

Table of Contents

	<u>Page</u>
TABLE OF CONTENTS	i
LIST OF TABLES	vi
LIST OF FIGURES	viii
LIST OF APPENDICES	xiii
ACKNOWLEDGEMENTS	xiv
INTRODUCTION	1
Background	1
Purpose and Study Components	2
SITE DESCRIPTION AND STUDY AREA	3
Study Area	3
General Description	3
The Blue Earth River Watershed	3
Precipitation and Stream Flow	3
The Rapidan Dam and Reservoir	7
Sampling Sites	7
Water Chemistry and Sediments Sites	7
Sediment Bedload Sites	10
Macroinvertebrate Sites	10
METHODS	11
Water Quality	11
Field Methods	11
Laboratory Methods	11
Statistical Methods	13
Sediments	14
Suspended Sediments	14
Field	14
Laboratory	14
Reservoir Sediments	16
Field	16
Laboratory	16
Bed Load Sediments	16
Field	16
Laboratory	16
Synthetic Organics	17
Field	17
Laboratory	17
Macroinvertebrates	19
Field	19
Surber sampling	19
Three-Kick sampling	19

	<u>Page</u>
Laboratory	19
Data Analysis	19
RESULTS/DISCUSSION	20
Hydrology	20
Rainfall	20
Flow	20
Water Depth per Peak Event	20
Peak Event of 8/9.....	20
Peak Event of 8/26.....	20
Peak Event of 8/30.....	20
Water Quality	31
Ammonia Nitrogen	31
Introduction.....	31
Baseline.....	31
Peak 8/9.....	31
Peak 8/26.....	31
Peak 8/30.....	31
Organic Nitrogen	34
Introduction.....	34
Baseline.....	34
Peaks.....	34
Nitrate Nitrogen	38
Introduction.....	38
Baseline.....	38
Peaks.....	38
Nitrite Nitrogen	42
Introduction.....	42
Baseline.....	42
Peaks.....	42
Total Phosphorous	46
Introduction.....	46
Baseline.....	46
Peaks.....	46
August 9.....	46
August 26.....	46
August 30.....	46
Filterable Phosphorous	50
Introduction.....	50
Baseline.....	50
Peaks.....	50
Total Non-Filterable Residue	53
Introduction.....	53
Baseline.....	53
Peaks.....	53
Total Volatile Non-Filterable Residue	58
Introduction.....	58
Baseline.....	58
Peaks.....	58

	<u>Page</u>
Conductivity	62
Introduction.....	62
Baseline.....	62
Peaks.....	62
pH	66
Introduction.....	66
Baseline.....	66
Peaks.....	66
Water Temperature	70
Introduction.....	70
Baseline.....	70
Peaks.....	70
Organic Matter	74
Introduction	74
Coarse Particulate Organic Matter (CPOM)	74
Introduction.....	74
Baseline.....	74
Peaks.....	77
Fine Particulate Organic Matter (FPOM)	80
Introduction.....	80
Baseline.....	80
Peaks.....	80
Very Fine Particulate Organic Matter (VPOM)	84
Introduction.....	84
Baseline.....	84
Peaks.....	84
Dissolved Organic Carbon (DOC)	88
Introduction.....	88
Baseline.....	88
Peaks.....	88
Sediments	92
Suspended Sediments	92
Introduction	92
Total Suspended Sediments	92
Baseline.....	92
Peaks.....	92
8/9.....	92
8/26.....	92
8/30.....	92
Suspended Sediment: Coarse and Medium Silt	97
Baseline.....	97
Peaks.....	97
Suspended Sediment: Fine and Very Fine Silt	100
Baseline.....	100
Peaks.....	100
Suspended Sediment: Clay	103
Baseline.....	103
Peaks.....	103

	<u>Page</u>
Suspended Sediment: Silt and Clay, Percent Organic	106
Baseline.....	106
Peaks.....	106
Suspended Sediment: Clay, Percent Organic	109
Baseline.....	109
Peaks.....	109
Reservoir Sediments	112
Grain Size.....	112
Percent Organic of Fines.....	112
Comparison of pre and post peaking reservoir sediment.....	118
Bedload Sources	120
Synthetics	123
Introduction	123
Peaks	123
Peak 1.....	123
Peak 2.....	123
Peak 3.....	123
Macroinvertebrates	128
Introduction	128
Macroinvertebrate Abundance	128
Taxonomic Richness	131
Community Diversity	131
Functional Feeding Groups	132
Collectors.....	133
Scrapers.....	133
Shredders.....	133
Predators.....	133
Discussion	133
CONCLUSIONS	134
Water Quality	134
Introduction	134
Impact of Rapidan Reservoir	134
Water Quality Parameters.....	134
OM Transport Parameters.....	134
Impact of Peak Events	134
Water Quality Parameters.....	134
OM Transport Parameters.....	137
Impact of Variations in Peak Events	137
Water Quality Parameters.....	137
OM Transport Parameters.....	137
Sediments	139
Introduction	139
Impact of Rapidan Dam Reservoir on Sediment Transport During Baseline Flow (Run-of-the-River)	139

	<u>Page</u>
Impact of Peak Power Generations (peak-events) in August, 1985 on Suspended Sediments	139
Nature of the Surficial Reservoir Sediment (Grain-size, and Percent organic) and relation to the old channel	141
Comparison of the Pre and Post Peaking Reservoir Surficial Sediment, July to October, 1985	141
Pre Reservoir Expansion Bed Load Sources	141
Summary	141
Synthetic Organics	142
Introduction	142
Synthetic Organics Found	142
Impact of the Peak Power Generation (Peaking Events)	142
Aquatic Macroinvertebrates	142
Introduction	142
Abundance	142
Richness	142
Community Diversity	142
Functional Feeding Groups	143
Conclusions	143
Overall Conclusions	143
LITERATURE CITED	144

LIST OF TABLES

Table	Title	Page
I	Baseline and peak water parameters analyzed.....	12
II	Suspended sediment, reservoir and bedload grain size classes.....	14
III	Monthly precipitation for 1984 and 1985 with monthly deviations based on a 29 year average as recorded in Winnebago, Minnesota.....	22
IV	Precipitation and sampling dates for the 1984 study period (Winnebago sampling station, NOAA, 1984).....	23
V	Precipitation and sampling dates for the 1985 study period(Winnebago sampling station, NOAA, 1985).....	24
VI	Flow of the Blue Earth River near Rapidan, Minnesota for the 1984 and 1985 calendar years, the historic record, and for each baseline sampling date during the 1984 and 1985 sampling periods.....	25
VII	1984 Daily flow data (Discharge) cfs at USGS gauging station near Site 5.....	26
VIII	1985 Daily flow data (discharge) cfs at USGS station near Site 5 (USGS-1985)	27
IX	Comparison of hydrologic characteristics of the three August peaks.....	28
X	Percent composition of the total OM in transport, within the study area, during the entire, early and late sampling periods of 1984 and 1985.....	76
XI	Baseline suspended sediment- grams per liter for each sampling date of the 1984 and 1985 sampling seasons at Sites S1-S8.	93
XII	Summary of baseline suspended sediments (grams/liter) and corresponding percent grain size and organic matter by precipitation periods and sampling sites.....	95
XIII	Grams per liter of suspended sediment for 1985 peaks.....	96
XIV	Baseline total percent of suspended sediments that is coarse and medium silt for each sampling date at the 1984 and 1985 sampling seasons of Sites S1-S8.....	97
XV	Percent of suspended sediment that is coarse and medium silt for 1985 peaks.....	99
XVI	Baseline total percent of suspended sediment that is fine and very fine silt.....	100

XXVII	Percent of suspended sediment that is fine and very fine silt for 1985 peaks.....	102
XXVIII	Baseline total percent of suspended sediment that is clay for each sampling date of the 1984 and 1985 sampling seasons at Sites S1-S8.....	103
XIX	Percent of suspended sediment that is clay for 1985 peaks....	105
XX	Baseline total percent of suspended sediment that is organic (both silt and clay) for each sampling date of the 1984 and 1985 sampling seasons at Sites S1-S8.....	106
XXI	Percent of suspended sediment that is organic (silt and clay)	108
XXII	Baseline total percent of suspended sediment that is organic (clay only)	109
XXIII	Percent of suspended sediment that is organic (clay only).....	111
XXIV	Percent organic silt and clay and percent organic clay (7/20-7/30/1985) of surficial reservoir sediment.....	117
XXV	Comparison of reservoir sediment percent coarse (sand and gravel) and fine (silt and clay) pre and post peaking in 1985.....	119
XXVI	General Sediment grain size breakdown for upstream Blue Earth and Watonwan Rivers.....	121
XXVII	Detailed sediment grain size breakdowns for upstream Blue Earth and Watonwan Rivers in percent.....	122
XXVIII	Shannon-Weiner diversity indices for Stations 1 and 2 of sites 2, 5e, 6, and 7 on the Blue Earth and LeSueur Rivers during 1983 , 1984, 1985.	131
XXIX	Feeding functional groups of insects sampled in the Blue Earth and LeSueur Rivers during 1983, 1984, 1985.....	132
XXX	Water Quality Parameters. 1985 baseline and peaking maximums in mg/L and ug/L.....	136
XXXI	Organic matter transport. 1985 baseline and peaking maximums in mg/l.....	138
XXXII	Suspended Sediment in transport, 1985, baseline and peaking maximums	140

LIST OF FIGURES

Figure	Title	Page
1.	Location of study area in Blue Earth County, Minnesota.....	4
2.	Location of sampling sites in the study area.....	5
3.	Blue Earth River watershed.....	6
4.	The Rapidan Dam looking south, in an upstream direction.....	8
5.	Fasching Water Sampler.....	15
6.	Water Depth for peak event of August 9, 1985 at Sites S3 and S5	29
7.	Water Depth for peak event of August 26, 1985 at Sites S3, S5 and S6.....	30
8.	Water Depth for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	30
9.	Ammonia-Nitrogen for peak event of August 9, 1985 at Sites S3 and S5	32
10.	Ammonia-Nitrogen for peak event of August 26, 1985 at Sites S3, S5 and S6	33
11.	Ammonia-Nitrogen for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	33
12.	Baseline Organic-Nitrogen for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth- 0.	35
13.	Organic-Nitrogen for peak event of August 9, 1985 at Sites S3 and S5.....	36
14.	Organic-Nitrogen for peak event of August 26, 1985 at Sites S3, S5 and S6.....	37
15.	Organic-Nitrogen for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	37
16.	Baseline Nitrate-Nitrogen for 1984 and 1985 sampling seasons at Sites S1-S8 and historic record for Blue Earth – 0.....	39
17.	Nitrate-Nitrogen for peak event of August 9, 1985 at Sites S3 and S5.....	40
18.	Nitrate-Nitrogen for peak event of August 26, 1985 at Sites S3, S5 and S6.....	41
19.	Nitrate-Nitrogen for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	41

20.	Baseline Nitrite-Nitrogen for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0.....	43
21.	Nitrite-Nitrogen for peak event of August 9, 1985 at Sites S3 and S5.....	44
22.	Nitrite-Nitrogen for peak event of August 26, 1985 at Sites S3, S5 and S6.....	45
23.	Nitrite-Nitrogen for peak event of August 30, 1985 at Sites S3, S5, S6 and S8	45
24.	Baseline Total Phosphorus for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth- 0.	47
25.	Total Phosphorus for peak event of August 9, 1985 at Sites S3 and S5.....	48
26.	Total Phosphorus for peak event of August 26, 1985 at Sites S3, S5 and S6.....	49
27.	Total Phosphorus for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	49
28.	Filterable Phosphorus for peak event of August 9, 1985 at Sites S3 and S5.....	51
29.	Filterable Phosphorus for peak event of August 26, 1985 at Sites S3, S5 and S6.....	52
30.	Filterable Phosphorus for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	52
31.	Baseline Total Non-Filterable Residue for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0.....	55
32.	Total Non-Filterable Residue for peak event of August 9, 1985 at Sites S3 and S5.....	56
33.	Total Non-Filterable Residue for peak event of August 26, 1985 at Sites S3, S5 and S6.....	57
34.	Total Non-Filterable Residue for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	57
35.	Baseline Total Volatile Non-Filterable Residue for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0.....	59
36.	Total Volatile Non-Filterable Residue for peak event of August 9, 1985 at Sites S3 and S5.....	60
37.	Total Volatile Non-Filterable Residue for peak event of August 26, 1985 at Sites S3, S5 and S6.....	61

38.	Total Volatile Non-Filterable Residue for peak event of August 30, 1985 at Sites S3, S5, S6 and S8	61
39.	Baseline Conductivity for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0.....	63
40.	Conductivity for peak event of August 9, 1985 at Site S5.....	64
41.	Conductivity for peak event of August 26, 1985 at Sites S3, S5..	65
42.	Conductivity for peak event of August 30, 1985 at Sites S3, S5 and S8.....	65
43.	Baseline pH for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0.....	67
44.	pH for peak event of August 9, 1985 at Site S5.....	68
45.	pH for peak event of August 26, 1985 at Sites S3, S5 and S6.....	69
46.	pH for peak event of August 30, 1985 at Sites S3, S5, S6 and S8	69
47.	Baseline Water Temperature for 1984 and 1985 sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0.....	71
48.	Water Temperature for peak event of August 9, 1985 at Site S5..	72
49.	Water Temperature for peak event of August 26, 1985 at Sites S3 and S5.....	73
50.	Water Temperature for peak event of August 30, 1985 at Sites S3, S5 and S8.....	73
51.	Baseline Coarse Particulate Organic Matter for 1984 and 1985 sampling seasons at Sites S1-S8.....	75
52.	Coarse Particulate Organic Matter for peak event of August 9, 1985 at Sites S3 and S5.....	78
53.	Coarse Particulate Organic Matter for peak event of August 26, 1985 at Sites S3, S5 and S6.....	79
54.	Coarse Particulate Organic Matter for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	79
55.	Baseline Fine Particulate Organic Matter for 1984 and 1985 sampling seasons at Sites S1-S8.....	81

56.	Fine Particulate Organic Matter for peak event of August 9, 1985 at Sites S3 and S5	82
57.	Fine Particulate Organic Matter for peak event of August 26, 1985 at Sites S3, S5 and S6.....	83
58.	Fine Particulate Organic Matter for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	83
59.	Baseline Very Fine Particulate Organic Matter for 1984 and 1985 sampling seasons at Sites S1-S8.....	85
60.	Very Fine Particulate Organic Matter for peak event of August 9, 1985 at Sites S3 and S5.....	86
61.	Very Fine Particulate Organic Matter for peak event of August 26, 1985 at Sites S3, S5 and S6.....	87
62.	Very Fine Particulate Organic Matter for peak event of August 30, 1985 at S3, S5, S6 and S8.....	87
63.	Baseline Dissolve Organic Carbon for 1984 and 1985 sampling seasons at Sites S1-S8.....	89
64.	Dissolved Organic Carbon for peak event of August 9, 1985 at Sites S3 and S5	90
65.	Dissolved Organic Carbon for peak event of August 26, 1985 at Sites S3, S5 and S6.....	91
66.	Dissolved Organic Carbon for peak event of August 30, 1985 at Sites S3, S5, S6 and S8.....	91
67.	Baseline Suspended Sediment-Grams per liter for 1984 and 1985 sampling seasons at Sites S1-S8.....	94
68.	Baseline Suspended Sediment- Percent of Sample that is Coarse and Medium Silt for the 1984 and 1985 sampling seasons at Sites S1-S8.....	98
69.	Baseline Suspended Sediment- Percent of Sample that is Fine and Very Fine Silt for the 1984 and 1985 sampling seasons at Sites S1-S8.....	101
70.	Baseline Suspended Sediment- Percentage of Sample that is Clay for 1984 and 1985 sampling seasons at Sites S1-S8.....	104
71.	Baseline Suspended Sediment-Percent of Sample that is Organic (Both Silt and Clay) for the 1984 and 1985 sampling seasons at Sites S1-S8.....	107

72.	Baseline Suspended Sediment- Percent of Sample that is Organic (Clay only) for 1984 and 1985 sampling seasons at Sites S1-S8.....	110
73.	Reservoir transects and sampling sites, July 1985.....	113
74.	Sediment analysis of grabs taken in the summer of 1985.....	114
75.	Sand analysis of grabs taken in the summer of 1985.....	115
76.	Silt and Clay analysis of grabs taken in the summer of 1985.....	116
77.	Pthalate Peak # 4.43 and turbidity for 8/9 peak at Site 3.....	124
78.	Pthalate Peak #4.43 and turbidity for 8/9 peak at Site 5.....	124
79.	Pthalate Peak # 4.43 and turbidity for 8/26 peak at Site 3.....	125
80.	Pthalate Peak # 4.43 and turbidity for for 8/26 peak at Site 5.....	125
81.	Pthalate Peak # 4.43 and turbidity for 8/26 peak at Site 6.....	125
82.	Pthalate Peak # 4.43 and turbidity for 8/30 peak at Site 3.....	126
83.	Pthalate Peak # 4.43 and turbidity for 8/30 peak at Site 5.....	126
84.	Pthalate Peak # 4.43 and turbidity for 8/30 peak at Site 6.....	126
85.	Pthalate Peak # 4.43 and turbidity for 8/30 peak at Site 8.....	127

List of Appendices

	<u>page</u>
A. Photographs of the sampling sites	148

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Rapidan Dam Hydroelectric Research Project Director
Professor Henry W. Quade

Note: For a more detailed presentation of the Water Chemistry and Macroinvertebrates refer to:

- 1.) Ruff, Greg. 1987. The Impact of A Non-Stratifying Reservoir and it's Small, Low-Head, Peaking Hydroelectric Dam on the Water Quality and POM Transport of the Blue Earth River, South central Minnesota, M.A. Thesis, Mankato State University, Mankato, Minnesota, 293 pp.
- 2.) Danks, Marilyn. 1991. Macroinvertebrate Community Response to Flow Fluctuations Causedly by a Peak-Operated Hydroelectric Dam. M.A. Thesis, Mankato State University, Mankato, Minnesota, 102 pp.

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The full Research Project Report and the Executive Summary are available on the Minnesota River Basin Data Center: Water Resources Center, Minnesota State University Mankato. <http://mrfdc.mnsu.edu>

INTRODUCTION

Background

At the turn of the 20th century, hydropower met 60% of the nation's electrical power demand. Thirty years later, its role had diminished as inexpensive oil and coal dominated as major energy sources. With the election of President Roosevelt in 1932, the United States embarked on an ambitious program of building the large hydroelectric dams on the Columbia and Colorado Rivers. By 1976, more than 2,000 megawatts of electrical power were being generated from the Columbia basin dams, while 3,200 megawatts were being produced in the Colorado basin (Reisner, 1985).

By the late 1960's, with nearly all the prime hydro sites occupied or found in national parks, with inexpensive oil and vast reserves of coal available, and with the increased use of nuclear power, hydropower's role in the nation's economy diminished once again.

The OPEC oil crisis of 1973 spurred a flurry of interest in hydropower. Since most of the available prime hydropower sites were developed earlier in the 20th century, attention was focused on the smaller hydroelectric producers. In 1978, the U.S. Congress passed the Public Utilities Regulatory Policies Act (PURPA), which required both private and public utilities to purchase the electric power produced by small private producers at a per-kilowatt cost. This cost would be equal to what the utility would have to spend to produce the power itself. PURPA, along with other new laws which provided small energy producers with investment tax credits and accelerated depreciation schedules, made small hydropower projects (less than 5 megawatts of potential output) like the Rapidan Dam economically feasible.

In 1864, with a change from subsistence to commercial grain farming in southern Minnesota, the first Rapidan Mill for grinding grain was built. The town of Rapids was built around the mill. An eight foot high, 260 foot long dam was built upstream from the mill with an 800 foot diversion tunnel, seven feet in diameter constructed from the pond to the mill to power the mill. The construction of a large iron bridge in 1878 connecting Rapids to the other side of the river, allowed easy transportation to Mankato. However, the railroad went four miles east of Rapids and the town of Rapidan grew rather than Rapids. With the construction of the hydroelectric dam, the town of Rapids would be underwater and therefore the power company bought 913 acres as far as five miles upstream (Pfaender, J. 1969).

Construction of the Rapidan Dam began in 1910 by the Ambursen Company under supervision of the H.M. Billesby Company of Chicago. Ambursen type dams are hollow-reinforced concrete buttress and slab dams. Construction of the dam lasted 11 months with a total cost of \$500,000 for the Consumer Power Company. Consumer Power eventually became Northern States Power Company (NSP). The powerhouse consisted of two 1250 horsepower horizontal Francis -type turbines manufactured by the Pelton Water Wheel Company, each driving a General Electric 750 Kw generator. The maximum potential output of the hydroelectric facility was 1500 Kw. The dam went into operation on March 11, 1911, and supplied power to the towns of Rapidan, Mankato, Lake Crystal, and Kasota. This doubled the existing capacity of Mankato's power supply and was the first electricity brought in from outside of the city (Tim Krohn, 2002).

The Rapidan Dam consisted of an 82-foot high structure extending 435 feet between rocky abutments. It also includes a 252-foot hollow concrete overflow spillway, a 90 foot powerhouse and inclined concrete decks slabs supported on reinforced concrete buttresses founded in sandstone bedrock. Sluice gates were installed to allow silt and sediments to be removed periodically from the upstream base of the dam. The gates failed to operate when first attempted due to sediment accumulation. The sediment then built up quickly to present level. Had the gates functioned, we probably would have had a thermally stratified reservoir.

Over the last 90 years, a series of repairs have been made to the dam. In 1916 and 1920 extensive repair work was needed on the concrete spillway apron due to a large hole scoured in the downstream apron of gate #4. The original apron of 50 feet was extended downstream to its present length of 300 feet. In 1937, concrete repair work was needed on the east bank retaining walls and during the 1950's the spillway pier noses were repaired.

In April of 1965, abnormal early ice break-up and greater than normal rainfall produced a peak flow of 43,100 cfs. The dam was left inoperable due to extensive damage to the dam's tainter gates and powerhouse caused by the record flow of the Blue Earth River. As stated earlier, the status of hydropower in the U.S. during the 1960's was considered bleak, therefore NSP decided against repairing the dam, and eventually presented ownership of the dam to Blue Earth County in 1975. The dam remained abandoned for 18 years until the rehabilitation project began in 1983. During this time the river was unregulated and

discharges from the dam were run-of-the-river. The dam began producing electricity in the fall of 1984 after a rehabilitation project, which included the following:

- Reinforcement of the dam itself.
- Installation of new tainter gates.
- Upgrading of the powerhouse with new equipment that would produce a maximum potential output of 5 megawatts.
- Dredging of reservoir sediment immediately upstream of the turbine intakes.
- Doubling the surface area of the reservoir to 168 hectares (145 acres).

Rapidan Dam was the first hydroelectric plant in the state to be resurrected (Tim Krohn, 2002). In order to achieve maximum output of electricity, and economic gain, the developer of the dam requested a store and release mode of operation. This required storing water in the reservoir during periods of low electrical demand and the releasing it through the turbines during periods of high electrical demand. This operational scheme of store-and-release is termed "peaking."

The relicensing of the Rapidan Dam provided an opportunity to study the effects of manipulated flows and its unstratified reservoir on the physical, chemical and biological aspects of the river.

Purpose and Study Components

As part of the relicensing of the Rapidan Dam Hydroelectric Facility, the Blue Earth County Board of Commissioners contracted Professor Henry Quade and his students at Mankato State University to determine "the effects of converting a run-of-the-river, unstratified reservoir, hydroelectric dam into a peaking operation."

The Rapidan Dam Research Project investigated four river components potentially impacted by the conversion to a peaking operation of the hydroelectric dam during the years of 1983 to 1985. The four components include: water quality, sediment transport, synthetic organics, and aquatic macroinvertebrates.

The Minnesota Department of Natural Resources conducted a separate study pertaining to the affect of the peaking on the downstream fishery.

In order to assess and quantify the potential impacts identified above, the following research was conducted:

- 1) The establishment of a spring to fall baseline set of data (run-of-the-river) for eleven water quality parameters and four size classifications of particulate organic material in transport within the water column. Three peak power generations in August 1985 were sampled with the data being compared to the baseline data set as well as historic data, impacts down stream, and effects of differences in peaks.
- 2) The establishment of a peaking season baseline set of data (run-of-the-river) for five sediment in transport parameters. Three peak power generations were sampled and compared to the seasonal baseline data.
- 3) The characterization of the surficial reservoir sediment by grain size and percent organic. This component also included an initial bed load study and post peaking reservoir sediment grain size comparison.
- 4) A survey of waters, baseline and peaks, for chlorinated hydrocarbons.
- 5) The permit for relicensing of the dam specifically required a study of the impact of fluctuating flows on the aquatic invertebrates of the Blue Earth River. Samples were collected over a three-year period beginning in 1983, the year before dam operation, and during dam operation from late 1984 through 1985.

The information gained from this study is intended to identify parameters impacted by the peaking versus "run-of-the-river" operation. The impacts identified, and their magnitude, can be utilized as a component in the decision making process of whether to remove, restore, or modify the dam. The results can further be utilized as input for future research and model development concerning the physical, chemical and biological impacts of small peaking hydroelectric dams on riverine systems .