STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-35-R-24

Study No.: 686 **Title:** Impact of hydropower facilities on water quality: an assessment of observed effects and potential for impacts in new facilities.

Period Covered: April 1, 1998 to September 30, 1999

Study Objectives: (1) Determine whether existing facilities violate temperature or dissolved oxygen standards, based on current data, (2) determine which factors associated with facility design or operation appear to contribute most heavily to violations of these standards, (3) from selected facilities representing a continuum from low to high impact, determine how fish populations respond to changes in water quality and substrate, (4) determine changes in substrate size composition due to the impoundment, (5) determine if fish population changes are more closely related to changes in water temperature, dissolved oxygen, substrate, or a combination of all three factors.

Summary: Little progress has been made on the water quality modeling component of this project. This summary, therefore, only includes information on the fish impact component. We sampled ten streams during the summers of 1998 (3) and 1999 (7). Streams were chosen with the help of MDNR personnel and were selected on the basis of 1) having at least one dam, 2) having a trout population, 3) being wadeable (due to equipment constraints) and 4) having no fish passage facilities. At least six sites were selected for each stream, three above and three below each dam. At each site we sampled the habitat (including temperature, dissolved oxygen, phosphorous, width, depth, flow, and substrate) and fish community. Age structures were taken from selected species (brook trout and brown trout) and lengths were taken from all species.

The streams in this study represent a gradient of impact from a slight cooling below the dams to more than 5 degree Celsius increase. Pebble counts revealed a slight coarsening downstream from sand/gravel to gravel dominated substrates. Upstream sites had on average three fewer fish species than downstream sites. Individual streams that had larger increases in temperature below the dam had larger increases in fish species richness as well. Trout and sculpin densities both tended to decrease with increasing temperatures below the dams. Length data indicates that growth is most likely variable and not significantly impacted by the dams, but this data will be analyzed further.

Job 1. Title: Assemble data into a consistent, uniformly formatted database

Findings: Fisheries division staff were unable to assist in the compilation of the database due to time and personnel constraints. This process, however, was initiated by Michigan State University personnel. An initial database on hydropower facilities was created, but progress thus far is not sufficient to allow completion of Jobs 2-5.

Job 2. Title: Determine factors leading to thermal stratification in impoundments

Findings: No work has been done.

Job 3. Title: Determine the effect of each hydropower facility on water quality

Findings: No work has been done.

Job 4. Title: Determine which variables best predict facilities that show substantial effects on water quality

Findings: No work has been done.

Job 6. Title: Review literature on effects of water temperature and dissolved oxygen on stream fish communities

Findings: Published research on dams and dam effects as well as research focusing on the importance of various habitat characteristics such as temperature, substrate and dissolved oxygen on cold-water fisheries was reviewed. This allowed for a better understanding of what type of work had been done in this area and what conclusions earlier researchers had made about effects of regulation on streams and stream fishes. There is a huge body of literature that has been published on dams and their impacts, but very little of this research focused on quantifying the impact. There is a real need for a better understanding of which habitat alterations caused by dams are most problematic for sustaining downstream fisheries that resemble their upstream counterparts. A quantification of these impacts will help move our understanding in this direction.

Job 7. Title: Group hydropower facilities and select streams for fish sampling according to water quality impacts

Findings: Selection of streams was performed with assistance of Fisheries Division personnel. Our discussions revealed that in Michigan, dams have rarely been found to substantially reduce oxygen downstream. For this reason we dropped D.O. from our list of impacts and were directed to streams that have dams that are suspected to warm downstream temperatures. Table 1 shows three levels of impact (low, moderate, and high temperature impact).

Job 8. Title: Conduct field sampling of fish and begin growth analysis of trout scales and sculpin otoliths

Findings: We sampled fish, substrate, temperature, dissolved oxygen and various other habitat and water quality parameters from 10 streams in Michigan over the summers of 1998 and 1999. A total of 61 sites were sampled. At least five or six sites were located on each river, three above and three below each impoundment (some rivers did not have six sites that were wadeable). Four of the study streams had two impoundments in close proximity to each other. In these cases an additional site was placed between the two impoundments. One stream had two branches flowing into one reservoir, so two additional sites were added to allow for adequate sampling of each branch.

Data collected on the fish community include population estimates of trout using triple pass removal, scales from all trout for age and growth analysis, identification and counts of all fish caught, and lengths from all trout and sculpin (Tables 2-5).

Point measurements of temperature, dissolved oxygen, and total phosphorous were taken at each site on the day of sampling (Table 6). Temperature loggers which documented hourly temperatures throughout the summer were placed at one site directly upstream of the impoundment and one site directly downstream of the impoundment. Rivers with two impoundments had an additional logger placed between the two impoundments.

Job 9. Title: Conduct field sampling of substrate in each stream selected

Findings: Substrate, flow, width, and depth were measured along transects at the top, bottom, and middle of each site above and below each impoundment (Table 7). Substrate was measured using the pebble count method.

Prepared by: Daniel B. Hayes
Date: September 30, 1999

Table 1.–Possible stream water quality impact combinations for temperature. Ideally at least one stream from each group will be sampled.

	Low D.O. Impact
Low Temperature Impact	Low D.O. Impact/ Low Temp. Impact
Moderate Temperature Impact	Low D.O. Impact/ Mod. Temp. Impact
High Temperature Impact	Low D.O. Impact/ High Temp. Impact

Table 2.–Mean trout length (mm) (all species and passes combined) at each site in each river (N/A is noted for streams without a "between" site 4, and "----" is noted for any other sites not sampled in each stream). A zero indicates no trout were caught at the indicated site.

	Upstream Sites			**Between Sites**	**Downstream Sites**		
Stream	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Manton	75.8	108.7	106.9	121.1	181.7	141.5	128.9
Dowagiac	0	186.6	91.0	0	0	0	0
Fish	198.8	0	----	N/A	0	0	----
Middle Branch	178.3	191.3	125.8	N/A	216.3	0	0
White	220.8	158.8	184.5	N/A	157.0	137.1	----
Sugar	0	143.8	166.5	N/A	0	0	0
Prairie	144.2	155.1	156.4	N/A	136.8	162.0	144.0
Boardman	145.1	174.9	122.4	N/A	239.6	186.7	162.0
Cedar	191.9	148.0	115.8	228.2	0	0	0
W. Branch Maple	0	198.0	198.0	N/A	207.0	159.5	176.2
E. Branch Maple	0	218.8					
Average	**165**	**161.3**	**140.8**	**174.7**	**189.7**	**157.4**	**152.8**

Table 3.–Total number of trout (all species and passes combined) caught at each site in each river (N/A is noted for streams without a "between" site 4, and "----" is noted for any other sites not sampled in each stream).

	Upstream Sites			Between Sites	Downstream Sites		
Stream	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Manton	81	62	97	42	9	20	21
Dowagiac	0	8	1	0	0	0	0
Fish	6	0	----	N/A	0	0	----
Middle Branch	4	24	8	N/A	4	0	0
White	12	20	6	N/A	17	10	----
Sugar	0	14	16	N/A	0	0	0
Prairie	12	24	5	N/A	21	2	2
Boardman	79	47	72	N/A	38	54	31
Cedar	27	56	79	12	0	0	----
W. Branch Maple	0	55	28	N/A	14	37	18
E. Branch Maple	4	4					
Average	**19.4**	**28.5**	**34.7**	**18**	**10.3**	**12.3**	**10.2**

Table 4.–Total number of sculpin (all species and passes combined) caught at each site in each river (N/A is noted for streams without a "between" site 4, and "----" is noted for any other sites not sampled in each stream).

	Upstream Sites			Between Sites	Downstream Sites		
Stream	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Manton	19	20	27	14	2	0	0
Dowagiac	1	76	108	0	0	0	0
Fish	13	1	----	N/A	0	0	----
Middle Branch	19	50	24	N/A	3	4	0
White	26	44	29	N/A	11	25	----
Sugar	0	0	4	N/A	0	0	0
Prairie	78	2	22	N/A	49	10	2
Boardman	28	93	58	N/A	14	13	36
Cedar	95	51	71	13	0	0	----
W. Branch Maple	9	40	30	N/A	98	36	34
E. Branch Maple	0	50					
Average	**26.2**	**38.8**	**41.4**	**9**	**17.7**	**8.8**	**10.2**

Table 5.–Total number of fish species caught at each site in each river (N/A is noted for streams without a "between" site 4, and "----" is noted for any other sites not sampled in each stream.

	Upstream Sites			Between Sites	Downstream Sites		
Stream	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Manton	4	4	6	8	14	8	9
Dowagiac	13	17	8	3	7	7	2
Fish	23	15	----	N/A	21	20	----
Middle Branch	10	11	11	N/A	14	11	10
White	7	4	8	N/A	11	13	----
Sugar	4	8	7	N/A	13	12	18
Prairie	12	10	10	N/A	15	9	7
Boardman	3	4	3	N/A	11	8	6
Cedar	4	3	4	7	7	8	----
W. Branch Maple	4	6	6	N/A	7	7	7
E. Branch Maple	12	10					
Average	**8.7**	**8.4**	**7**	**6**	**11.2**	**10.3**	**8.4**

Table 6.–Temperature (°C) from point measurements taken at each site in each river (N/A is noted for streams without a "between" site 4, and "----" is noted for any other sites not sampled in each stream).

	Upstream Sites			Between Sites	Downstream Sites		
Stream	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Manton	13	14.6	13.2	18	22.9	22.7	17.6
Dowagiac	21.9	19.9	19.2	23.4	24.5	24.3	23.6
Fish	20.2	24	20.6	N/A	16.3	23.1	21.3
Middle Branch	17.4	19.1	20.5	N/A	24.2	24.5	15.1
White	15.1	14.4	16.9	N/A	18.8	19	----
Sugar	24.1	18.8	19.7	N/A	23.1	19	21.6
Prairie	19.6	16	14.9	N/A	18.4	18.4	15.2
Boardman	18.8	16.1	14.7	N/A	20.3	20.8	21.9
Cedar	12.6	12.7	12.8	15.6	22.1	18.6	----
W. Branch Maple	20.1	16	18.2	N/A	17.7	17.6	14.9
E. Branch Maple	21.1	17.3					
Average	**18.54**	**17.17**	**17.07**	**19**	**20.8**	**20.8**	**18.9**

Table 7.–Mean substrate particle size at each site in each river (N/A is noted for streams without a "between" site 4, and "----" is noted for any other sites not sampled in each stream). Particle codes are as follows: clay=1, silt=2, sand=3, gravel=4, cobble=5, boulder=6, bedrock=7.

	Upstream Sites			**Between Sites**	**Downstream Sites**		
Stream	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Manton	2.8	3.4	3.1	3.3	3.3	3.3	3.2
Dowagiac	3.1	3.3	3.5	2	3.6	4.3	4.9
Fish	4.6	4.6	4.0	N/A	4.8	3.6	3.9
Middle Branch	3.7	4.4	3.7	N/A	2.9	4.4	4.3
White	2.9	3.7	3.4	N/A	4.4	2.9	----
Sugar	3.5	4.1	3.8	N/A	4.0	2.8	4.3
Prairie	3.6	4.2	3.9	N/A	4.9	4.3	4.2
Boardman	4.0	3.3	4.1	N/A	4.2	4.1	4.4
Cedar	2.5	3.3	3.8	3.3	4.4	3	----
W. Branch Maple	2.4	2.8	3.4	N/A	4.0	3.5	3.1
E. Branch Maple	2.9	4.3					
Average	**3.3**	**3.8**	**3.7**	**2.9**	**4.1**	**3.6**	**4**