ALTERNATIVE PLANS FOR MITIGATING FISHERIES RELATED IMPACTS AT THE PROPOSED LITTLEFIELD HYDROELECTRIC PROJECT SITE, FERC PROJECT NO. 8158-002

Prepared for

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TABLE OF CONTENTS

1.0 BACKGROUND

Current plans to redevelop a hydroelectric facility at the Littlefield site on the Little Androscoggin River would inundate an approximately half mile section of riffle-pool riverine habitat. Of particular interest within this half mile section are the approximately 700 linear feet of boulder strewn riffles. Because of the limited amounts of riffle habitat within this river, and the general importance of this habitat type to salmonid species, federal and state fisheries agencies are concerned that the proposed development would significantly effect stream fishery resources within the area. The greatest concerns are for the potential losses of trout habitat and for impacts to spawning and nursery habitat of possible future populations of anadromous Atlantic salmon and American shad.

Normandeau Associates (1987) quantified these impacts using the Habitat Evaluation Procedures (HEP). This study indicated that the proposed impoundment at Littlefield would adversely affect the quality of habitat for juvenile and adult trout in the lower 0.5 mile section of the impoundment. However, trout habitat would not be adversely affected either above or downstream from this half mile long section. The HEP analysis showed that, as the result of project construction, 5.9, 5.9, and 3.2 units (i.e. HEP habitat units) of nonsummer habitat would be lost respectively for brook, rainbow and brown trout. However, losses of summer habitat would be minimal. The consensus of the project's HEP team is that, in this area of the Little Androscoggin River, summer water temperatures are too warm for brook trout and probably only marginal for rainbow trout and brown trout. An additional finding of the HEP study was that the potentially impacted river section contains only very minimal amounts of useable spawning habitat for trout or salmon. It is unlikely that the existing spawning conditions would be sufficient in area to sustain natural populations of trout in this river section.

Given the habitat conditions and limited number of tributaries to the lower and middle sections of the Little Androscoggin River, spawning habitat for trout is probably very limited in these areas of the watershed. Indeed, within the area of the proposed impoundment any fishery for salmonid species is undoubtedly largely if not entirely dependent upon trout stocking.

Nevertheless, the project applicant has attempted to identify meaningful and economically viable alternatives for mitigating (compensating) losses of fish habitat associated with the Littlefield Hydroelectric Project. The remainder of this discussion outlines the options available for mitigation and/or compensating for the fishery impacts associated with this project.

2.0 OPPORTUNITIES FOR HABITAT IMPROVEMENT

The clearest and most direct means to mitigate for the loss of habitat at Littlefield is to enhance habitat values elsewhere, to a level that sufficiently offsets the original habitat loss. The HEP calculations generated for this study have quantified the potential losses of habitat due to the project; they also provide a means to evaluate the sufficiency of a mitigation plan. In developing alternative scenarios for mitigating the Littlefield project, the developer has attempted to identify every opportunity available for in-kind mitigation. This effort to attain in-kind mitigation has included low overflights of the Little Androscoggin River, instream inspection of the mainstem by canoe and boat, conversations with prominent local fishermen and officials, and discussions with federal and state district fisheries personnel.

Because of the general habitat conditions provided by most of the Little Androscoggin River, and the nature of the HEP models used to quantify habitat at Littlefield, it appears that the only way to provide in-kind mitigation within this drainage is to improve stream substrate conditions. Throughout almost its entire length, the Little Androscoggin is a highly sinuous, low gradient stream with a substrate consisting generally of sand and fine gravel. Reductions in the percentage of fine materials within the existing riffles or the creation of new riffles would produce quantifiable improvements (i.e., increased HSI's). Deep pools and numerous snags, undercut banks, and felled trees already provide abundant cover for fish. Therefore, improvements in cover would provide only minimal benefits and no increase in HSI values. Likewise, improving the stream's water quality in terms of the HEP variables for minimum dissolved oxygen, maximum summer temperatures, or pH do not appear to be viable options for increasing habitat suitability indices, given the inherent technical difficulties and costs.

The entire drainage of the Little Androscoggin River has been examined for potential sites that might benefit from stream improvement activities. The areas of greatest interest were those where riffle habitat might be created or enhanced. Sites offering the greatest opportunities for in-kind mitigation are within the mainstem of the Little Androscoggin River. Tributaries of this stream appear unsuitable as mitigation sites because of their relatively small sizes and low gradients.

Within the mainstem of the Little Androscoggin River, only two sites have been identified that have potential value as in-kind mitigation areas. These include the Welchville Dam impoundment, and the free flowing section between the Welchville impoundment and the town of Norway, Maine. Stream habitat can be significantly improved at both of these sites. However, each site has certain limitations in its value as a mitigation area for the Littlefield Project.

2.1 REMOVAL OF THE WELCHVILLE DAM

The 12 foot high Welchville Dam in the township of Oxford, Maine, 16 miles upstream from the proposed site at Littlefield, impounds approximately 3.1 miles of the Little Androscoggin River. Owned and operated by the applicant for the Littlefield Project, the dam at Welchville historically provided storage capacity for downstream hydroelectric projects. As part of a scenario to mitigate (compensate) for the Littlefield Project, the applicant is prepared to breach the Welchville Dam.

During the summer of 1987, field studies were conducted in the Welchville impoundment area to assess the gains in fish habitat that might be achieved by removing the dam. These studies were done following a draw down of the Welchville impoundment and while the normally impounded area was free flowing. The same habitat information was collected as was collected for the Littlefield baseline assessment (Normandeau Associates 1987). Width, depth, velocity, and substrate data were collected at 25 transects (Figure 1), and the length of each riffle area was recorded.

During the drawdown, the usually impounded river section at Welchville contained six riffles, which together totalled 568 linear feet of stream. Within these riffles, thalweg depths were approximately 2-3 feet and mean current velocities were generally 1 to 2 feet/second. When drawn down, the remainder of the impoundment area consisted of runs and pools with thalweg depths of approximately 6 to 8 feet. Within the pools there was substantial cover in the form of snags and felled trees. Width, depth and velocity data for each transect are provided in Appendix A.

The Habitat Suitability Indices (HSI's) for brook trout, brown trout, and rainbow trout in this stream section were 0.2, as calculated using the salmonid models applied in the Littlefield site assessment. This relatively low value is due directly to the quality of substrate, which throughout the area is nearly 100% sand. Even within the riffles created by the drawdown, the streambed was predominantly sand with only limited amounts of fine gravel. Because of this, the HEP model variables for "percent fines within riffles and runs" and "dominant riffle substrate" are at their minimum values. Nevertheless, except for the sandy streambed, when drawn down, the Welchville site has habitat conditions that appear suitable for trout. Depth, instream cover, current velocities, and pool class were all near optimal for trout, although spawning habitat was obviously nonexistent.

Given the geology of the Welchville area, it may be that a breach of the Welchville Dam would not quickly produce high gradient riffles with minimal amounts of fine material. This section of the Little Androscoggin possesses a lower gradient than either adjacent upstream or downstream sections. This may well be due to the accumulation over many years of sediments within the backwaters of the Welchville Dam. If the Welchville Dam were removed, the longitudinal profile of the stream and its tributaries would be readjusted by the erosion of channel sediments and the subsequent incision of the stream channel into its former streambed. It would probably require several years before most of the sediment bedload would be transported downstream and a dynamic equilibrium would be reestablished.

Because the percentage of fine materials within the riffles would probably remain high for many years regardless of whether the dam were breached, HSI's within the impoundment area would probably be unaffected by the removal of the dam. As a consequence, the removal of the Welchville Dam would not create habitat units as defined by the HEP models. Therefore this option for mitigation is not a HEP quantifiable in-kind mitigation plan. Rather, it is a scenario that would create three miles of free flowing river, including several hundred feet of shallow riffle habitat. Removing the Welchville Dam would also promote increased oxygenation of the Little Androscoggin River, and it would probably help to lower summer water temperatures in this area by reducing the width and depth of the stream channel, changes that would contribute to increased shading. These latter changes would undoubtedly benefit the aquatic community at Welchville.

One potential adverse affect of removing the Welchville Dam is the reduction in habitat for certain wildlife species. Currently the Welchville area contains a high degree of interspersion of open water, wetlands, and forested cover types. These conditions provide excellent habitat for several semiaquatic species. Removing the Welchville Dam to mitigate for the Littlefield Project would probably result in a net loss of habitat for these wildlife species. A further discussion of the effects of removing the Welchville Dam on wildlife habitat is provided in Appendix C.

2.2 ENHANCEMENT OF RIFFLES IN THE NORWAY AREA

The second opportunity to compensate habitat losses through offsite habitat improvements was identified as the result of the studies at Welchville. The 4.7 mile section of the Little Androscoggin River immediately upstream from the Welchville impoundment contains habitat that appears highly similar to that in the Welchville area during periods of drawdown. Similarities include such stream characteristics as average gradient, depth, width, general geomorphology, riparian vegetation, a predominantly sand substrate, and a highly irregular and meandering stream channel with several adjacent oxbow ponds. This upstream section located in the northwest corner of Oxford, ME, hereafter referred to as the Norway area, is also known to support a fishery for large brook trout (S. Pierce, ME Dept. of Inland Fish & Wildlife (MDIFW), personal communication). Given this information, if the two stream sections were indeed shown to have similar habitat, then the breaching of the Welchville Dam could be shown to provide increased habitat for juvenile and adult trout, regardless of whether these sections met the substrate requirements specified in the HEP models.

To evaluate the similarities in habitat between the Welchville and Norway areas, a geologist, a fishery biologist, and the Manager of Environmental Affairs for Consolidated Hydro examined these sections during a canoe trip that began upstream at the Route 26 crossing near the Norway town line and ended at the Welchville Dam. During this site visit observations were made on the geomorphology of the two stream sections, and special considerations were given to the quantity and quality of riffles in the Norway section. In several of these riffles, the percentage of fine material (diameter < 3 mm) was determined volumetrically using a McNeil substrate sampler and related sample processing equipment. Discussions of the surficial geology and fluvial geomorphology in the Welchville and Norway areas are presented in Appendix B.

Within the Norway area (the section between the Route 26 bridge and a point approximately 0.7 miles upstream from the Route 121 bridge) 14 riffles were identified. Each of these was approximately 50 to 100 feet in length. Their average current velocities generally ranged from 1 to 2 feet/second, and their depths ranged from approximately 0.5 to 1.5 feet. Of the 14 riffles, only four had substrates with HEP suitability indices (SI's) greater than the minimum value of 0.2. Average percent fines (< 3 mm) within the substrates of these four riffles was 39% (range = 33-50%). The remainder had substrates consisting of at least 60% sand, and were therefore rated the minimum value.

It is this large amount of sand within its riffles that makes the Norway area a potential place for implementing habitat improvement measures. Reducing the percentage of sand within several of these riffles would increase the value of the streambed as a substrate for food organisms. This would directly improve Habitat Suitability Indices (HSI's) for the Norway area by raising the suitability index value for the variable: "Percent fines (<3 mm) in riffle-runs during average summer flows".

To mitigate the impact of the development of a new hydroelectric dam at Littlefield, the developer has the option of improving riffle habitat in the Norway area by enhancing the quality of the existing riffles. This can be done by increasing the gradient of the existing riffles, stabilizing them, and introducing gravel and cobble sized aggregate materials. This would involve the placement of upstream and downstream control structures in the stream channel and the stabilization of banks with boulders, gabions, or other structures. At each enhanced riffle, an upstream control structure would act as a flow control and form a small pool. The downstream structures would act as a structural control to contain aggregate placed between the two structures. Regular monitoring and maintenance of these structures would be required to sustain the volume of aggregate, prevent deposition of fines in the structures, and prevent the breaching or erosion of the control structures and adjacent stream banks. If this alternative is adopted as the only mitigative measure for the Littlefield project, then approximately 500 to 600 linear feet of riffle habitat would be enhanced. This distance equals the length of riffles that would be inundated by the proposed project.

The enhancement or creation of artificial riffles to improve stream fisheries has had mixed results in its application. It has been an effective, although costly, alternative for renovating spawning beds for salmonid species (Mih 1978). Artificial riffles have also been shown to produce increased densities and species diversity of stream dwelling macroinvertebrates (Edwards *et al*. 1984). In contrast, White and Brynildson (1967) and White (1974) caution that attempts to enhance or create riffles for spawning are prone to a number of problems including siltation, loss of bed materials due to the scouring of spring floods, and unsightly appearance. However, riffle enhancement has been usually used to create salmonid spawning habitat; whereas, in this case, the enhancement of existing riffles will primarily serve to increase the production of invertebrate food organisms. This latter objective would be easier to obtain than having to produce the complex substrate conditions suitable for spawning salmonid species, which require particularly clean substrates with substantial interstitial flow. Any spawning habitat created within the artificial riffles would be a bonus.

2.3 OUT OF BASIN OPPORTUNITIES

Opportunities may exist for improving salmonid habitat outside of the Little Androscoggin River watershed for the purpose of mitigating the effects of the Littlefield Project. However, discussions with state fishery personnel and local sportsmen have not been fruitful in this area. To date, overflights and consideration of riverine habitat conditions within the larger Androscoggin River basin have failed to yield significant opportunities for mitigation. Nevertheless, the developer for the Littlefield Project remains willing to provide economically justifiable, in-kind mitigation for the project through improvements of habitat, wherever and whenever such opportunities avail themselves.

3.0 OPPORTUNITIES FOR OUT-OF-KIND COMPENSATION

An alternative means of mitigating (compensating) for fisheries related impacts due to the proposed project at Littlefield is to contribute significantly to the enhancement of fisheries in the Little Androscoggin River. Because water temperatures in the project area appear marginal or limiting to natural populations of the salmonid evaluation species, except for salmon, and because spawning habitat for all salmonids is very limited in the Little Androscoggin River including the project area, it does not appear that existing wild populations of the evaluation species would be significantly effected by the proposed project. Therefore, a mitigation scenario involving an intensification of fisheries management efforts in the Little Androscoggin River should benefit fisheries in this river and thereby provide ample mitigation (compensation) for the fisheries losses attributed to the proposed project.

The upper and middle sections of the Little Androscoggin River have considerable potential for supporting coldwater fisheries. As previously noted, the Norway area is known to support a fishery for large brook trout, although the source of these fish and their abundance is unknown (S. Pierce, MDIFW, personal communication). The deep pools, abundant cover, undercut banks, and stream currents in this area also suggest that this river can support a seasonal trout fishery. Unfortunately there is a paucity of scientific data concerning the aquatic life in this river.

To improve fisheries in the Little Androscoggin River, it is first necessary to develop a data base concerning the resident fish populations in this river's mainstem and tributaries. The presence or absence of game fish species must be established; and if present, their relative abundance, age structure, and spawning grounds or source must be documented. The suitability of this river's water temperatures for cold water species should also be documented. This could be done through a multiyear water temperature monitoring program involving the use of thermographs placed at two or more stations.

It may well be that no salmonid spawning habitat or juvenile trout are present in the middle and lower mainstem, given the very sandy substrate throughout these sections. Indeed, it is likely that natural reproduction is at least limited in this river. Therefore, enhancement of trout fisheries in the mainstem could be accomplished through a stocking program designed to maximize survival, fisherman yield, or other desirable goals. Annual inventories of the fish populations during the first three to five years of the management program could be conducted to establish the best species, life stages, and stocking densities needed to achieve the desired management goals. A multiyear creel survey of the Little Androscoggin River would also be of value in documenting changes in fishing pressure, angler satisfaction, and harvest rates. Data from creel surveys would be helpful in developing a long term strategy for managing fisheries in the Little Androscoggin River.

As an alternative means to mitigate (compensate) for fisheries related losses due to the Littlefield Project, the license applicant for the project is prepared to contribute to fisheries management efforts in the Little Androscoggin in the following ways:

1. Provide a baseline inventory of fishes in the Little Androscoggin River and its tributaries between South Paris and the river's confluence with the Androscoggin River.

2. Actively implement or provide funding to the State of Maine for an annual trout stocking program for the mainstem of the Little Androscoggin River. This would be carried out for the life of the Littlefield Hydroelectric Project.

3. Monitor the survival and growth of stocked trout in the Little Androscoggin through three additional years of biological surveys of this river.

4. Provide continuous monitoring of summer water temperatures in the Little Androscoggin using thermographs positioned at a minimum of two stations. Summer water temperatures would be monitored for three consecutive years.

5. Conduct three separate eight week long creel surveys to assess such factors as fishing pressure, harvest rates, and angler satisfaction. The creel surveys would be conducted during the same season on different years.

6. Develop an appropriate long term fishery management plan for the Little Androscoggin River using the data generated from the above listed studies.

4.0 SUMMARY

The license applicant for the Littlefield Hydroelectric Project has developed alternative plans for mitigating fishery losses associated with their proposed project. Alternative ways of mitigating (compensating) for the anticipated fisheries impacts at Littlefield include in-kind replacement of habitat through stream improvement activities or enhancement of fisheries management efforts and the development of an optimum trout stocking program.

Opportunities for in-kind habitat replacement (i.e. stream habitat improvements) are limited in the Little Androscoggin River Basin, because of the river's gradient, geomorphology, and the already existing abundant pools and fish cover. However, enhancement of riffle habitat in the vicinity of northwest Oxford, ME would increase the capacity of this section for producing invertebrate food organisms. This would directly improve the suitability of this habitat in terms of Habitat Suitability Indices (HSI's). Additional opportunities for mitigating the Littlefield Project may exist outside of the Little Androscoggin River basin; however, despite efforts in this area, none have been identified. Nevertheless, Consolidated Hydro remains willing to provide economically justifiable, in-kind mitigation for the project through improvements of habitat, wherever and whenever such opportunities are identified.

An alternative means of improving habitat in the Little Androscoggin River is to remove the dam at Welchville. This would partially compensate for habitat losses at Littlefield in that 3.1 miles of free flowing stream would be created. However, because of the large sediment deposits in the Welchville impoundment and the predominance of sand in the natural streambed of the Little Androscoggin River, this alternative would not directly produce in-kind mitigation (compensation) as determined by the HEP process. Removal of the Welchville Dam as mitigation for the Littlefield Project would also probably result in a net loss of habitat for semiaquatic wildlife species such as waterfowl, mink, and muskrat.

Intensification of fishery management efforts in the Little Androscoggin River is suggested as the most suitable means of mitigating the proposed project on the basis that anticipated losses of fish habitat at Littlefield are primarily units of habitat used by stocked fish. The baseline HEP study indicated that summer water temperatures in the project area are limiting to brook trout and marginal for brown trout and rainbow trout. Spawning habitat is also very limited in this area and probably insufficient to sustain a wild trout fishery. Development of data bases concerning the fish populations and summer thermal conditions of the Little Androscoggin River and the collection of creel survey information are suggested as important steps needed to develop a long term management program for enhancing fisheries in this river. With this information, a long term trout stocking program could be undertaken to enhance the river's fisheries. Several follow up field studies and creel surveys would be conducted to establish the appropriate species, life stages, and stocking densities needed to achieve the desired management goals.

5.0 LITERATURE CITED

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APPENDIX A

Transect Data Collected Within The Welchville Impoundment Area During a Period of Draw Down, July 21-22, 1987. The Location of Each Transect is Shown in Figure 1.

TRANSECT 1 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.3	0.1
8	0.4	0.7
12	0.4	1.0
16	0.6	1.3
20	1.0	1.5
24	1.1	1.6
28	1.3	1.6
32	1.2	1.6
36	1.1	1.6
40	1.0	1.5
44	1.1	1.7
48	0.8	0.7
52	0.8	1.9
56	1.0	1.6
60	1.5	0.2
64	1.5	0.3
68	1.5	0.0
72	2.8	0.0
76 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 2 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	1.0	0.0
8	0.8	0.0
12	0.8	0.9
16	0.4	1.5
20	0.4	1.1
24	0.7	1.2
28	0.5	1.6
32	0.6	1.5
36	0.5	1.4
40	0.5	1.3
44	0.3	1.3
48	0.2	0.8
52	0.1	-
56	0.0	-
60	0.0	-
64	0.0	-
68	0.0	-
72	0.3	1.5
76	0.5	1.2
80	0.7	1.6
84	2.0	0.0
88	2.5	1.2
92	3.0	1.0
96	3.3	0.9
100	3.1	0.5
104	2.4	0.0
108	1.1	0.0
110 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 3 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	1.1	1.0
8	1.2	0.9
12	1.1	0.9
16	0.7	0.8
20	0.4	1.1
24	0.4	1.1
28	0.4	1.4
32	0.1	-
36	0.0	-
40	0.0	-
44	0.0	-
48	0.0	-
52	0.0	-
56	0.0	-
60	0.0	-
64	0.0	-
68	0.3	-
72	0.7	-
76	1.5	0.5
80	2.1	0.5
84	2.8	1.0
88	3.5	0.2
88-100	>3.5	0.2
102 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 4

HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.1	-
8	0.2	0.3
12	0.4	0.3
16	0.5	0.6
20	0.6	1.1
24	1.2	1.3
28	1.8	1.4
32	2.3	1.6
36	2.8	1.0
40	2.8	1.1
44	3.3	0.9
48 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 5 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.2	0.0
8	0.3	0.0
12	0.3	0.0
16	0.1	0.0
20	0.4	0.6
24	0.5	0.9
28	0.7	1.1
32	1.2	1.6
36	1.4	1.3
40	1.3	1.7
44	1.4	1.7
48	1.4	1.4
52	1.8	0.5
56	2.0	0.3
60 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 6 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.3	0.3
8	0.5	0.5
12	0.7	0.8
16	0.7	0.7
20	0.8	1.1
24	0.9	1.2
28	1.2	1.8
32	1.5	1.1
36	1.9	1.0
40	2.5	1.4
44-72	data not collected	-
75 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 7 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.3	-
8	0.2	-
12	0.7	1.8
16	0.6	1.7
20	1.3	-
24	0.0	-
28	0.5	0.1
32	0.7	2.4
36	1.0	2.0
40	1.3	2.2
44	1.1	2.1
48	1.0	2.2
52	0.8	1.5
56	2.1	0.9
64	2.3	1.2
68	2.0	0.8
78 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 8 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.1	0.0
8	0.2	0.0
12	0.4	0.7
16	0.6	1.2
20	0.4	1.1
24	1.3	0.1
28	2.1	0.0
32	2.5	0.7
36	2.9	0.6
40	3.0	0.9
44	3.0	0.8
48	1.9	0.4
50 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 9 HABITAT TYPE: Run

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	2.7	Velocities not measured in runs
16	3.8	
24	3.5	
32	3.0	
40	2.8	
48	2.8	
56	3.5	
64	3.1	
72	3.6	
80	4.1	
88	5.0	
96	5.4	
104	4.6	
112	3.5	
118 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 10 HABITAT TYPE: Run

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	2.5	velocities not measured in runs
16	2.5	
24	2.5	
32	2.7	
40	3.5	
48	3.9	
56	3.6	
64	3.7	
72	3.8	
80	4.1	
88	4.3	
96	4.6	
104	4.8	
112	3.8	
120	2.2	
124 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 11 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.3	0.0
8	1.1	1.6
12	1.0	0.8
16	1.9	2.1
20	0.9	1.5
24	1.2	0.5
28	1.0	0.1
32	0.3	0.0
36	2.0	1.3
40	2.5	1.2
44	1.2	0.0
48	1.2	0.0
52	1.2	0.0
56	1.2	0.0
60	1.2	0.0
62 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 12 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.3	0.0
8	0.8	0.0
12	1.3	0.0
16	1.5	0.3
20	1.6	1.6
24	1.5	1.8
28	2.3	1.7
32	2.9	0.9
36	2.1	0.6
40	2.0	1.0
44	1.5	0.0
46 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 13 HABITAT TYPE: Run

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
11	2.7	velocities not measured in runs
19	3.3	
27	3.3	
35	3.8	
43	4.0	
51	4.3	
59	4.3	
67	4.1	
75	4.2	
83	3.6	
91	3.8	
99	3.1	
108	1.1	
109 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 14 HABITAT TYPE: Run

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	2.3	velocities not measured in runs
16	3.1	
24	3.8	
32	3.5	
40	4.0	
49	4.1	
56	4.1	
64	4.0	
72	2.0	
80	1.2	
88	0.7	
96	1.2	
104	1.3	
110 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 15 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	1.2	0.6
8	1.4	1.2
12	1.5	1.3
16	1.2	1.5
20	1.1	1.7
24	1.1	1.7
28	1.0	1.5
32	0.9	1.6
36	1.0	1.7
40	1.0	1.7
44	0.8	1.7
48	0.7	1.5
52	0.6	1.5
56	0.8	1.5
60	0.8	1.5
64	1.0	1.5
68	1.0	1.7
72	1.0	1.4
76	1.0	1.7
80	1.0	1.5
84	1.5	1.4
88	1.8	1.2
92	2.0	1.2
93 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 16 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4	0.7	0.0
8	0.4	0.0
12	0.3	0.0
16	1.0	1.7
20	1.2	1.9
24	1.3	1.7
28	1.0	1.7
32	0.8	2.0
36	0.7	1.8
40	0.6	1.8
44	0.5	1.9
48	0.6	1.3
52	1.1	1.4
56	1.5	1.4
60	1.5	1.6
64	1.7	2.0
68	1.8	2.1
72	2.3	1.7
76	1.9	2.0
80	2.1	1.5
84	1.9	0.6
88 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 17 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
3-14	shallow backwater	0.0
18	1.7	0.7
22	1.7	1.1
26	2.0	0.4
30	1.5	0.0
34	0.9	1.6
38	0.5	1.4
42	0.4	1.6
46	0.6	0.3
48	0.4	1.5
50	0.4	1.6
54	0.3	1.5
58	0.7	1.3
62	1.1	1.2
66	1.1	1.5
70	1.4	1.6
74	1.2	1.7
78	2.1	2.0
82	1.8	1.7
86	2.1	2.1
90	2.1	1.8
94	2.0	1.7
98	1.1	0.7
105 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 18 HABITAT TYPE: Pool

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
9	2.1	velocities not measured in pools
17	3.3	
25	2.9	
33	4.7	
41	4.2	
49	3.9	
57	2.3	
65	2.9	
73	2.9	
81	1.3	
82 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 19 HABITAT TYPE: Pool

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	2.2	velocities not measured in pools
16	2.8	
24	4.6	
32	6.3	
40	6.7	
48	4.9	
56	1.5	
64	1.7	
72	1.9	
80 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 20 HABITAT TYPE: Run

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	0.6	velocities not measured in runs
16	1.0	
24	1.2	
32	1.8	
40	2.5	
48	4.0	
56	6.1	
64	6.1	
72	4.6	
80 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 21 HABITAT TYPE: Run

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	8.1	velocities not measured in runs
16	6.4	
24	3.5	
32	1.8	
40	1.8	
48	1.3	
56	2.0	
64	1.0	
72	0.9	
80	1.1	
82 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 22 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
4-24	data not collected	-
28	1.5	1.4
32	0.8	1.2
36	0.3	0.7
40	0.0	-
44	0.5	1.2
48	0.7	1.4
52	0.7	1.4
56	0.0	-
60	0.0	-
64	0.0	-
68	0.3	1.1
72	0.6	0.9
76	1.2	1.0
80	1.7	1.0
84	2.1	0.8
88	1.0	1.0
92	0.9	1.0
96	1.4	1.0
100	1.9	1.9
104	1.5	2.0
108	2.1	1.5
112	1.9	1.4
116	1.4	0.8
120	1.5	0.8
122 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 23 HABITAT TYPE: Riffle

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
3-28	data not collected	-
32	1.7	0.6
36	0.7	0.4
40	0.7	0.0
48	0.6	0.1
52	0.5	1.1
56	1.3	1.5
60	0.7	1.5
64	1.8	1.5
68	1.6	1.3
72	1.5	1.0
76	1.3	0.2
80	1.0	0.8
84	1.8	1.4
88	1.7	1.8
92	1.7	1.0
96	1.6	1.5
100	1.7	0.3
103 (right bank)	0.0	-

*left bank as viewed looking upstream

TRANSECT 24 HABITAT TYPE: Pool

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	3.7	velocities not measured in pools
16	4.8	
24	6.0	
32	7.5	
40	5.0	
48	2.0	
52 (right bank)	0.0	

*left bank as viewed looking upstream

TRANSECT 25 HABITAT TYPE: Pool

DISTANCE FROM LEFT BANK* (ft)	DEPTH (ft)	MEAN VELOCITY (ft/s)
8	1.5	velocities not measured in pools
16	5.8	
24	6.5	
32	3.6	
38 (right bank)	0.0	

*left bank as viewed looking upstream

APPENDIX B

Surficial Geology and Fluvial Geomorphology Of The Little Androscoggin River In The Vicinity Of Norway and Oxford, Maine

SURFICIAL GEOLOGY

The topography and surficial geology of the Norway-Welchville, Maine area are the result of the advance and retreat of the Pleistocene Age continental ice sheet. The landforms and surficial deposits of the area reflect both the erosional and depositional processes active during this period. In general, the topography of the study area consists of low rolling hills of moderate relief (300 to 500 feet) which are divided by low lying valleys. These valleys are drained by the main stem and the tributaries of the Little Androscoggin River.

The hills and valleys, of the study area are typically oriented in a northwest-southeast direction. The preferred orientation of these landforms reflects the principal direction of ice movement during the advance of the ice sheet from the northwest to the southeast towards the Gulf of Maine. The movement of the ice sheet across the land surface eroded the pre-existing landscape forming u-shaped valleys and elongated hills, known as drumlins. Allen Hill, west of Oxford, Maine and Robinson Hill, east of Welchville, Maine represent drumlin-type landforms.

With the advance of the ice sheet a poorly sorted mixture of silt, sand and gravel was deposited onto bedrock. This deposit is referred to as lodgement till and is typically exposed on upland areas or on hillslopes.

During the retreat of the ice sheet, from the study area, sediments which were previously transported by the ice sheet became ice free and were transported by meltwater streams. The Little Androscoggin River was a significant meltwater drainage during deglaciation as evidenced by extent of the unconsolidated deposits observed in the valley. Based upon mapping performed by the Maine Geological Survey

(Smith and Thompson 1980) the stratigraphy of the surficial deposits of the Little Androscoggin River valley consists of a sequence of glacial-fluvial and alluvial sands and gravels which overlie glacial-marine silts and clays and or lodgement till.

As discussed previously, the lodgement till was deposited during the advance of the ice sheet onto bedrock. During the reglaciation of southern Maine, the Gulf of Maine advanced inland, innundating low lying river valleys (Thompson 1980). In these areas a thick sequence of silt and clay was deposited. Simultaneously, at the margin of the ablating ice sheet, sands and gravels were being discharged into the valley by meltwater streams, and formed kame terraces, kame deltas, outwash plains and eskers. With the retreat of the ice sheet from the area, the channel of the Little Androscoggin River began to erode into and rework the glacial deposits.

In the Norway-Welchville area, the present channel of the Little Androscoggin River is bordered by a broad flat plain consisting of silt, sand and some fine gravel. The active channel has eroded approximately 5 to 10 feet into these deposits and into the silts and clays of the glacial-marine Presumpscott formation. The floodplain and streambed of the active channel consist of sands and some fine gravel which have been eroded from the stream banks and or transported to the stream by tributaries.

FLUVIAL GEOMORPHOLOGY

The Little Androscoggin River, in the vicinity of Norway and Welchville, Maine is a highly sinuous stream with numerous meanders, oxbow lakes and cutoffs. The width and depth of the stream channel generally increases from Norway, down gradient to Welchville.

In the vicinity of Norway, Maine the Little Androscoggin River is highly sinuous with frequent meanders. The channel is broad (30 to 50 feet wide) and flat with alternating sequences of relatively shallow riffles and deeper pools. The bed material consists primarily of fine to coarse sand with some gravel. In the riffle zones, the average grain size of the bed material is coarser, but the maximum grain size is limited to pebble size gravels. Areas of coarse gravel were observed at three locations where the stream channel had eroded into either an esker deposit or into a till covered hillslope.

In the vicinity of Welchville, the increase in channel width and depth and the decrease in stream velocity are the result of backwaters from the impoundment of stream flow at the Welchville Dam. The stream channel in this reach is relatively broad (30-80 feet) and flat. The bed material primarily consists of fine to coarse sands.

APPENDIX C

Effects Of Removing The Welchville Dam On Wildlife Habitat

On October 27, 1987 a wetland scientist and wildlife biologist from Normandeau Associates Inc. (NAI) visited the Little Androscoggin River north of the Welchville Dam to consider questions relative to the effects that breaching this dam would have on wetlands and wildlife. Most of both sides of the river was walked from the gravel pit and trailer park off Skeetfield Road, the northerly extent of potential water level change, to the dam site in Welchville. Aerial photo interpretation was field checked.

Wetlands

Throughout this area forested floodplain wetlands are interspersed with and grade gradually to areas dominated by upland vegetation. The land form and vegetation of this area is similar to that described by NAI for the proposed Littlefield impoundment area. However, the present river meanders and old oxbows which are now ponds or wetlands are more numerous and pronounced in the Welchville Dam area. The area from the dam to north of Whitney Pond comprises a large forested wetland, with much interspersion of open water and vegetation in many successional stages due to past forest cutting and abandonment of agricultural lands. Breaching the dam is likely to alter the hydrology and reduce open water and eventually the extent of these wetlands. The river, dam, and the Whitney-Hogan Pond formation appear to be the dominant factors in the hydrology of this area.

The area to the north of this large wetland and certainly north of Rollerrink Road are less likely to be affected. The proposed water level drop will be much less; the hydrology of the floodplain wetlands in this area appear to be more influenced by surrounding run-off and less likely to be changed by breaching the dam.

Present Wildlife Habitat Value

The high degree of interspersion of open water, wetlands, and forested cover types in the Oxford-Welchville section of the Little Androscoggin River creates an area of high wildlife habitat value. The river and its surrounding cover types provide habitat for many furbearer animals. During the site visit, we talked with two trappers who have harvested furbearers along this section of the river for several years. They have trapped muskrat, mink, otter, and raccoon in the area.

The many oxbows, meanders, and surrounding wetlands provide excellent waterfowl habitat, due to the high interspersion of water, food, and cover. Black ducks and mallards were observed using the area. Many wood duck nesting boxes are also present throughout the area; thus, it appears that the area is actively managed for this species or other cavity nesters such as goldeneyes and hooded merganzers.

Red oaks are present throughout the forested cover types, especially in the floodplain forest. These oaks provide mast, an important food for many wildlife species including white-tailed deer, black bear, red fox, squirrels, chipmunks, ruffed grouse, wood ducks, bluejays, and many songbirds.

The emergent marshes, though small in size, add habitat diversity to the area. The sedges, cattails, pickerelweed, pond lily, and surrounding shrubs provide food and cover for a variety of wildlife species including wading birds such as great-blue herons and bitterns, waterfowl, furbearers, and many songbirds.

In summary, the area currently has high wildlife habitat values due to the diversity and interspersion of the cover types.

Changes In Wildlife Habitat Value

The wildlife habitat values of the cover types northwest of the Whitney Pond-Hogan Pond area would probably not be affected by breaching the Welchville Dam. The water level changes in this section of the river would be 4-8 inches. This would appear to have little effect on the surrounding wetlands, and therefore, would not change the wildlife habitat.

The areas downstream of Whitney Pond and Hogan Pond would experience greater changes in water levels (1-5 feet). These water level changes, due to the interconnections of channels in the wetlands with the mainstem of the river, would greatly reduce the amount of surface water present in the area, reduce the interspersion of water and vegetation, and change the vegetative characteristics of the wetlands, especially those located farther from the main channel. This would result in a reduction in the habitat value of the area for waterfowl, furbearers, and certain other wildlife that use the area.

The creation of wetlands, mostly shallow and deep marsh, by the Littlefield Dam project would probably not offset the loss of wildlife habitat value created by breaching the Welchville Dam. The marshes created at Littlefield would have different wildlife habitat values than the Welchville wetlands because they would be structurally and vegetatively different, resulting in a different mix of species using the site. Also, and perhaps more importantly, the proposed Littlefield wetlands would not have the high degree of interspersion that makes the Welchville area such good wildlife habitat for a large variety of species.