodge website (http://www.virtualnorth.com/tumblehome/).

Please indicate if you wish to be entered in the draw to win the trip at Crotch Lake.

Yes		**No**	

Survey Guidelines:

1. Please read and follow the instructions carefully and answer each question in sequence. Do not go back to fill in or change answers.

2. All lists in survey questions are presented in alphabetical or chronological order.

3. When asked to check boxes or indicate, mark with an **X**.

4. For electronic surveys, **Comments** box will expand as needed. If comments are long, formatting on following pages may be affected. This is not a problem as long as you can follow the questions.

5. For paper surveys, additional comments can be made at the end of survey. Indicate the Section, Question Number, and any information needed to match your comments to the proper question. Please print clearly.

6. Three main groups associated with fish resources in Ontario are being asked to participate in this survey. They are:
    a. Anglers—(casual to avid)
    b. Business Service Providers—(lodges, camps, etc.)
    c. Fish Resource Professionals—(career or occupation)

    In Section 2 of the survey you will be asked which of these three groups best describes your association with fish resources in Ontario. Some participants may find they belong to more than one group.
    Note: A similar survey is also being conducted with bait fishers, commercial fishers, and First Nations.

7. The survey is shorter than it appears as you will not have to answer all sections of the survey. Sections are designed for the three different fish resource groups. **Anglers—18 pages; Businesses—16 pages; Professionals—15 pages.**

8. Only answer sections that apply to you. If you belong to more than one group, complete the sections that apply to groups you belong to.

9. If you indicated 'Other' (Group 4), for your Group association with fish resources, complete sections that best describes your association with fish resources.

10. Depending on the detail of comments you provide, tests indicate the survey **takes 30-60 minutes** to complete if you are answering for one group associated with fish resources.

11. For non-Ontario residents, answer questions as they relate to your experiences and fishing in Ontario only.

12. We hope to have the completed surveys returned by February 11, 2008.

Thank you in advance for your time and effort, we look forward to your response.

Lucian A. Marcogliese and John M. Casselman

Ontario Fish Resource Study

Section 1—Issues—To be completed by all Participants

1. Below are listed some issues of concern regarding fish resources in Ontario. Please list in order of importance the **four (4)** issues that you consider to have the highest priority for Ontario's fish resources. Rank the most important as one (1), the second most important as two (2), and so on.

No.	Issue	Rank	Comments
1	Administration powers to Clubs and Associations (more or less)		
2	Climate change (affects)		
3	Enforcement services		
4	Invasive species—non-native		
5	Habitat		
6	Hatchery operations and stocking		
7	Lamprey control		
8	Pollution control		
9	Property owner and fish user relations		
10	Public education		
11	Regulations and laws		
12	Research: biological aspects of the fish resource		
13	Research: needs of the fish resource user		
14	Water conditions—levels, flow, temperature		
15	Other: please specify		

Section 2—Primary Fish Resource Users, Businesses, Professionals, and Associations—To be completed by all Participants

1. Indicate the **Group (No. 1-4, bolded and shaded)** that best describes your association with fish resources. If more than one **Group** pertains to you, indicate the **Group** that pertains most to you with one (1), and second most with two (2), and so on. If you indicated more than one **Group**, estimate by percent, how often that **Group** pertains to you in a given year. Total percent should equal 100%.

2. Listed under each **Group** are **Associations** and/or uses of the fish resource. For the **Group(s)** you indicated, check as many **Associations** or uses that pertain to you.

No.	Group	Check	%	Comments
1	**Anglers—Resource Users**			
	Associations/Uses	**Check**		
	Cottage/ Lake Associations			
	Derby fishing			
	First Nations			
	Fish Clubs or Federations			
	Recreational/Sport fishing			
	Sustenance (food)			
	Tournament fishing			
	Waterfront land owner			
	Other: please specify			
No.	**Group**	**Check**	**%**	**Comments**
2	**Businesses—Service Providers**			
	Associations	**Check**		
	Camp operator			
	Charter operator or guide			
	Lodge/Resort operator			
	Outfitter/Tourist operator			
	Other: please specify			
No.	**Group**	**Check**	**%**	**Comments**
3	**Fish Resource Professional**			
	Associations/Occupations	**Check**		
	Biologist			
	Conservation Officer			
	Manager			
	Scientist			
	Technician			
	Other: please specify			
No.	**Group**	**Check**	**%**	**Comments**
4	**Other: please specify**			
		Check		

3. What **Species or Group** of fish do you usually attempt to catch (Anglers); your customers attempt to catch (Businesses); or are considered most important in the area you work in fisheries (Resource Professionals)? Rank the **4**

(four) most important species in order of importance. Rank the most important as one (1), the second most important as two (2), and so on.

4. Of these four species, estimate by percent, How often you (anglers), or your customers (businesses) attempt to catch this **Species or Group**; or for fish resource Professionals, it's importance in your District or Area . Total percent should equal 100%. If possible, indicate species for Salmon, and Sunfish.

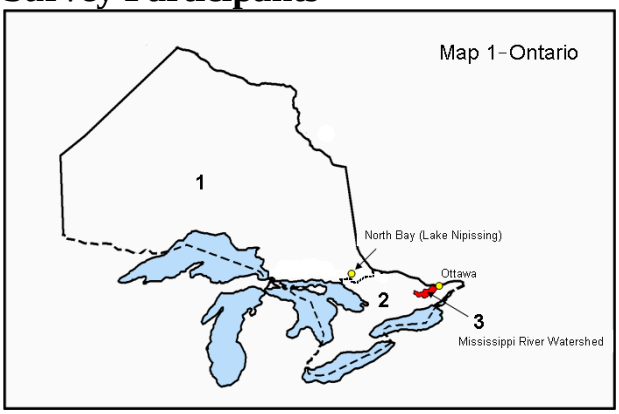
No.	Species or Group	Anglers		Businesses		Professionals		Comments
		Rank	%	Rank	%	Rank	%	
1	Brook trout							
2	Brown bullhead							
3	Brown trout							
4	Burbot							
5	Carp							
6	Channel catfish							
7	Ciscoe (herring)							
8	Crappie (white and black)							
9	Lake sturgeon							
10	Lake Trout							
11	Largemouth bass							
12	Muskellunge							
13	Northern pike							
14	Rainbow trout							
15	Rock bass							
16	Salmon (indicate type)							
17	Sauger							
18	Smallmouth bass							
19	Sunfish (bluegill, pumpkinseed)							
20	Walleye (pickerel)							
21	Whitefish							
22	White perch							
23	White sucker							
24	Yellow perch							
25	Other: please specify							

5. How long have you had an association with fish in any capacity?

Years	

Section 3—To be completed by all Groups (Groups 1-4)

Survey Participants



Please answer or check the appropriate box.

1. Name and contact information. Strictly confidential will not be used except for quality control purposes and the draw.

Name	
Contact Information	

2. Sex

Male		**Female**	

3. Age (yrs)

Under 20		**50-59**	
20-29		**60-69**	
30-39		**70-79**	
40-49		**80 and over**	

4. Were you born in Ontario?

Yes		**No**	

5. Are you a resident of Ontario?

Yes		**No**	

6. If yes, what County in Ontario do you reside?

County	

7. If yes, using Map 1, indicate the area in Ontario that you reside?

Area	Description	Check
1	Northern Ontario (north of North Bay-Lake Nipissing)	
2	Southern Ontario (south of North Bay-Lake Nipissing)	
3	Mississippi River Watershed (Lennox, Lanark, Frontenac counties, City of Ottawa)	

8. How long have you lived in this Area of Ontario?

Years	

9. If you are not a resident of Ontario, where do you reside?

Province	
State	
Other: please specify	

Section 4—To be completed by all Groups (Groups 1-4)
Observations and Affects

1. In the areas you fish; operate a fish resource business; or work in fisheries; Have you noticed any meteorological (weather) related environmental changes? (see list below)

Yes		**No**	

2. If yes, from the list below:
   - Rank the environmental changes you have noticed. Rank the most noticeable change as 1 (one), the second most noticeable change as 2 (two), and so on. **Only rank the changes you have noticed.**
   - Indicate the year you first noticed the environmental change, or provide an approximate time period (i.e. 1970-75).
   - For the changes you have indicated, please comment on how they have changed.

No.	Environmental Changes	Rank	Year(s)	How have conditions changed?
1	Air temperature			
2	Drought			
3	Flooding			
4	Ice-cover (duration)			
5	Ice-cover (thickness)			
6	Rainfall			
7	Snowfall			
8	Spring runoff (snow melt)			
9	Water flow			
10	Water levels			
11	Water temperature			
12	Winds			
13	Other: please specify			

3. Have any of these environmental changes you indicated affected your fishing; your customer's fishing; or your work in fisheries?

Yes		**No**	

- If yes, rank the environmental change with the most affect as 1 (one), the second most as 2 (two), and so on. **Include and rank only the environmental changes you have indicated in the previous question (Question # 2).**

- Have the environmental changes you listed had a positive **(P),** negative **(N)**, or no affect **(NA)** on your fishing; your customer's fishing; or your work in fisheries? Please **check** the appropriate box.

- For environmental changes you indicated as having either a **positive** or **negative** affect, please **Comment** on how these changes affected your fishing; your customer's fishing; or your work in fisheries.

No.	**Environmental Changes**	**Rank**	**Affect**			**Comments**
			P	**N**	**NA**	
1	Air temperature					
2	Drought					
3	Flooding					
4	Ice-cover (duration)					
5	Ice-cover (thickness)					
6	Rainfall					
7	Snowfall					
8	Spring runoff (snow melt)					
9	Water flow					
10	Water levels					
11	Water temperature					
12	Winds					
13	Other: please specify					

4. In the areas you fish; have fish resource businesses; or work in fisheries; Have you noticed any fish community changes?

Yes		**No**	

If yes, from the list below:

- Rank the fish community changes you have noticed. Rank the most noticeable change as 1 (one), the second most noticeable change as 2 (two), and so on. **Only rank the changes you have noticed.**

- Indicate the year you first noticed the fish community change, or provide an approximate time period (i.e. 1970-75).

- For the changes you have indicated, please comment on how they have changed. If applicable, indicate the species you are referring to.

No.	**Fish Community Changes**	**Rank**	**Year(s)**	**How has the fish community changed?**
1	Introduced species (fish stocking)			
2	Invasive species — non-native (fish, animal, plant)			
3	Plants—protruding above water (weeds)			
4	Plants—submerged (weeds)			
5	Species type (fish)			
6	Species abundance (fish)			
7	Species size (fish)			
8	Water clarity (algae blooms)			
9	Other: please specify			

5. Have any of these fish community changes you indicated affected your fishing; your customer's fishing; or your work in fisheries?

Yes		**No**	

- If yes, rank the fish community change with the most affect as 1 (one), the second most as 2 (two), and so on. **Include and rank only the fish community changes you have indicated in the previous question (Question # 4).**

- Have the fish community changes you listed had a positive **(P),** negative **(N)**, or no affect **(NA)** on your fishing; your customer's fishing; or your work in fisheries? Please **check** the appropriate box.

- For fish community changes you indicated as having either a **positive** or **negative** affect, please **Comment** on how these changes affected your fishing; your customer's fishing; or your work in fisheries.

No.	**Fish Community Changes**	**Rank**	**Affect**			**Comments**
			P	**N**	**NA**	
1	Introduced species (fish stocking)					
2	Invasive species—non-native (fish, animal, plant)					
3	Plants protruding above water (weeds)					
4	Plants submerged (weeds)					
5	Species type (fish)					
6	Species abundance (fish)					
7	Species size (fish)					
8	Water clarity (algae blooms)					
9	Other: please specify					

6. Do you know of any examples of how global climate change has affected fish communities in Ontario?

Yes		No	

7. Do you feel that global climate change has impacted the use of fish resources in Ontario?

Yes		No		Do Not Know	

8. Do you attribute any of the environmental or fish community changes you listed previously in this Section (Questions 2 & 4) on global climate change?

Yes		No		Do Not Know	

- If yes, list the environmental and fish community changes you attribute to global climate change?

No.	Environmental Changes	Fish Community Changes
1		
2		
3		
4		
5		
6		
7		
8		

Please complete the following Sections that pertain to the Group that best describes your association with fish resources (Section 2).
Group 1—Angler—Resource User
Group 2—Business Service Providers (guide, resort operator etc.)
Group 3—Fish Resource Professional (Conservation Officer, Technician etc.) —Occupation
Group 4—Other (answer sections that best match your association with fish resources, i.e. Group 1, 2, 3)

If you indicated in Section 2 that you belonged to more than one of these Groups (i.e. Business Service Provider and Angler), please complete Sections pertaining to all Groups that you belong.

Section 5--To be completed by Anglers (Group 1)

Current Use

1. Including yourself, how many people in your household fish in Ontario?

Number	

2. How long have you fished in Ontario?

Years	

For questions 3 to 7, refer to Section 3, Map 1 (Ontario), page 6.

3. Using Map 1, what percent of your yearly fishing occurs in each area of Ontario? Total should equal 100%.

Area	Description	Percent
1	Northern Ontario (north of North Bay-Lake Nipissing)	
2	Southern Ontario (south of North Bay-Lake Nipissing)	
3	Mississippi River Watershed (Lennox, Lanark, Frontenac counties, City of Ottawa)	

4. Using Map 1, how long have you fished in each area?

Area	Description	Years
1	Northern Ontario (north of North Bay-Lake Nipissing)	
2	Southern Ontario (south of North Bay-Lake Nipissing)	
3	Mississippi River Watershed (Lennox, Lanark, Frontenac counties, City of Ottawa)	

5. If you fish in Areas 1 or 2 (southern or northern Ontario--Map 1), what percent of your yearly fishing occurs in the Great Lakes and their tributaries in Ontario?

Area	Description	Percent
1	Northern Ontario (north of North Bay-Lake Nipissing)—Lake Superior, N. Channel	
2	Southern Ontario (south of North Bay-Lake Nipissing)—lakes Huron, Erie, Ontario, Georgian Bay	

6. If you fish in Areas 1 or 2 (southern or northern Ontario--Map 1), what lakes, rivers, streams, do you fish most often? List up to three. **If known**, what watershed do they belong to?

No.	Lakes, Rivers, Streams	Watershed
1		
2		
3		

7. If you fish in Area 3 (Mississippi River Watershed—Map 1), what lakes, rivers, streams, do you fish most often? List up to three.

No.	Lakes, Rivers, Streams
1	
2	
3	

8. Are you a member of an Association, Club, or Federation? If yes, please indicate the name.

Yes		No		Name:	

9. Why do you fish? Rank in order of importance the reasons why you fish. Rank the most important as one (1), the second most important as two (2), and so on. **Only rank the reasons that pertain to you.**

No.	Reason	Rank	Comments
1	Challenge		
2	Competition		
3	Culture/Heritage		
4	Enjoyment		
5	Family time		
6	Food		
7	Outdoor lifestyle		
8	Relaxation		
9	Right to fish		
10	Socialize		
11	Sport		
12	Tradition		
13	Other: please specify		

10. Approximately how many days a year do you fish in Ontario?

Days	

11. What percent of your fishing occurs during the open-water season, and during the ice-fishing season?

Season	**Percent (%)**
Open-water	
Ice fishing	

12. By season, estimate how much you spend **per year** on fishing trips and equipment for you and your family. Some items have been listed to help you estimate expenses. If you do not know the expense related to specific **Items**, estimate your **Total** expenses.

Items	**Open-water Expenses ($)**	**Ice fishing Expenses ($)**
Bait		
Boat and motor (purchases, repairs, rentals etc.)		
Charter or guide services		
Food and beverage		
Gas		
Gear (rods, reels, lures, clothing, etc.)		
Lodging		
Supplies		
Souvenirs		
Other: please specify		
Total		

Section 6—To be completed by Business Service Providers (Group 2—Guides, Outfitters, Resort Operators etc.)

Current Use

1. Do you own a fish resource business or are you employed by a fish resource business?

Own		**Employed**	

- If you are employee of a fish resource business (i.e. Guide), answer questions on the basis of the service you provide.

If you operate your own business, how many people do you employ?

Employees	**Number**	**Employees**	**Number**
Contract		Part-time Seasonal	
Fulltime		Seasonal	
Part-time		Other: please specify	

2. How long have you worked in the fish resource business in Ontario?

Years	

3. Indicate the years in which you have worked in the fish resource business in Ontario.

	From	**To**
Current		2007
Past		

For questions 4 to 7, refer to Section 3, Map 1 (Ontario), page 6.

4. Using Map 1, what percent of your yearly business occurs in each area of Ontario? Total to equal 100%.

Area	Description	Percent
1	Northern Ontario (north of North Bay-Lake Nipissing)	
2	Southern Ontario (south of North Bay-Lake Nipissing)	
3	Mississippi River Watershed (Lennox, Lanark, Frontenac counties, City of Ottawa)	

5. If your business operations or work in fisheries are in Areas 1 or 2 (Map 1), what percent of your yearly business or work occurs in the Great Lakes Region and their tributaries in Ontario?

Area	Description	Percent
1	Northern Ontario (north of North Bay-Lake Nipissing)—Lake Superior, N. Channel	
2	Southern Ontario (south of North Bay-Lake Nipissing)—lakes Huron, Erie, Ontario, Georgian Bay	

6. If your business operations or work in fisheries are in Areas 1 or 2 (Map 1), what lakes, rivers, streams, are you located or work on? List up to two. **If known**, what watershed do they belong to?

No.	Lakes, Rivers, Streams	Watershed
1		
2		

7. If your business operations or work in fisheries are in Area 3 (Mississippi River Watershed—Map 1), what lakes, rivers, streams, are you located or work on? List up to two.

No.	Lakes, Rivers, Streams
1	
2	

8. Approximately how many days a year do you operate your business or work in fisheries in Ontario?

Days	

9. What percent of your fisheries business or work occurs during the open-water season, and the ice-cover season?

Season	Percent (%)
Open-water	
Ice-cover	

10. Approximately how many customers do you have in each season?

Season	Number
Open-water	
Ice-cover	
Total	

11. By season, what percent of your customers are local Ontario residents (within 100 km or 1 hour drive), Regional Ontario residents (between 100-200 km or 1-2 hours drive), Provincial Ontario residents (greater than 200 km or 2 hours drive), and Non-Ontario residents?

Customers	Open-water (%)	Ice-cover (%)
Local Ontario residents		
Regional Ontario residents		
Provincial Ontario residents		
Non-Ontario residents		

12. By season, does your business or service cater strictly to customers that fish, or do you run a multi-use facility (beach, water sports, snowmobiling, skiing etc.)? Check boxes as they pertain to your business.

Customers	Open-water	Ice-cover
Anglers		
Multi-use facility		

13. If your business is multi-use, by season, what percent of your customers fish?

Season	Percent fish (%)
Open-water	
Ice-cover	

14. If your business is multi-use, by season, what percent of your business would you attribute to fishing?

Season	Percent of business (%)
Open-water	
Ice-cover	
Total	

15. By season, estimate how much each fish resource customer would spend at your business or for your service **in a day**. Some items have been listed to help you estimate expenses and only pertain to you if you operate a store or gas bar. Only estimate customers expenses that pertain to your business or service. If you do not know the expense related to specific **Items**, estimate your customers **Total** expenses.

Items	Open-water daily expenses ($)	Ice-cover daily expenses ($)	Comments
Bait			
Boat and motor (rentals)			
Charter or guide services			
Food and beverage			
Gas			
Gear (lures, line, etc.)			
Souvenirs			
Lodging			
Supplies			
Other: please specify			
Total			

Section 7—To be completed by Fish Resource Professionals (Group 3—Conservation Officers, Biologists etc.).

1. How long have you been a Fish Resource Professional?

Years	

2. How long have you been a Fish Resource Professional in Ontario?

Years	

3. Using Map 1 (Section 3), what Area in Ontario do you currently work?

Area	Description	Check
1	Northern Ontario (north of North Bay-Lake Nipissing)	
2	Southern Ontario (south of North Bay-Lake Nipissing)	
3	Mississippi River Watershed (Lennox, Lanark, Frontenac counties, City of Ottawa)	
4	All of the above	

4. How long have you worked in this Area?

Years	

5. If you work in Areas 1 or 2 (Map 1, Section 3), does your jurisdiction include any of the Great Lakes Region?

Area	Description	Check
1	Northern Ontario (north of North Bay-Lake Nipissing)—Lake Superior, N. Channel	
2	Southern Ontario (south of North Bay-Lake Nipissing)—lakes Huron, Erie, Ontario, Georgian Bay	

Section 8—Adaptations and Economic Consequences

Introduction&Impacts of Global Climate Change

Environmental Changes

- Changes can be variable across regions that include: extreme air temperatures, flooding or drought, changes in precipitation, water temperature, flow, run-off, and ice cover.
- Seasonal changes include: earlier springs and later falls, delayed lake cooling and fall turnover, decreased duration of winter ice cover, lack of winter precipitation, reduced spring run-off and flow.

Fish Community Changes

- Subtle environmental changes can result in significant changes in fish resources that include: growth, maturity, reproductive success, survival, abundance, and changes in community structure.
- Adaptation by the fish community will occur: changes in thermal guild will occur, but degree and type of change in any given waterbody is locale and species dependent.
- In general, freshwater fish in Ontario are classified as warm, cool, or coldwater species on the basis of their thermal requirements.
- While relatively new, the scientific literature is growing and indicates that as global climate change and warming progresses, warm water species will thrive and become more abundant while coldwater species will diminish.
- Some species will most likely be lost to local communities, especially coldwater species in the southern portion of their range.
- Species that become too abundant within a waterbody, risk being stunted because of limited space and food.

- Presently, adult coldwater species are surviving, but recruitment failure has been documented in several lake trout lakes, resulting in progressively large and aging fish populations.
- Increased warming can alter the thermocline, which would threaten survival of adult coldwater species.
- Impacts on coolwater species are less well known, but their range appears to be shifting progressively northward.

Below are listed a number of species and their thermal classification.

Warmwater	Coolwater	Coldwater
Brown bullhead	Brown trout	Brook trout
Carp	Lake sturgeon	Burbot
Channel catfish	Muskellunge	Ciscoe (herring)
Crappie (white and black)	Northern Pike	Lake trout
Cyprinids (minnows)	Sauger	Salmon
Largemouth bass	Rainbow trout	Whitefish
Rock bass	Walleye (pickerel)	
Smallmouth bass	Yellow perch	
Sunfish (bluegill, pumpkinseed)		
White perch		
White sucker		

Section 8A to 8C—Adaptations to Environmental and Fish Community Changes

- **Sections 8A to 8C deal with impacts of environmental and fish community changes due to global climate change (listed above) and how Groups (1-4) associated with fish resources would adapt to these changes.**

Section 8A—To be completed by all Groups (Groups 1-4)

- If the environmental and fish community changes listed above (Section 8) occurred in your area, answer the following questions by indicating how you believe these changes would affect your future fishing (anglers); your customers future fishing (businesses); or for Fish Resource Professionals, fishing in your District.
- Check the box corresponding to the number that best reflects your opinion of the statement.
- If you are answering these questions as a member of more than one Group, answer using one (1) for Angler, two (2) for Business Service Provider, or three (3) for Fish Resource Professional. If you are filling two numbers in one box, separate them with a comma (,).

1. There will be less time and effort spent fishing during the ice-cover season.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

2. There will be a shorter ice-cover season, but effort will be more intense during that period.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

3. There will be more time and effort spent fishing during the open-water season.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

4. There will be more time and effort spent fishing at night (i.e. walleye).

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

5. There will be less time and effort spent fishing during the day.

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

6. Dates in which Anglers typically book fishing trips will have to be altered to coincide with the weather.

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

7. Fishing patterns and techniques will have to change.

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

8. Fishing depths will have to change.

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

9. Habitat fished will have to change.

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

10. New fishing sites within a waterbody will have to be located.

Agree																**Neutral**														**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	

- On the basis of the areas you fish; your customers fish; or your work in fisheries in Ontario, answer the following question. Answer for all **Groups** you belong to.

11. What one species is the most important to your fishing (anglers); your customers fishing (business); or fishing in your District (professionals)?

No.	**Group**	**Species**
1	Angler	
2	Business Service Provider	
3	Resource Professional	

12. Using the list of thermal classifications (Section 8), How is this species classified? **Check** the appropriate box.

No.	**Group**	**Warmwater**	**Coolwater**	**Coldwater**	**Not listed**
1	Angler				
2	Business Service Provider				
3	Resource Professional				

13. Would you consider an increase in warmwater species a positive (**P**) or negative (**N**) change in your area, or both (**B**)?

No.	Group	P	N	B	Comments
1	Angler				
2	Business Service Provider				
3	Resource Professional				

14. Any additional Comments

Comments

Section 8B—To be completed by Anglers (Group 1)

15. How far do you travel to the area you most often fish?

Traveling Distance	Open-water	Ice-cover
Locally (within 100 km or 1 hour drive)		
Regionally (between 100-200 km or 1-2 hours)		
Provincially (greater than 200 km or 2 hours)		
Out-of-Province		

16. Approximately how many day, weekend, or weekly trips do you take in a year to the area you most often fish?

Duration	Open-water	Ice-cover
Day		
Weekend		
Weekly		
Other: please specify		

- If you consider an increase in warmwater species a **positive change** in the area you most often fish, answer questions **17 to 20**.
- If you consider an increase in warmwater species a **negative change** in the area you most often fish, answer questions **21 to 28**.
- If you consider an increase in warmwater species **both a positive and negative change** in the area you most often fish, answer all questions from **17 to 28**.

Positive change

17. I would increase my fishing effort in the area I most often fish.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

18. Since abundance of warmwater species is increasing, I would look for new fishing areas closer to where I live.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

19. Would you **I**ncrease, **D**ecrease, or **N**ot **C**hange how often you go fishing? Check the appropriate box.

Duration of fishing trip	**Open-water**			**Ice-cover**		
	I	**D**	**NC**	**I**	**D**	**NC**
Day						
Weekend						
Weekly						
Other: please specify						

20. Any additional Comments

Comments

Negative Change

21. I would decrease my fishing effort in the area I most often fish.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

22. I would stop fishing completely.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

23. I would change locations and find a new lake or river to fish.

Agree								**Neutral**								**Disagr**
1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**

24. How much farther would you be willing to travel to find a new lake, river, or area to fish?

Traveling Distance	**Open-water**	**Ice-cover**
I would not travel farther (0 km)		
Locally (within 100 km or 1 hour drive)		
Regionally (between 100-200 km or 1-2 hours)		
Provincially (greater than 200 km or 2 hours)		
Out-of-Province		

25. Would you **I**ncrease, **D**ecrease, or **N**ot **C**hange how often you go fishing? **Check** the appropriate box.

Duration of fishing trip	**Open-water**			**Ice-cover**		
	I	**D**	**NC**	**I**	**D**	**NC**
Day						
Weekend						
Weekly						
Other: please specify						

26. I would not change locations, instead I would target different species that are more abundant.

Agree						Neutral												Disagr
1		2		3		4		5		6		7		8		9		

If you would target different species, would you have to purchase new fishing gear or equipment?

Yes		No	

27. I would get just as much satisfaction from catching a different species (warmwater).

Agree						Neutral												Disagr
1		2		3		4		5		6		7		8		9		

28. Any additional Comments

Comments

Section 8C—To be completed by all Groups (Groups 1-4)

Impacts to Fish Resource Use

29. On the scale below, estimate by percentage whether future changes in environmental conditions and the fish community due to climate change would increase, decrease, or not change:

Answer question for your Group:

- Anglers (Group 1)–**How often you go fishing.**
- Business Service Providers (Group 2)–**The impacts on your customer base.**
- Fish Resource Professionals (Group 3)–**The impacts on fish resource use in your area.**

- **Check** the appropriate box. **NC** is 0% or **N**o **C**hange.

- If you are answering this question as a member of more than one Group, answer by using one (1) for Angler, two (2) for Business Service Provider, or three (3) for Fish Resource Professional.

% Decrease										NC										% Increase
-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100

30. On the scale below, estimate by percentage whether future changes in environmental conditions and the fish community would increase, decrease, or not changed:

Answer question for your Group:

- Anglers (Group 1)–**The yearly amount you spend on fishing trips and equipment.**
- Business Service Providers (Group 2)–**The impacts on your business income.**
- Fish Resource Professionals (Group 3)– **The impacts on fish resource revenue in your area.**

- **Check** the appropriate box. **NC** is 0% or **N**o **C**hange.

- If you are answering this question as a member of more than one Group, fill the appropriate box with a one (1) for Angler, two (2) for Business Service Provider, or three (3) for Fish Resource Professional.

% Decrease **NC** **% Increase**

-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100

Section 9—To be completed by all Groups (Groups 1-4)

Future Direction and Management of Fish Resources

Environmental and fish community changes are occurring in Ontario. The real and changing value of fish resources, and social and economic impacts to communities will be determined by adaptation to these changes by resource users, businesses, and professionals.

1. Should management actions be taken that adopt and incorporate environmental and fish community changes due to climate change?

Yes		No	

- Listed below are examples of adaptive Management Actions that could be taken to offset social and economic impacts of environmental and fish community changes due to global climate change.

- **Check** the box corresponding to the number that best reflects your opinion of the statement.

Management Action # 1—Public Education

2. A public education program should be developed to inform people of fish resource changes due to climate change.

Agree **Neutral** **Disagr**

1		2		3		4		5		6		7		8		9	

3. Education programs should emphasize the value of all fish resources in Ontario.

Agree **Neutral** **Disagr**

1		2		3		4		5		6		7		8		9	

Management Action # 2—Promotion

4. All types of fishing (boat, shoreline, ice), of more abundant species (warmwater) should be encouraged.

Agree **Neutral** **Disagr**

1		2		3		4		5		6		7		8		9	

5. Catch-and-keep of more abundant species (warmwater) should be encouraged.

Agree **Neutral** **Disagr**

1		2		3		4		5		6		7		8		9	

6. Fishing of less abundant species (cool and coldwater) should be discouraged.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

7. Catch-and-release of less abundant species (cool and coldwater) should be encouraged.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

Management Action # 3—Removal and Harvest Programs

8. If warmwater species become too abundant, removal programs should be implemented to reduce their numbers.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

9. Removal programs should be initiated before warmwater species become too abundant.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

10. Catch-and-keep fishing derbies of warmwater species should be initiated that encourage family and youth participation, and includes fisheries education, prizes, and fish fry.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

Management Action # 4—Stocking

11. If recruitment failure is occurring, cool and coldwater species should be stocked to support and maintain the existing fishery.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

12. Stocking should be used to support put-and-leave fisheries where recruitment failure is occurring.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

13. Stocked fish should be the progeny (young) of wild adults from the same waterbody.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

14. Genetic diversity and the loss of wild gene pool that stocking could cause is a big concern.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

15. Catching a stocked fish provides just as much satisfaction as catching a wild fish.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

16. Only existing species within a waterbody should be stocked.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

17. Stocking should only occur when native fish have been essentially eliminated from the waterbody.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

18. Stocking should be used to create put-grow-and-take fisheries where and when native stocks have been eliminated.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

Management Action # 5—Regulations

19. Regulations should be adaptable to temporal and abundance changes in fish resources caused by climate change.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

20. Regulations should be flexible to address annual and site specific changes in fish resources caused by climate change.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

21. Regulations on abundant (warmwater) species should be more liberal.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

22. Regulations on less abundant species (cool and coldwater) should be more restrictive.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

23. A creel limit on all species would promote the value of fish resources.

Agree								Neutral								Disagr
1		2		3		4		5		6		7		8		9

Adaptation—Offsetting Social and Economic Impacts of Changing Fish Resources Caused by Climate Change

24. Indicate which management actions you would support (**Yes**), and not support (**No**) in your area.
Check

- Of the management actions you would support (**Yes**), **Rank** them in order of what you believe would be the most effective in offsetting social and economic impacts of a changing fish resource caused by climate change. **Rank** the most important with a one (1), second most important with two (2), and so on.

Management Action	Yes	No	Rank	Comments
Public Education				
Promotion				
Removal and Harvest Programs				
Stocking				
Regulations				
No management action				
Other: please specify				

25. On what basis should management actions be taken? **Check** the appropriate box.

- What basis would be most important? **Only Rank numbers 1 to 3, and 5 if used.** Rank most important as one (1), second most important as two (2), and so on.

No.	Basis	Check	Rank	Comments
1	Economic			
2	Scientific			
3	Social			
4	All of the above			
5	Other: please specify			

26. Should a Fish Policy and Management Plan be developed to deal with impacts and adaptations to climate change?

Yes		No	

If yes, Who should participate in developing the Policy and Management Plan? Please indicate.

Participants	Comments

27. Any additional Comments

Comments

Section 10—To be completed by all Groups (Groups 1-4)

Water Management and Multi- Purpose Use

1. In your area, are water levels and flows natural or regulated by dams?

Natural		Regulated	

2. In areas that are regulated, primary importance during high abundance of water is to manage flows and levels to prevent flooding. However, during periods of low water abundance several water uses need to be considered. Please list in order of importance the uses that you consider should have the highest priority for managing water flow and levels during low water abundance. **Rank** the most important use as one (1), the second most important as two (2), and so on.

Water Use	Rank	Comments
Agriculture		
Consumption		
Environmental Sensitive Areas		
Fish nursery habitat		
Fish spawning areas		
Historical or traditional sites		

Homes and cottages		
Hydro generation		
Navigation/Transportation		
Water sports and recreation		
Other: please specify		

Thank you!

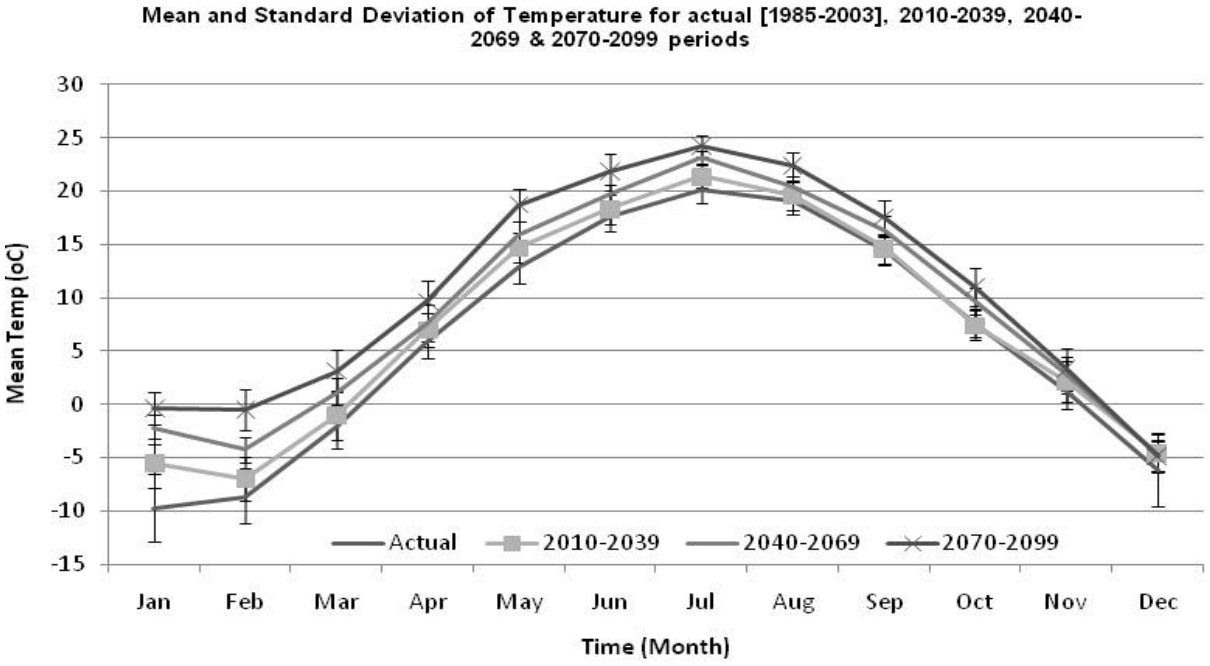
If you are completing and returning this survey electronically, be sure to save it and attach it to an e-mail addressed to Lucian Marcogliese, otherwise, follow instructions on cover page.

Any Additional Comments

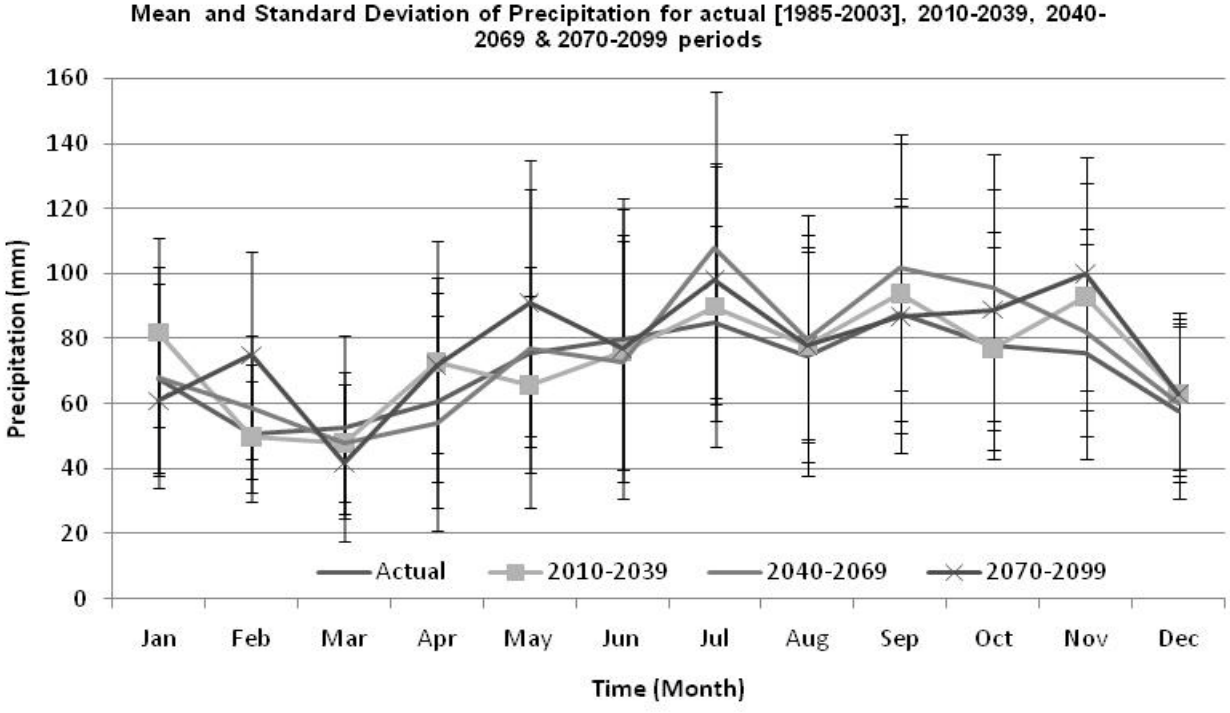
Section	Question	Comments

7.3 Appendix A4 Water Management Response to Climate Change

Appendix A4.1. Mean and standard deviation of actual and generated temperature data



Appendix A4.2. Mean and standard deviation of actual and generated precipitation data



Appendix A4.3. Statistical analysis results of ClimGen generated climate data for 2010-2039.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet-day count	389	322	322	347	350	335	342	313	396	361	445	366
Dry-day count	541	525	608	553	580	565	588	617	504	569	455	564
Wet days following dry-days count	191	171	170	170	149	157	182	157	189	183	190	214
Wet days following wet-days count	198	151	152	177	201	178	160	156	207	178	255	152
Days of valid data count	930	847	930	900	930	900	930	930	900	930	900	930
Precipitation mean	83.52	51.31	47.5	72.31	65.46	77.58	90.73	78.08	93.9	78.93	93.09	62.86
Maximum temperature for all days												
mean	-0.63	-1.185	4.566	12.6	21.97	24.85	27.67	26.28	20.79	12.82	6.903	-0.54
sum	-589	-1003	4246	11343	20436	22366	25729	24443	18712	11925	6213	-500
SD	6.033	5.792	6.771	7.463	5.305	4.656	3.917	4.405	4.955	5.797	6.397	6.194
min.	-20.6	-25.28	-14.9	-8.82	3.786	10.45	15.64	13.32	5.57	-4.36	-10.7	-20.7
max.	17.01	18.84	24.55	34.95	38.05	38.39	40.62	40.85	38.44	29.24	25.81	17.9
count	930	847	930	900	930	900	930	930	900	930	900	930
Minimum temperature for all days												
mean	-10.5	-12.79	-6.74	1.392	7.452	11.8	15.16	12.92	8.392	2.047	-2.67	-8.84
sum	-9757	-10829	-6265	1253	6930	10617	14095	12017	7553	1903	-2403	-8220
SD	9.039	8.435	8.44	3.857	5.099	4.506	3.877	4.817	5.084	5.253	5.805	5.06
min.	-44.1	-41	-37.2	-12.2	-8.8	-1.32	4.225	-2.35	-8.37	-13.6	-17.8	-26.6
max.	10.39	9.536	13.89	12.95	23.58	24.57	26.48	25.88	22.82	19.87	13.61	9.743
count	930	847	930	900	930	900	930	930	900	930	900	930

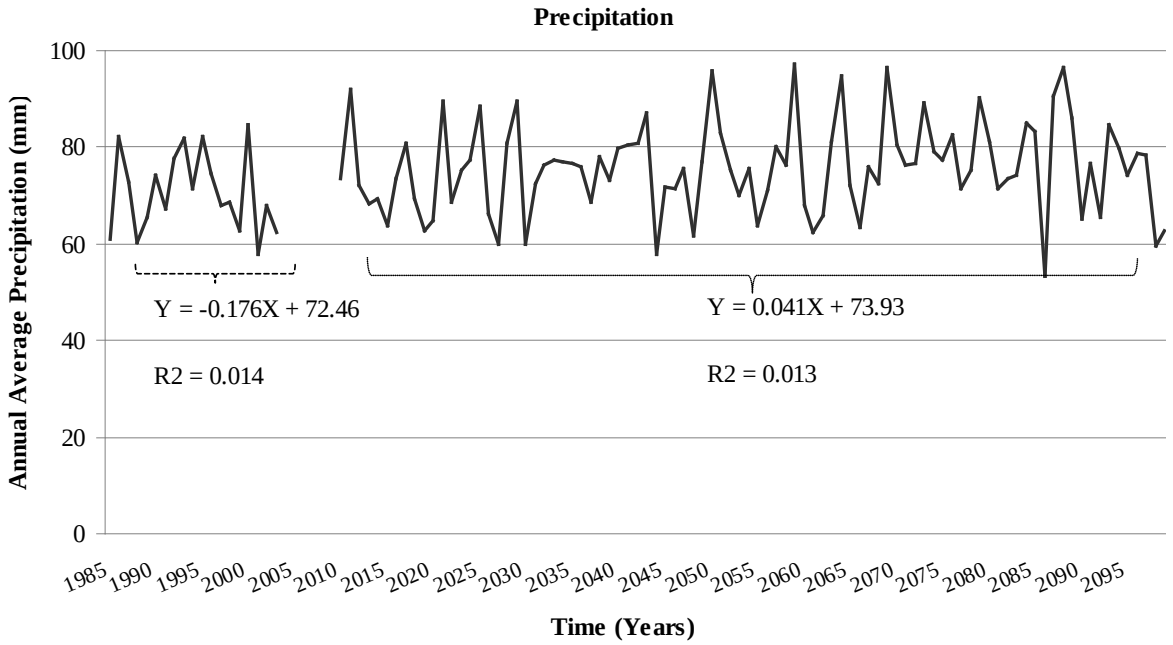
Appendix A4.4. Statistical analysis results of ClimGen generated climate data for 2040-2069.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet-day count	348	346	283	283	354	356	377	300	407	399	422	386
Dry-day count	582	502	647	617	576	544	553	630	493	531	478	544
Wet days following dry-days count	194	194	158	147	155	172	207	160	174	181	170	199
Wet days following wet-days count	154	152	125	136	199	184	170	140	233	218	252	187
Days of valid data count	930	848	930	900	930	900	930	930	900	930	900	930
Precipitation mean	68.81	58.81	48.22	53.84	79.29	76.57	108	79.64	104.7	96.85	83.82	61.62
Maximum temperature for all days												
mean	1.557	0.779	5.69	13.41	23.55	26.15	29.32	27.06	22.44	14.99	7.68	-0.64
sum	1448	660.9	5292	12066	21902	23533	27268	25162	20200	13941	6912	-598
SD	5.166	4.955	6.376	8.196	4.863	4.418	3.402	4.358	5.184	5.196	6.688	5.741
min.	-18.3	-15.24	-11.3	-9.5	2.972	14.04	17.03	12.76	4.111	-0.95	-10.5	-18
max.	22.1	13.92	30.33	40.97	41.76	44.5	38.9	39.98	40.08	31.78	26.56	16.87
count	930	848	930	900	930	900	930	930	900	930	900	930
Minimum temperature for all days												
mean	-6.28	-9.172	-3.53	1.754	8.317	13.57	17.1	13.91	10.26	4.426	-2.16	-9.06
sum	-5837	-7778	-3282	1578	7735	12214	15900	12940	9231	4116	-1941	-8425
SD	7.216	7.333	6.923	4.037	5.478	4.307	2.999	4.435	5.528	5.406	6.353	4.821
min.	-39.1	-30.51	-30.8	-20.8	-7.72	-1.75	7.641	-1.53	-9.99	-15.6	-19.5	-27.6
max.	12.58	10.85	15.39	17.28	24.38	25.6	26.89	26.73	27.61	18.9	15.83	5.638
count	930	848	930	900	930	900	930	930	900	930	900	930

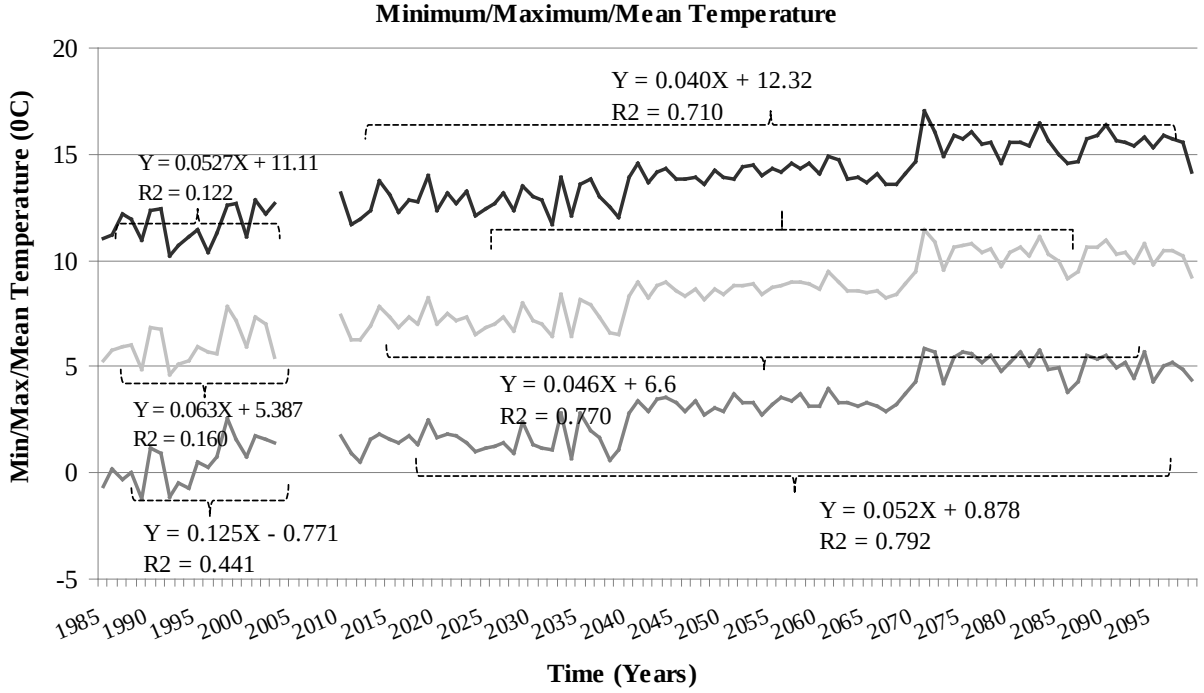
Appendix A4.5. Statistical analysis results of ClimGen generated climate data for 2070-2099.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet-day count	370	337	249	338	375	343	362	314	421	406	420	360
Dry-day count	560	510	681	562	555	557	568	616	479	524	480	570
Wet days following dry-days count	206	163	138	161	166	147	201	178	198	185	182	205
Wet days following wet-days count	164	174	111	177	209	196	161	136	223	221	238	155
Days of valid data count	930	847	930	900	930	900	930	930	900	930	900	930
Precipitation mean	61.32	74.17	41.42	72.15	91.43	78.72	96.72	76.66	87.44	89.29	101	64.03
Maximum temperature for all days												
Mean	2.038	3.376	6.939	15.83	26.56	27.75	30.26	28.75	23.8	16.61	8.444	-0.88
sum	1895	2859	6453	14247	24701	24975	28141	26739	21424	15446	7600	-820
SD	4.443	4.561	6.186	9.647	4.231	4.51	3.689	4.506	5.482	5.581	6.919	6.559
min.	-10.9	-7.98	-11	-6.66	9.329	12.74	17.7	8.207	9.02	-1.53	-13	-21.7
max.	24.12	23.37	33.28	46.08	39.55	40.3	41.15	40.36	38.79	34.74	29.61	20.06
count	930	847	930	900	930	900	930	930	900	930	900	930
Minimum temperature for all days												
mean	-2.89	-4.422	-0.7	3.288	10.93	15.98	18.14	15.65	11.22	5.548	-1.83	-9.19
sum	-2691	-3745	-649	2959	10161	14379	16870	14558	10100	5160	-1649	-8545
SD	4.784	6.786	6.27	3.896	6.213	4.661	3.617	4.295	5.718	5.825	6.915	4.777
min.	-22.9	-30.52	-29.4	-18.2	-9.73	1.838	6.108	0.729	-7.67	-14.2	-21	-25.8
max.	9.898	10.84	15.75	17.12	32.9	31.91	28.86	29.97	27.8	22.89	20.06	9.14
count	930	847	930	900	930	900	930	930	900	930	900	930

Appendix A4.6. Actual and predicted precipitation trend at Mississippi watershed (1985-2099 periods).



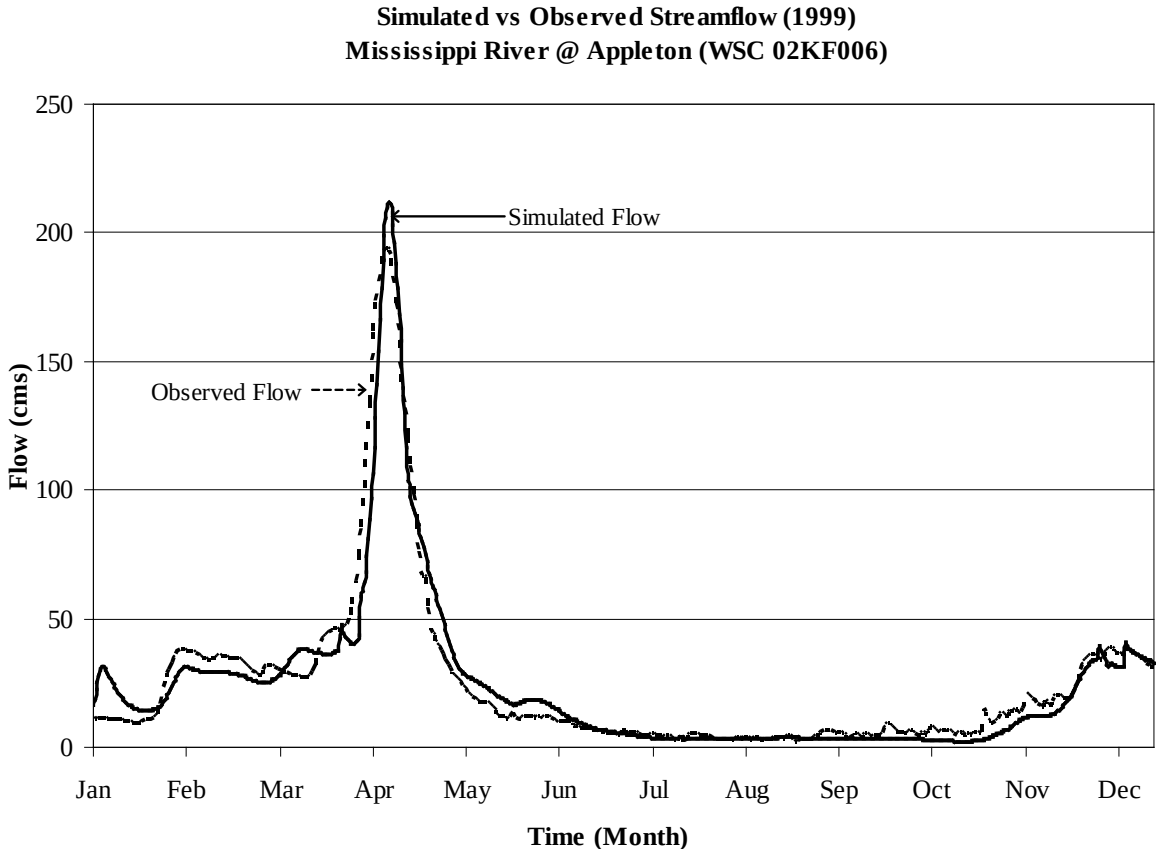
Appendix A4.7. Actual and predicted minimum, maximum, and mean temperature trend in the Mississippi watershed (1985-2099 periods).



Appendix A4.8. Regression and Mann-Kendall Statistics.

Data period	Regression equation	Coefficient of determination (r)	Mann-Kendall Statistics	
			Z value	Significant level (α)
1985-2003				
Precipitation	Y = -0.176T + 72.46	0.118321596	-0.28	>0.1
Min. temp.	Y = 0.125T - 0.771	0.664078309	2.73	0.001
Max. temp.	Y = 0.052T + 11.11	0.349284984	1.68	0.1
Mean temp.	Y = 0.063T + 5.387	0.4	1.54	>0.1
2010-2099				
Precipitation	Y = 0.041T + 73.93	0.114017543	1.43	>0.1
Min. temp.	Y = 0.052T + 0.878	0.889943818	8.93	0.001
Max. temp.	Y = 0.040T + 12.32	0.842614977	8.97	0.001
Mean temp.	Y = 0.046T + 6.6	0.877496439	9.2	0.001

Appendix A4.9. Simulated vs. observed stream flow for the Mississippi River at Appleton for the year 1999.



Appendix A4.10. Simulated vs. observed stream flow at Mississippi River at Appleton for the year 2001