U.S. Generating Company New England, Inc.

FIFTEEN MILE FALLS HYDROELECTRIC PROJECT

(FERC No. 2077)

Flow Effects on Riverine Habitat in the Main Stem of the Connecticut River

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1.0 Background

U.S. Generating Company New England, Incorporated (USGenNE) is completing the relicensing of the Fifteen Mile Falls Hydroelectric Project (FERC No. 2077). The relicensing process was initiated by New England Power Company (NEP). This study was conducted in response to an outstanding information need identified in the Final Settlement Agreement.

In 1996, NEP contracted the services of Gomez and Sullivan Engineers, P.C. (Gomez and Sullivan) to collect information on the characteristics of the riverine aquatic habitats that are associated with the project. Gomez and Sullivan evaluated the riverine habitat areas in July and August of 1996. Many of the stakeholders, including both resource agencies and non-governmental organizations, participated in these evaluations. Gomez and Sullivan produced a draft report titled "*New England Power Company Fifteen Mile Falls Hydroelectric Project Draft Riverine Habitat Report*". This report described the riverine habitats, the species of interest identified by the stakeholders, and the potential habitat evaluation methods that were discussed by the stakeholders. NEP distributed this report in early 1997 to provide information to the stakeholders for the settlement negotiations.

The largest riverine area associated with the Fifteen Mile Falls Hydroelectric Project is located downstream of the Comerford Station. The riverine habitat downstream of Comerford includes a man-made channel which was excavated as part of the project construction as well as portions of the original river channel. In 1996, the stakeholders assessed these habitats at flows of 800 and 10,000 cfs. They agreed that the habitat in the excavated channel was of lower quality than the habitat located between this excavated area and the McIndoes impoundment. Riffle habitats in the Nine Islands area were of particular interest to the various stakeholders – primarily the main stem riffle habitat, but also the habitat in the side channels which are associated with the islands in this reach. These side channels are dry at low flows but become wetted as flows increase. The species and life stages of interest in these areas were rainbow trout, brown trout and macroinvertebrates. Initially, all life stages of the three species were of interest since it was unknown whether natural reproduction may occur in this area.

In the spring of 1997, NEP contacted Gomez and Sullivan to conduct a demonstration flow study for the Nine Islands area. NEP indicated that these data were required for the ongoing settlement negotiations. NEP and Gomez and Sullivan contacted the various stakeholders and, with their participation, conducted the demonstration flow study on May 21, 1997. Gomez and Sullivan produced a draft report titled "*New England Power Company, Fifteen Mile Falls Hydroelectric Project, Demonstration Flow Study for the Nine Islands Reach of the Connecticut River*", which described the flow/habitat relationships in the side channels of the Nine Islands area. The

principal conclusion of this report was that almost all of the side channel habitat is dry at flows up to 1,600 cfs (approximately 1.0 cfm).

The Final Settlement Agreement for the Fifteen Mile Falls Project included provisions for fisheries mitigation and enhancement. One of the these provisions specifies that "... the Project Owner will prepare a flow/habitat study to assess the habitat that will be available under the proposed flow regime below Comerford and below McIndoes." To satisfy this provision, Gomez and Sullivan prepared a Study Plan Outline which NEP distributed in July, 1998. Comment letters were received in August from the Vermont Agency of Natural Resources (VANR) and Trout Unlimited (TU). The comments suggested that the scope of the study be expanded to include reconnaissance of the reach downstream of East Ryegate Dam (VANR and TU) and to include additional assessment of high flows (VANR). The stakeholders were contacted to schedule the field work, and the study was conducted on August 31 through September 2, 1998. This report describes the methods and discusses the results of this study.

2.0 Riverine Habitat Descriptions

The study area for the 1998 field work encompassed three separate riverine areas; downstream of Comerford Station, downstream of McIndoes Station, and downstream of the East Ryegate Dam. The first two areas were surveyed as part of the 1996 riverine habitat assessment. The latter area was included in this study in response to comments noted above – these comment correctly pointed out that project releases affect downstream riverine habitat.

No additional field data were collected in this study for the area immediately downstream of the McIndoes powerhouse. The resource agencies had not identified any specific fisheries objectives or evaluation species for this part of the river. This was noted in the Study Plan Outline and the comments from the stakeholders did not include any specific information needs downstream of McIndoes. Furthermore, the stakeholders that participated in the second day of the field work in 1998 (the day scheduled for McIndoes) felt that no additional information was needed on the small amount of riverine habitat downstream of McIndoes Station.

2.1 Main Stem Habitat Downstream of Comerford Station

The riverine habitats located downstream of Comerford Station extend from the tailrace of the Comerford Station to the upstream end of the McIndoes impoundment (Figure 1). The Settlement Agreement specifies that the McIndoes pond elevation will normally be operated between 447.5 and 451.0 feet msl – three to six and a half feet lower than the historic normal upper pond elevation. This lower elevation was selected during the settlement negotiations in order to create additional riverine habitat at the upstream end of the McIndoes impoundment (see the habitat description in section 2.1.4 below).

The riverine habitats downstream of Comerford Station were initially mapped in July and September of 1996. At that time, aquatic habitats were delineated and classified as riffles, runs or pools. The length of each of these habitat reaches was measured on 1"=200' scale aerial photographs. Substrates were documented and depths and velocities were estimated at flows of 800 cfs and 9,400 cfs. A second site visit was conducted in late September 1996 at a leakage flow to better document substrates. The data from the 1996 and 1997 studies were utilized in this study to evaluate the flow/habitat relationships in the main stem at discharges of 818 cfs and 1,635 cfs.

Main stem habitat characteristics are shown in Table 1. Four different riverine habitat reaches were delineated in the main stem. Side channels in the Nine Islands area were evaluated in 1997 and are not discussed in this report, as noted earlier.

2.1.1 Reach 1 – Excavated Tailrace Channel

Immediately downstream of the Comerford Station powerhouse there is an excavated channel which extends downstream approximately 1,600 yards. Because it was excavated to convey Comerford Station discharges downstream, it is deep (approximately 15 feet, depending on discharge), with relatively steep sides, and a relatively uniform cross sectional profile. This reach is classified as run habitat, although it is somewhat deep for this habitat classification. The substrates are cobble and boulder with some ledge. The substrates are heavily embedded, they are not reworked by typical flows, and no new bed load is transported through this reach due to the presence of the Comerford impoundment. The boulders, as well as the depth and low clarity of the water, provide some instream cover. Trees provide some overhead cover near the shores.

2.1.2 Reach 2 – Run Habitat Upstream of Nine Islands

Downstream of the excavated channel, the river channel widens and becomes shallower. This reach is approximately 500 yards long and was classified as run habitat, similar to the excavated channel. However, it was evaluated separately from the excavated channel since it is wider and

TABLE 1.--Aquatic habitat characteristics of four reaches of the main stem of the Connecticut River from the Comerford Station tailrace to the McIndoes Station impoundment.

Reach[1]	Habitat Type	Substrate Types (dominant/secondary)	Substrate Embeddedness	Velocity Refuge	Instream Cover	Overhead Cover
1	Run	Cobble/Boulder	75-100%	Few	Boulders and Depth/Clarity	Trees
2	Run	Cobble/Boulder	75-100%	Few	Boulders	Trees
3	Riffle	Cobble/Boulder	25-50%	Few	Boulders	None
4	Run	Cobble	50-75%	Few	Boulders	Trees

[1] Reaches are numbered from upstream to downstream and are shown on Figure 1.

shallower and was not disturbed during the construction of the project. The substrates are similar to the excavated channel, although there are more cobbles. The substrates are in this reach are also heavily embedded. Boulders provide some instream cover and trees along both shores provide some overhead cover.

2.1.3 Reach 3 – Main Stem Riffle Habitat at Nine Islands

The main stem at Nine Islands was classified as riffle habitat. This reach was approximately 700 yards long. (Note: Riffle habitats in the side channels were evaluated in 1997 and are not described here.) Substrates were similar to the upstream areas with moderately embedded cobbles and small boulders. The small boulders provide very little instream cover. The banks consisted of gently sloping armored substrates (embedded cobbles) with trees further back on the banks. There was no overhead cover near shore.

2.1.4 Reach 4 – Run Habitat Downstream of Nine Islands

Historically, McIndoes Station re-regulated the flow of the Connecticut River and as a result, the impoundment level varied. This altered the location of the upstream extent of the McIndoes impoundment and thus, the extent of the riverine habitat. At the historic maximum operating level of 454.0 feet, the riverine reach downstream of Nine Islands was only a few hundred feet long. The Settlement Agreement specifies an operating elevation range of 447.5 to 451.0 feet msl for the McIndoes Pond. This pond level creates a riverine reach downstream of Nine Islands which is approximately 1,430 yards long at 447.5 feet elevation.

This reach was classified as run habitat although there was a small riffle area midway down the New Hampshire shore where a small island created a side channel. The substrates were moderately embedded and consisted primarily of cobbles with a few boulders and some ledge. The boulders provided some instream cover. The small riffle area had cobble and large gravel substrates. Trees and brush, particularly along the steep bank on the Vermont side of the river, provided some overhead cover.

2.2 Main Stem Habitat Downstream of East Ryegate Dam

McIndoes Station discharges directly into the East Ryegate Project impoundment. The Settlement Agreement specifies that McIndoes Station will normally fluctuate within a 3.5 foot daily operating range in order to smooth out discharges from the upstream stations. Since the East Ryegate Project is operated in a run-of-river mode, then the future discharges from McIndoes Station will affect the riverine habitats that are located downstream of the East Ryegate Dam. Trout Unlimited and the VANR requested that this reach of the river be investigated as part of the demonstration flow study.

A reconnaissance survey of the Connecticut River from East Ryegate Dam to the USGS Wells River gaging station (just downstream of the confluence with the Ammonoosuc River) was

conducted on September 1, 1998. The length of this the Connecticut River from the East Ryegate Dam to the Wells River gaging station is approximately 8,000 yards, as measured on the USGS 7.5 minute series topographic map (Figure 2).

Most of this section of the Connecticut River is composed of pool habitat – deep slow moving water with sand and silt substrates. There were two short riffle reaches which are located just upstream of the confluence with the Ammonoosuc River in an area known as the narrows (Figure 2). The upstream riffle apparently acts as a hydraulic control which creates the pool habitat from there upstream to the East Ryegate Dam. This riffle is very wide, approximately 150 yards long, 0.5-1.0 feet deep, with cobble and large gravel substrates. The downstream riffle has two channels flowing around a small island. The riffle in the river left channel (looking downstream) was very shallow and had cobble and large gravel substrates. The channel at river right was approximately 130 yards long, 1.0-2.0 feet deep, with cobble substrates. Based on the total reach length measured on the topographic map, and the estimated lengths of these two riffles reaches, there are a total of approximately 280 yards of riffle (3.5% of the river) in the portion of the Connecticut River from East Ryegate Dam to the Wells River gaging station.

3.0 Study Methods

The Study Plan Outline, which was distributed to the stakeholders for review and comment, specified that demonstration flow methods would be used for the areas downstream of Comerford and McIndoes Stations. In response to the written comments and discussions during the study, two modifications were incorporated into the Study Plan; (1) a qualitative habitat assessment of the area from East Ryegate Dam to the Wells River gaging station was added to the study, and (2) additional data collection downstream of McIndoes Station was dropped. In addition, the VANR had requested additional study of high flows. However, no VANR staff participated in the field work nor did they provide any specific requests for additional high flow data. As a result, high flows were evaluated based on the flow data in the Fifteen Mile Falls Initial Consultation Document and the data from the 1996 and 1997 riverine habitat studies.

The demonstration flow study downstream of Comerford Station was conducted on August 31 and September 1, 1998. The habitat assessment at each flow was based on the consensus of the study participants. The riverine habitat was broken down into the four reaches described in Section 2.1, above. The study participants viewed each of the four reaches at a particular flow, discussed the quality and amount of the habitat for each evaluation species, and then reached a consensus on the suitability of the habitat in that reach. The study participants were Ralph Abele (US EPA, 8/31 only), Scott Decker (NHFG, 9/1 morning only), Cleve Kapala (USGenNE, 8/31 only), Larry Miller (Acres International), Gary Moore (Gary Moore Associates), John Ragonese (USGenNE), Steve Shepard (Gomez and Sullivan), Kirk Smith (Gomez and Sullivan), Stan Swain (Trout Unlimited), Bill Wandle (US EPA, 8/31 only), and John Warner (USFWS, 9/1 morning only).

The available habitat for brown trout, rainbow trout and macroinvertebrates was evaluated at each flow. These two species of trout were included because they are known to inhabit the riverine area downstream of Comerford. Rainbow trout prefer the fast water which is generally found in riffle habitats, while brown trout prefer somewhat lower water velocities that are found in runs and pools. Both species spawn in gravel substrates in moderately fast current. Macroinvertebrates were included since they are believed to be an important forage base for the trout. Macroinvertebrates tend to be more abundant and have greater species diversity in riffle habitats with moderately high water velocity.

The habitat evaluation criterion was the amount of "good" habitat at each flow, expressed as a percentage of the wetted habitat within the reach in question. Good habitat was defined as habitat with suitable substrate, and SI values of 0.5 or higher for velocity and depth. A reference sheet, which showed the depths and velocities corresponding to SI values of 0.5 or greater as well as the suitable substrates, was prepared prior to the field work and then used in the field. These SI data had been used for the study of the Nine Islands side channels in 1997 and were originally used in IFIM studies on various New England streams. Macroinvertebrate SI data were originally provided by the VANR, which developed composite SI data based on the requirements of a number of species which prefer riffle habitats.

Two flows were evaluated, 818 cfs and 1,635 cfs, which correspond to 0.5 and 1.0 cfs per square mile of drainage area, respectively. A flow of 1,145 cfs was also included in the Study Plan Outline. However, there were only very slight differences in habitat suitability at 818 cfs versus 1,635 cfs and the participants decided that evaluating a flow of 1,145 was unnecessary. Following the completion of the field work, reach lengths were measured on aerial photos and the wetted area at each flow was calculated from digitized topographic maps. The wetted area of each reach was estimated based on bank full wetted areas (calculated from digitized topographic maps) with an adjustment for the reduced width at each flow. The width adjustments were based on aerial photographs and field measurements at the lower flows.

A qualitative survey of the area from the East Ryegate Dam to the Wells River gaging station was conducted on the afternoon of September 1, 1998. Participants were Larry Miller (Acres International), Gary Moore (Gary Moore Associates), John Ragonese (US Generating Company), Steve Shepard (Gomez and Sullivan), Kirk Smith (Gomez and Sullivan), and Stan Swain (Trout Unlimited). The Gomez and Sullivan staff recorded habitat conditions, photographed each reach, and noted the location of each reach. Following the field work, reach lengths were estimated from the USGS 7.5 minute series topographic map.

4.0 Results

4.1 Main Stem Habitat Downstream of Comerford

Downstream of Comerford Station, four main stem habitat reaches were delineated in the previous studies, as described in Section 2.1. The dimensions and wetted areas of the four

Comerford Tailrace habitat reaches are shown in Table 2. The results of the demonstration flow evaluations at 818 and 1,635 cfs are presented below by reach.

4.1.1 Reach 1 – Excavated Tailrace Channel

The banks in this reach are steep and the water depth was generally about 15 feet deep. Thus, this reach was deep and slow moving at both discharges – 818 and 1,635 cfs. The uniform cobble and boulder substrates which dominated this reach were generally suitable for all of the species and life stages of interest, with the exception of spawning brown trout and rainbow trout which require clean gravel substrates. The absence of any gravel in this reach precludes spawning by either brown trout or rainbow trout. Although adult fish cannot spawn in this reach, one of the participants had fished this area extensively and noted that it is a productive angling location, particularly just downstream of the Comerford Station discharge. The wetted area at 818 cfs was estimated to be 106,000 square yards and did not increase appreciably at 1,635 cfs due to the steep banks (Table 2). Habitat suitability estimates for each species and life stage, and the respective square yards of available habitat, are shown in Table 3.

Both water depth and velocity limited the suitability of the habitat in this reach. The depths and velocities did not change appreciably when the discharge was increased from 818 cfs to 1,635 cfs. As a result, the study participants rated the habitat the same at both flows. They concluded that this reach did not have habitat for either brown trout or rainbow trout fry due to excessive water depth and inadequate water velocity. For juvenile brown trout, they determined that appropriate depths were limiting and narrow bands near each shore (approximately 5% of the area) had suitable habitat. In contrast, juvenile rainbow trout can use deeper water and therefore, they estimated that 90% of the area was suitable. However, the water velocity was barely adequate for juvenile rainbow trout. Higher water velocity would improve the habitat for juveniles of both species.

TABLE 2.--Wetted area of the four riverine aquatic habitat reaches from the Comerford Station tailrace to the McIndoes Station impoundment. Wetted areas are shown as square yards at each flow and percent of the total riverine habitat downstream of Comerford.

	Length	Ave.Width[b]	818 cfs		1,635 cfs	
Reach[a]	(yards)	(yards)	Sq. Yards[c]	Percent	Sq. Yards[c]	Percent
1	1,600	70	106,000	28%	106,000	27%
2	500	117	39,600	10%	44,000	11%
3	700	132	70,400	19%	74,100	19%
4	1,430	147	160,000	43%	168,000	43%
Total	4,230	112	376,000	100%	392,100	100%

[a] Reaches are from upstream to downstream and are shown on Figure 1.

[b] Average width at bank full discharge determined from aerial photographs.

[c] Square yards of wetted area for each reach were estimated from field measurements, aerial photographs, and digitized topographic data.

The study participants estimated that 85% of the area was suitable for adult trout, although the water velocity was barely within the suitable range at both discharges. Higher water velocity would improve adult trout habitat, similar to juvenile trout. The study participants concluded that the habitat would not support macroinvertebrates at the minimum flows since the water velocity at both discharges was too low. However, a limited macroinvertebrate assemblage might be able to live in the intermittent flow regime provided by the operation of the Comerford Station turbines.

4.1.2 Reach 2 – Run Habitat Upstream of Nine Islands

Although this reach was significantly wider and shallower than the excavated channel, it was also run habitat with similar substrates and water velocities. The cobble and boulder substrates were suitable for most of the species and life stages of interest, except for brown trout or rainbow trout spawning due to the lack of suitable gravel substrates. The wetted area was estimated to be 39,600 square yards at 818 cfs and 44,000 at 1,635 cfs (Table 2). Habitat suitability estimates for each species and life stage in this reach, and the respective square yards of available habitat, are shown in Table 4.

Water depth was the critical parameter for trout fry. For brown trout fry, the participants estimated that the band of suitable depths near each shore was 50% of the wetted area at 818 cfs and 45% at 1,635 cfs. This resulted in the same amount of habitat at both flows since the wetted area estimate increased by 10% with the higher flow. Since rainbow trout fry prefer shallower water, the usable habitat was estimated to be 30% at 818 cfs and 25% at 1,635 cfs. The participants noted that these fry habitat estimates were somewhat meaningless since there was no spawning habitat to produce fry.

There was abundant juvenile salmonid habitat at both discharges – only the shallowest areas near the shores were unsuitable. The suitability estimates for juvenile brown trout were 80% and 75% at the 818 and 1,625 cfs discharges, respectively (a few areas were too deep at the higher flow). For juvenile rainbow trout, the suitability was estimated to be 80% at both flows.

Adult salmonid habitat was somewhat limited by low water velocity and shallow areas near shore. Sixty percent of the wetted area was estimated to be suitable for both brown and rainbow trout, at both discharges.

The participants agreed that there was no macroinvertebrate habitat at the 818 cfs discharge since the water velocity was too low. They thought that the 1,635 cfs discharge created a few areas with adequate velocity for macroinvertebrates and they estimated that 25% of the wetted area was suitable.

4.1.3 Reach 3 – Main Stem Riffle Habitat at Nine Islands

The riffle reach in the Nine Islands area was the only reach with significant water velocity at either discharge. Like the upstream reaches, cobbles and boulders dominated the substrates in this area and there was no gravel for spawning trout. The wetted area increased from an estimated 70,400 square yards at 818 cfs to 74,100 square yards at 1,635 cfs (Table 2). Habitat suitability estimates for each species and life stage in this reach, and the respective square yards of available habitat, are shown in Table 5.

Water velocity was the dominant physical habitat parameter in this reach. Water velocities were estimated to be about two feet per second at the 818 discharge and closer to three feet per second at the 1,635 cfs discharge. For trout fry the participants agreed that the only suitable areas would be near the shores where fry could find suitable water velocity out of the main flow. For both species, they estimated that 10% of the wetted area would be suitable at 818 cfs and 5% at 1,635 cfs. Like the reach upstream, they noted that these fry habitat estimates were somewhat meaningless since there was no spawning habitat to produce fry.

For juvenile and adult salmonids, there were marked differences in suitability for brown trout versus rainbow trout. For juvenile brown trout, the participants estimated that only 10% would be suitable at 818 cfs and 5% at 1,635 cfs. However, juvenile rainbow trout prefer higher velocities and the suitability estimates were 80% at 818 cfs and 60% at 1,635 cfs. For adult brown trout, the suitability was estimated to be 10% at both flows. For adult rainbow trout, the suitability was estimated to be 80% at both flows. For both species, the participants felt that the boulders in this reach provided some velocity refuges. However, they though additional velocity refuges would improve the quality of the habitat.

The high water velocity and cobble/boulder substrates in this area provided good macroinvertebrate habitat. At a discharge of 818 cfs, the participants felt that 90% of the area was suitable. At 1,635 cfs, some areas were too deep and 80% of the area was judged to be suitable.

4.1.4 Reach 4 – Run Habitat Downstream of Nine Islands

This reach is wide, moderately shallow, and quite long under the new McIndoes impoundment operating range. Although this reach was classified as a run, there was a small riffle located midway down the New Hampshire shore where a small island divided the flow. This small riffle contained some large, moderately embedded, gravel that may be suitable for rainbow trout and brown trout spawning, particularly by larger individuals. The substrates in the remainder of this reach were suitable for the species and life stages of interest, primarily cobbles with a few boulders and some ledge. One of the participants had fished throughout this area and noted that this reach was a productive location, particularly for brown trout. This was also the largest of the four reaches – the wetted area increased from an estimated 160,000 square yards at 818 cfs to

168,000 square yards at 1,635 cfs (Table 2). Habitat suitability estimates for each species and life stage in this reach, and the respective square yards of available habitat, are shown in Table 6.

The Settlement Agreement specified that the McIndoes impoundment will normally be operated between elevation 447.5 to 451.0 feet in the future. This elevation determines the downstream boundary of the fourth riverine habitat reach (i.e., the transition from riverine habitat to the McIndoes impoundment). The transition at elevation 447.5 feet was located in this study for the purpose of estimating the length and wetted area of this reach.

Prior to this study, this area had not been evaluated as thoroughly as the other riverine habitats. This was largely because the lower boundary of this reach is determined by the elevation of the McIndoes impoundment and to date, only elevations above 451.0 feet were evaluated. As a result, the participants conducted a reconnaissance survey at the 818 cfs discharge and only discussed habitat suitability in general terms. The habitat suitability was evaluated more rigorously at 1,635 cfs. Although the gravel described above was somewhat large and embedded, the participants felt that it may be suitable for spawning. Based on this assumption, then the spawning potential for the two trout species was governed by the water depths and velocities. Much of the riffle area had suitable depths and velocities for brown trout and therefore, 3% of the reach was judged to be brown trout spawning habitat. Only a portion of this riffle had adequate depth and velocity for rainbow trout therefore, 1% of the reach was judged to be rainbow trout spawning habitat.

Of the four reaches downstream of Comerford Station, this reach has the most habitat for fry of both species. At 1,635 cfs, the water depth and velocity in 80% of the reach is suitable for brown trout fry and 50% of the reach is suitable for rainbow trout fry due to their preference for greater depth and velocity. This reach is also good juvenile habitat – 75% was judged to be suitable for brown trout and 90% for rainbow trout. The lower suitability for brown trout was due to a deeper channel along the Vermont shore which was too deep.

The habitat suitability for adult trout was good, which was not surprising since one of the study participants had fished this area extensively with good success. For both species of trout, 80% of the area was judged to have suitable habitat. Macroinvertebrate habitat was driven primarily by areas with appropriate water velocity, since most of this reach had suitable water depth and substrates. At 1,635 cfs, the study participants thought that 80% of the area had good macroinvertebrate habitat, although the velocity appeared to be marginal. Generating flows would result in higher water velocity which would improve the habitat quality.

4.2 Main Stem Habitat Downstream of East Ryegate Dam

The habitat downstream of the East Ryegate Dam was evaluated on the afternoon of 9/1/98 at a discharge of approximately 1,200 cfs (this flow had been discharged from McIndoes Station all morning). Although four very small tributaries were noted in this reach, the flow regime is dominated by the discharge from McIndoes Station.

From just downstream of the East Ryegate Dam to Woodsville, the river is deep and slow moving with sand and silt substrates. This reach was estimated to be 6,500 yards long and classified as pool habitat. This long pool reach is the dominant feature – more than 80% of the distance – of the Connecticut River from East Ryegate to the confluence with the Ammonoosuc River.

The long pool ends in a short transitional run/glide followed by a riffle. This riffle is about 150 yards long and is located upstream of the constriction known as the narrows. At a discharge of 1,200 cfs, the riffle was less than one foot deep with fast current and cobble substrates. Downstream of this riffle there was a very deep eddy pool and then a narrow chute with ledge substrate (i.e., the narrows). Apparently the narrows constricts high discharges, backing up water in the eddy pool and the riffle. Apparently, the hydraulic control from the narrows stabilizes the characteristics of the river upstream to East Ryegate.

Downstream of the narrows is another deep pool which extends downstream to an island. The two channels flowing around this island contained riffle habitats. The riffle on the river right channel (west) was about 130 yards long, one to two feet deep with moderate water velocity and cobble and boulder substrates. The river left channel (east) was not checked but appeared to be much shallower with similar substrates. Downstream of this island, there was another pool which extended downstream to the confluence with the Ammonoosuc River. The survey was ended at this location since both the Ammonoosuc and Wells Rivers contribute to the flow of the Connecticut River.

5.0 Conclusions

The Final Settlement Agreement specifies that the seasonal minimum flows downstream of Comerford will be 818 cfs in the summer, 1,145 cfs in the fall and winter, and 1,635 cfs in the spring. The most significant conclusions regarding the relationship between aquatic habitats downstream of Comerford Station and these minimum flows are; (1) habitat suitability is very similar over the range of flows from 818 to 1,635 cfs, (2) water velocity was generally the most important parameter and higher water velocity will improve the habitat in three of the four reaches, and (3) trout spawning habitat is almost completely absent due to the lack of appropriate gravel substrates. These conclusions are discussed in more detail below.

Only minor changes were apparent over the range of flows from 818 to 1,635 cfs. Reach one was rated the same at both flows, while habitat quality in reach two improved with more flow. In reach three, some loss of fry and juvenile habitat was apparent at the higher flow because of increased water velocity. However, increased flow in reach three improved the habitat for adult trout and macroinvertebrates. Although reach four was only qualitatively evaluated at 818 cfs, the habitat conditions appeared to be very similar at both flows. Because of the size of reach four, and the suitability of the habitat for most of the species and life stages, it contained from 43% to100% of the total habitat, depending on the species and life stage in question (Table 7).

TABLE 7.-- Comparison of the square yards of suitable habitat in Reaches 1-3 versus Reach 4 at a discharge of 1,635 cfs from Comerford Station, Connecticut River.

Species and Life Stage	Reach No. 1-3	Reach No. 4	Total	Percent in Reach 4
Brown Trout				
Spawning/Incubation	0	5,000	5,000	100%
Fry	23,500	134,500	158,000	85%
Juvenile	42,000	126,100	168,100	75%
Adult	123,700	134,500	258,200	52%
Rainbow Trout				
Spawning/Incubation	0	1,700	1,700	100%
Fry	14,700	84,100	98,800	85%
Juvenile	174,800	151,400	326,200	46%
Adult	175,600	134,500	310,100	43%
Macroinvertebrates	70,300	134,500	204,800	66%

The water velocities were generally only barely adequate for the species and life stages studied. At higher flows (i.e., Comerford Station generation flows) the water velocities are higher and habitat suitability should improve, particularly for macroinvertebrates and rainbow trout. The 1996 riverine habitat study is useful in assessing this possibility since a discharge of 10,000 was observed during that study. At a flow of 10,000 cfs, the water velocity was moderate in the excavated channel and high in the main stem riffle (as well as the side channels). However, 10,000 cfs is an unusually high discharge – Comerford Station seldom exceeds 5,000 cfs (Figure 3). Therefore, it seems likely that the riffle reach is the only area that will have high water velocities during typical Comerford Station operations. It is worth pointing out that fish adjust their position in the water column and/or their location in the river in response to hydraulic conditions and, as a result, fish may come and go from the main stem riffle as flows change. Placing additional cover in the riffle, in the form of boulders or artificial structures, would improve habitat quality by providing velocity refuges.

Despite fluctuating flows and the lack of spawning gravel, the riverine habitats downstream of Comerford Station have historically produced very large rainbow trout and brown trout. In fact, the former New Hampshire state record rainbow trout was caught in this reach (Connecticut River in the town of Monroe). The demonstration flow results verify that the proposed minimum flow regime will provide high quality habitat for juvenile and adult trout of both species. The study also showed that the minimum flows will provide abundant fry habitat in reach four, the new riverine habitat created by lowering the McIndoes impoundment.

With regard to the aquatic habitat downstream of McIndoes Station, no specific aquatic habitat issues were raised. The Study Plan Outline specifically requested target species and life stages for this reach. However, none were suggested in the comment letters. Furthermore, the agency

Figure 3.-- Weekly discharge statistics for the Comerford Station. Five thousand cfs is shown for reference. Statistics are based on mean daily flow from 1975 to 1994.

and NGO representatives who participated in the field work felt there was no need for further study of this area. In any event, only a small area at the terminus of the tailrace shows any influence from station discharges. Most of the habitat immediately downstream of McIndoes Station consists of deep, slow moving, pools. By definition, the quality of pool habitat is insensitive to flow changes.

The comment letters correctly pointed out that discharge from the Fifteen Mile Falls Project affect the Connecticut River downstream to the confluence with the Ammonoosuc River. However, almost all of this reach is pool habitat – the survey determined that only about 3.5% of the linear distance is comprised of riffle habitat. The pool habitat may support walleye, which occur further downstream in the Connecticut River (downstream of the confluence with the Ammonoosuc River). Although pool habitat quality is essentially unaffected by changes in flow, the two small riffle reaches near the narrows are affected by discharge from the Fifteen Mile Falls Project. Since walleye are present in this part of the Connecticut River, and these two riffles have appropriate spawning substrates for walleye, then spring flow conditions may affect walleye spawning. The Final Settlement Agreement established a McIndoes Station spring minimum flow of 4,420 cfs or inflow. This minimum flow should improve walleye spawning conditions in these riffles.

TABLE 3.-- Habitat suitability data for Reach 1, the excavated reach of the Connecticut River downstream of the Comerford Powerhouse.

	818 cfs Flow		1,635 cfs Flow		
Species and Life Stage	Percent	Sq. yd.[a]	Percent	Sq. yd.[a]	Comments
Brown Trout					
Spawning/Incubation	0%	0	0%	0	No spawning substrate (gravel)
Fry	0%	0	0%	0	
Juvenile	5%	5,300	5%	5,300	Band of appropriate depths near each shore
Adult	85%	89,900	85%	89,900	Marginal water velocity
Rainbow Trout					
Spawning/Incubation	0%	0	0%	0	No spawning substrate (gravel)
Fry	0%	0	0%	0	
Juvenile	90%	95,200	90%	95,200	
Adult	85%	89,900	85%	89,900	Marginal water velocity
Macroinvertebrates	0%	0	0%	0	Velocity too low at both flows

[a] The wetted area was estimated to be 106,000 square yards at both discharges.

TABLE 4.-- Habitat suitability data for Reach 2, the run habitat upstream of the Nine Islands area, Connecticut River.

	818 cfs Flow		1,635 cfs Flow		
Species and Life Stage	Percent	Sq. yd.[a]	Percent	Sq. yd.[a]	Comments
Brown Trout					
Spawning/Incubation	0%	0	0%	0	No spawning substrate (gravel)
Fry	50%	19,800	45%	19,800	Smaller % usable at 1,635 cfs due to increase in overall size
Juvenile	80%	31,700	75%	33,000	Mostly suitable depth and velocity with suitable substrates
Adult	60%	23,800	60%	26,400	Marginal water velocity, depth too shallow near shore
Rainbow Trout					
Spawning/Incubation	0%	0	0%	0	No spawning substrate (gravel)
Fry	30%	11,900	25%	11,000	Smaller % usable at 1,635 cfs due to increase in overall size
Juvenile	80%	31,700	80%	35,200	Mostly suitable depth and velocity with suitable substrates
Adult	60%	23,800	60%	26,400	Marginal water velocity, depth too shallow near shore
Macroinvertebrates	0%	0	25%	11,000	Some areas of suitable velocity at 1,635 cfs

[a] The wetted area was estimated to be 39,600 square yards at 818 cfs and 44,000 square yards at 1,635 cfs.

TABLE 5.-- Habitat suitability data for Reach 3, the riffle habitat in the main stem of the Connecticut River at Nine Islands.

	818 cfs Flow		1,635 cfs Flow		
Species and Life Stage	Percent	Sq. yd.[a]	Percent	Sq. yd.[a]	Comments
Brown Trout					
Spawning/Incubation	0%	0	0%	0	No spawning substrate (gravel)
Fry	10%	7,000	5%	3,700	Velocity too high
Juvenile	10%	7,000	5%	3,700	Velocity too high
Adult	10%	7,000	10%	7,400	Velocity too high
Rainbow Trout					
Spawning/Incubation	0%	0	0%	0	No spawning substrate (gravel)
Fry	10%	7,000	5%	3,700	Velocity too high
Juvenile	80%	56,300	60%	44,400	Some loss due to higher velocity at 1,635 cfs
Adult	80%	56,300	80%	59,300	Based on adequate velocity refuges
Macroinvertebrates	90%	63,300	80%	59,300	Some portions too deep at 1,635 cfs

[a] The wetted area was estimated to be 70,400 square yards at 818 cfs and 74,100 square yards at 1,635 cfs.

TABLE 6.-- Habitat suitability data for Reach 4, the run habitat downstream of the Nine Islands area, Connecticut River.

	818 cfs Flow[b]		1,635 cfs Flow		
Species and Life Stage	Percent	Sq. yd.[a]	Percent	Sq. yd.[a]	Comments
Brown Trout					
Spawning/Incubation			3%	5,000	Very limited areas of suitable spawning substrate
Fry			80%	134,500	Some areas too deep
Juvenile			75%	126,100	Some areas too shallow or too deep
Adult			80%	134,500	Some areas too shallow
Rainbow Trout					
Spawning/Incubation			1%	1,700	Very limited areas of suitable spawning substrate, depth, and velocity
Fry			50%	84,100	Some areas too shallow or too deep
Juvenile			90%	151,400	Some areas too shallow
Adult			80%	134,500	Some areas too shallow
Macroinvertebrates			80%	134,500	Marginal water velocity (i.e., barely fast enough)

[a] The wetted area was estimated to be 160,000 square yards at 818 cfs and 168,000 square yards at 1,635 cfs.

[b] A qualitative survey was conducted at 818 cfs to determine the extent and characteristics of this reach.

New England Power Company
Fifteen Mile Falls
Habitat Reaches Below
Comerford Station
Figure 1

New England Power Company
Fifteen Mile Falls

Riverine Reach Below
East Ryegate Dam
Showing Riffle Areas

Figure 2