



NORMANDEAU ASSOCIATES, INC.

CHARACTERIZATION OF MUSSEL HABITAT UTILIZATION IN THE VICINITY OF THE HOLTWOOD HYDROELECTRIC PROJECT



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Cover Photo: Eastern floater in Lake Aldred on 28 September 2005.



INTRODUCTION

The Holtwood Hydroelectric Project (Project) is located on the Susquehanna River in Lancaster and York Counties, Pennsylvania. PPL Holtwood, LLC. (PPL), the Project owner and operator, is evaluating the potential to redevelop the Project and add a new 125-MW powerhouse. One of the environmental concerns identified with respect to potential Project redevelopment is the effect on mussel habitat utilization in Lake Aldred and in the Holtwood spill pool.

Currently, allowable water level fluctuations in Lake Aldred due to project operations are dependent on the time of year. During the period from 15 September to 15 May fluctuations up to 6.25 feet (elevation 169.75 to 163.5 MSL) are allowed. During the recreation season from 15 May through 15 September, fluctuations are limited to 2.25 feet (elevation 169.75 to 167.50 MSL). As part of the redevelopment, water level fluctuations up to 4.75 feet (elevation 169.75 to 165.0 MSL) on weekdays during the summer months are being considered.

Utilization of mussel habitat downstream of Holtwood Dam could be affected because the proposed increase in hydraulic capacity of the powerhouse may reduce the frequency and magnitude of water entering the spill pool. Secondly, some areas of the spill pool and tailrace would be excavated during Project redevelopment. Also, a barrier dam in the spill pool area is being considered. This might backwater some areas below the dam.

Normandeau Associates, Inc. was contracted to characterize the mussel resources present in Lake Aldred and in the spill pool and tailrace and their utilization of the habitat. The effort was conducted by William S. Ettinger, a macroinvertebrate biologist with 31 years professional experience, including other mussel surveys in the Susquehanna River. The field survey was conducted on 14, 15 and 28-30 September, 2005.

METHODOLOGY

The survey was conducted downstream of Holtwood Dam on 14 and 15 September when little water spilled over the dam. Therefore, the spill pool (that is, the area extending from Holtwood Dam downstream to approximately 0.3 miles downstream of the Norman Wood Bridge – PA Route 372 and from the river's west shoreline to Piney Island) was largely dewatered. Because boat use in the spill pool was impractical, this part of the survey was conducted on foot from access points located at the hydroelectric facility and along the river's west shoreline.

The area between the river's east shoreline and Piney Island functions as the Project's tailrace. This part of the river is a deep water-filled channel during all project operating conditions. Therefore, a boat was used in survey of much of the tailrace. The upper end of the tailrace, which is closed to boat traffic, was surveyed on foot along the river's east shoreline.

As part of a separate study effort, 30 transects were established in Lake Aldred to evaluate the effect of water level fluctuations on aquatic habitat (Kleinschmidt Associates, in preparation). The mussel survey was conducted at these locations on 28-30 September when the Lake Aldred water level was drawn down to 163.0 to 164.5 feet MSL to allow for Project maintenance. With the water surface at this level, much substrate that ordinarily is submerged was exposed, allowing for easy survey. In addition, nearby shallow



(wadeable) water was surveyed. The survey was limited to water depth less than approximately 3 feet (i.e. the survey was conducted above elevation 160.0 MSL).

The spill pool, tailrace, and transects in Lake Aldred were surveyed for substrate conditions considered supportive of mussels, i.e., not thick silt or boulders/bedrock. Where appropriate substrate conditions were identified, these areas were formally searched for live mussels and spent (dead or empty) shells. The results of each search and the amount of time spent in the effort were recorded. In the water, submerged substrate was searched with or without viewing buckets, depending on water surface conditions, i.e., still or rippled by wind or flow. In the case of Lake Aldred, the substrate that was usually submerged, but newly exposed by water level drawn down, was also searched. No excavation for buried mussels was conducted at any location.

Middens, accumulations of spent shells discarded by feeding muskrat or other wildlife, were sought along the waterline. These accumulations have been shown to contain shells of species removed from deeper waters not subject to survey.

All live mussels encountered were identified and returned to submerged substrate. The shell length of all live mussels was measured, with exception of one commonly occurring species – eastern floater (*Pyganodon cataracta*). In the case of this species, the shell length of a number of them, especially the smallest and the largest, was measured. Shell length was estimated for the rest of the eastern floater.

RESULTS

The habitat observed in all of the areas formally searched for mussels is described in Table 1. Table 2 contains a summary of the live mussels encountered in the survey and Table 3 lists all live mussel data by individual search area.

Spill Pool

The spill pool on 14-15 September was a rugged landscape overwhelmingly composed of cobbles, boulders, and bedrock and containing only very small amounts of coarse sand and gravel. Finer material was not observed. Surface water was limited to shallow pools scattered throughout the river channel, several larger and deeper pools located just downstream of Holtwood Dam and generally along the islands in mid-river, and in shallow stream-like channels in bedrock located a short distance upstream of the Norman Wood Bridge. A relatively small amount of water flowed slowly through the spill pool.

The survey crew walked much of the spill pool and determined that very little submerged substrate appeared supportive of mussels. Nevertheless, two areas that appeared worthy of formal mussel search efforts were identified – an area located in the northeast corner of the spill pool and one located mid-river in the lower end of the spill pool.

The search area located in the northeast corner of the spill pool encompassed approximately 90,000 square feet of pool environment. Maximum water depth was approximately 3 feet and the substrate was composed of mostly cobbles and small boulders and occasional small sand and gravel deposits. No submerged aquatic vegetation was observed. No live mussels and only a few deteriorated fragments of shell were discovered in 80 biologist-minutes of search.



The second spill pool search area was located mid-river in the lower end and encompassed approximately 275,000 square feet. This area consisted of a series of stream-like channels in bedrock in which water flowed slowly. The water tumbled over bedrock and small boulders with some cobble and gravel also present. No submerged aquatic vegetation was seen. No live mussels were encountered and only one spent eastern floater shell was discovered in 90 biologist-minutes of search.

No middens of discarded spent shell were observed in the spill pool and, in fact, only one intact spent shell was discovered (noted above).

Tailrace

The tailrace formed by Piney Island and the river's eastern shoreline is a deep channel conveying relatively fast-moving water. Water level and current velocity fluctuate substantially depending on river flows and project operation. The mussel survey in this area was conducted on 14-15 September during periods when electricity was not generated, thereby allowing observation of river substrate that would otherwise be submerged.

Survey in this area was initiated by boat travel along the river's east shoreline searching for suitable substrate, starting approximately 0.5 mile downstream of the Norman Wood Bridge. Most of the river shoreline and that of the nearby islands up to the bridge was observed to be steeply pitched and composed of cobbles, boulders, and much bedrock. The exception was an area located along an island shoreline 0.25 mile downstream of the bridge (Figure 1). This location, sheltered from the relatively fast-flowing offshore tailrace water by an island located immediately upstream, is approximately 5,000 square feet in area. Here, the substrate consists of flat fractured bedrock and cobbles and small boulders in a matrix of sand and gravel.

The only live mussels identified downstream of Holtwood Dam were discovered partially buried at this location, including one yellow lampmussel (*Lampsilis cariosa*) and five eastern elliptio (*Elliptio complanata*). All were large (the yellow lampmussel 114 millimeters in shell length and the eastern elliptio 127 to 146 millimeters) with eroded shells (Figures 2 and 3). In addition, several spent shells of eastern elliptio and eastern floater were found here. The search for mussels totaled 180 biologist-minutes at this location.

Moving upstream, a formal search for mussels was conducted in the channel between the downstream end of Piney Island and the upstream end of another island. Water flows through this channel when the Project is generating electricity, but when it was searched, it was dewatered except for several small shallow pools. The substrate was very coarse and consisted almost entirely of cobbles and boulders on top of bedrock. No live mussels and no spent shells were encountered in 50 biologist-minutes of search. Approximately 10,000 square feet were searched.

The third area searched for mussels in the tailrace was located approximately 800 feet downstream of the Project powerhouse. It encompassed approximately 450 feet of the river's east shoreline, jutting a short distance into the tailrace. The substrate consisted of cobbles and boulders on fractured bedrock. No live mussels and no spent shells were discovered in 20 biologist-minutes of search.

No middens were observed in the tailrace.



Lake Aldred

By boat, the survey crew visited the 30 Lake Aldred transects that were previously established during the water level fluctuation study and characterized the substrate present. All substrate types identified in Lake Aldred were included in formal searches. However, 12 transects were omitted after inspection because of redundancy. The transects not formally searched contained either silt and/or sand or bedrock with only occasional small deposits of sand and gravel and these substrate types were included in other transect locations.

Four species of live mussels, including 153 individuals, were identified in the 18 transects that were searched. By far, most (137 individuals – 90%) of the mussels were eastern floater. Second was eastern elliptio (11 individuals – 7%). Lesser numbers of yellow lampmussel (4 individuals) and triangle floater (*Alasmidonta undulata*) (1 individual) also were identified.

The eastern floater were widely distributed, being encountered at 15 of the transects. The greatest numbers were collected in silt/sand at TM16 (50 individuals) and TM7 (30 individuals) and in silt/sand/gravel at TM29 (20 individuals).

None of the other species were widely distributed. The eastern elliptio were encountered at only three transects, with 8 individuals identified at TM16. The yellow lampmussel were encountered at only two transects, with 3 individuals identified at TM16 (Figure 4). The other yellow lampmussel was discovered stranded in sand/gravel at TM18, a large bedrock outcrop located at the upper end of Lake Aldred (Figures 5 and 6).

A wide size range of eastern floater was observed (19 to 127 millimeters shell length). However, all of the eastern elliptio (76 to 127 millimeters) and the yellow lampmussel (114 to 127 millimeters) were large and their shells were eroded.

More mussels (61 individuals) were encountered at TM16 than at any other transect. The largest number of eastern floater (50 individuals) and most of the eastern elliptio (8 individuals) and yellow lampmussel (3 individuals) were identified here. This location was a silt/sand island shoreline containing significant numbers of cobbles and small boulders with much bedrock (Figure 7).

The only triangle floater was encountered at TM20 on the upstream tip of an island, partially buried in sand among scattered cobbles and boulders (Figure 8). A fairly intensive search (135 biologist-minutes) yielded no other triangle floater and only three eastern floater at this location.

Many spent eastern floater shells and approximately 10 spent eastern elliptio shells were discovered in Lake Aldred. No spent yellow lampmussel and triangle floater shells were observed, nor were any middens encountered at any location in Lake Aldred.

DISCUSSION

The survey effort conducted downstream of Holtwood Dam yielded only six live individuals of two species, strong indication that the mussel community in the spill pool and the tailrace is severely restricted by coarse substrate conditions and fluctuating water levels. In Lake Aldred, two additional species (for a



total of four species) and many more individuals were discovered. However, most (90%) were eastern floater, a species that is “usually confined to slow-moving portions of riverine environments, in sandy or muddy substrates” (Nedeau, *et. al.* 2000).

Eastern floater is widely distributed throughout Lake Aldred and abundant at several locations. Identification of small individuals in the survey effort indicates successful reproduction is occurring.

Eastern floater is widespread in the Susquehanna River basin in New York and among the most common and widely distributed mussels in that state (Strayer and Jirka 1997). The Pennsylvania Fish and Boat Commission (PAFBC) considers this species to be widely distributed in the Susquehanna River basin in Pennsylvania (PAFBC 2005).

The second most abundant species in the survey, including upstream and downstream of Holtwood Dam, was the eastern elliptio. This species can be found in clay, mud (silt), sand, gravel, and cobble substrates, but not in thick silt (Nedeau, *et. al.* 2000). Strayer and Jirka (1997) report that eastern elliptio is abundant at many locations in New York. The PAFBC considers eastern elliptio to be widespread and common in the Susquehanna River basin in Pennsylvania (PAFB 2005).

Yellow lampmussel “exists in a variety of substrate types, including silt, sand, gravel, and cobble” and “seems to prefer medium to large rivers” (Nedeau, *et. al.* 2000). These authors also indicate that the species “seems to do well in impounded sections of rivers”. Nevertheless, only five individuals were discovered in the present survey (one downstream of Holtwood Dam and four in Lake Aldred), an indication that a large population is not likely present. The fact that all were large individuals suggests that reproduction is limited.

Yellow lampmussel is an Atlantic drainage species distributed from Georgia through Nova Scotia and Cape Breton Island (Nedeau, *et. al.* 2000). However, “this species has been declining throughout its range, prompting many states to add it to their lists of endangered and threatened species”. Yellow lampmussel is not a listed species in Pennsylvania. The PAFBC considers it to be widespread in the Susquehanna River basin in Pennsylvania, although present in generally low numbers at most locations (PAFBC 2005).

One triangle floater was discovered in Lake Aldred. Although this species “is most frequently found in streams and rivers, it also occurs in many lakes and ponds, where it is never abundant (Nedeau, *et. al.* 2000). These authors also state that triangle floater “is most frequently encountered in sand and gravel”. Therefore, triangle floater apparently can tolerate impoundments like Lake Aldred, but the population likely would be small.

Triangle floater is present in the Delaware, Hudson, and Susquehanna River basins in southcentral and southeastern New York and “is still widespread and abundant” (Strayer and Jirka 1997). However, the PAFBC considers the species rare in the Susquehanna River basin in Pennsylvania (PAFBC 2005). Triangle floater is not a listed species in Pennsylvania.

All four of the species identified in the survey, like nearly all freshwater mussels, depend on fish in order to successfully complete their lifecycle. After fertilization, the embryos develop into larval mussels, or glochidia, which are released by the females into the water. The glochicia must find and attach to a suitable fish host in order to metamorphose into juvenile mussels, which drop from the fish onto the substrate. From this point, the mussel remains free-living, either on the surface of the substrate or buried within it.



Not all fish species are suitable hosts for each mussel species. The known fish hosts for each mussel found in the survey are shown in Table 4. The host fish present in the Project area of the Susquehanna River are bold and italicized.

Of the four mussels identified in the survey, eastern elliptio is a short-term brooder (Table 4). A short-term brooder is a species in which the eggs are fertilized in early spring and the glochidia are released later in the summer. The other three mussels are long-term brooders, species in which the eggs are fertilized in August and the glochidia are released in the following spring.

There are two critical periods in the lifecycle of mussels, both related to reproduction. The first critical period occurs when the males release sperm into the water and the females receive the sperm for egg fertilization through water drawn into their incurrent siphons. In general, this critical period is in early spring in the case of eastern elliptio and in August for the other species. The second critical period is when the glochidia are expelled from the females into the water and suitable host fish must be nearby. This critical period is in the summer for eastern elliptio and in the spring for the other species.

All of the mussels identified in the survey are warmwater species typically found in systems with temperature regimes similar to the Project area. Secondly, none of the identified mussel species is known to be restricted to any particular water depth by habitat preference. Therefore, none are expected to be at greater risk than the others due to the water level fluctuations under consideration.

REFERENCES

- Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. *The Freshwater Mussels of Maine*. Maine Department of Inland Fisheries and Wildlife. Augusta, Maine.
- Kleinschmidt Associates (In Preparation). The Effects of Water Level Fluctuation on Aquatic and Terrestrial Habitat, Biota and Recreational Resources in Lake Aldred.
- Pennsylvania Fish and Boat Commission. 2005. "Mussels of the Susquehanna River in Pennsylvania", received in email from Mr. Robert Morgan to Normandeau Associates on 14 October 2005.
- Strayer, D.L. and K.J. Jirka. 1997. *The Pearly Mussels of New York State*. New York State Museum Memoir 26. The New York State Education Department. Albany, New York.

FIGURES



Figure 1. Island shoreline near the Norman Wood Bridge on 14 September 2005.



Figure 2. Yellow lamp mussel encountered along island shoreline near the Norman Wood Bridge on 14 September 2005.



Figure 3. Two of five eastern elliptio encountered along island shoreline near the Norman Wood Bridge on 14 September 2005.



Figure 4. One of three yellow lampmussel encountered at TM16 in Lake Aldred on 14 September 2005.



Figure 5. Yellow lampmussel stranded at TM18 in Lake Aldred on 28 September 2005.



Figure 6. TM18 in Lake Aldred on 28 September 2005.



Figure 7. TM16 in Lake Aldred on 28 September 2005.



Figure 8. TM20 in Lake Aldred on 29 September 2005.

TABLES

Table 1. Mussel search area habitat in the Susquehanna River near Holtwood Dam in September 2005.

Search Area	Description
<i>Downstream of Dam</i>	
1. Northeast corner of the spill pool ¹	Cobbles and boulders with patches of gravel.
2. Mid-river in the lower end of the spill pool ²	Boulders and bedrock with patches of gravel.
3. Island shoreline near the Norman Wood Bridge ³	Flat fractured bedrock, sand, gravel, cobbles, and small boulders along island shoreline.
4. Channel between the downstream end of Piney Island and the upstream end of another island ⁴	Cobbles and boulders on bedrock.
5. East shoreline of the tailrace ⁵	Cobbles and boulders on fractured bedrock.
<i>Upstream of Dam (in Lake Aldred)</i>	
1. TM2	Sand flat grading into silt at downstream tip of island.
2. TM3	River shoreline silt/sand flat with some gravel at the waterline.
3. TM4	Silt/sand island shoreline.
4. TM5	Cobble substrate with some interstitial sand.
5. TM6	Steep sand shoreline (river) with cobbles/boulders upstream and downstream.
6. TM7	Silt/sand flat (island) containing occasional cobbles/boulders.
7. TM11	Silt deposit connecting island and river shoreline. Some patches of cobbles/boulders with interstitial silt/sand.
8. TM16	Silt/sand island shoreline with significant numbers of cobbles and boulders with bedrock.

Table 1. Continued.

Search Area	Description
<i>Upstream of Dam (in Lake Aldred) (continued)</i>	
9. TM17	Gravel/cobble with interstitial silt/sand.
10. TM18	Large bedrock outcrop in the upper end of the lake, with scattered pools containing some sand/gravel.
11. TM19	Bedrock outcrop in silt/sand on island shoreline.
12. TM20	Sand with many scattered cobbles/boulders and some clay and bedrock at upstream tip of island.
13. TM21	Silt/sand with small bedrock outcrop on island shoreline.
14. TM23	Silt/sand with some gravel/cobble on river shoreline.
15. TM26	Clay/silt/sand spit extending from downstream tip of island.
16. TM27	Sand/gravel/cobble with some bedrock on river shoreline.
17. TM29	Gravel/cobble with interstitial silt.
18. TM30	Sand with boulders/bedrock connecting river shoreline with island.

¹ 375 feet downstream of Holtwood Dam

² 0.25 mile upstream of the Norman Wood Bridge.

³ 0.25 miles downstream of the bridge and 330 feet from the Lancaster County (east) shoreline.

⁴ 300 feet upstream of the Norman Wood Bridge.

⁵ 800 feet downstream of the Project powerhouse.

Table 2. Summary of live mussels encountered in survey of the Susquehanna River near Holtwood Dam in September 2005.

Species	Total Number	Range of Shell Length millimeters (inches)
Downstream of Dam		
eastern elliptio ¹	5	127 - 146 (5.0 - 5.75)
yellow lampmussel ²	1	114 (4.5)
Total	6	
Total Search Time:	420 Biologist-Minutes (7.0 Biologist-Hours)	
Upstream of Dam (in Lake Aldred)		
eastern elliptio ¹	11	76 - 127 (3.0 - 5.0)
eastern floater ³	137	19 - 127 (0.75 - 5.0)
triangle floater ⁴	1	37 (1.5)
yellow lampmussel ²	4	114 - 127 (4.5 - 5.0)
Total	153	
Total Search Time:	855 Biologist-Minutes (14.25 Biologist-Hours)	

¹ *Elliptio complanata*

² *Lampsilis cariosa*

³ *Pyganodon cataracta*

⁴ *Alasmidonta undulata*

Table 3. Live mussels (by search area) encountered in survey of the Susquehanna River near Holtwood Dam in September 2005.

Search Area / Species	Total Number	Range of Shell Length millimeters (inches)
<i>Downstream of Dam</i>		
1. Northeast corner of the spill pool. ¹ Total search time - 80 biologist-minutes.		
No live mussels encountered.		
2. Mid-river in the lower end of the spill pool. ² Total search time - 90 biologist-minutes.		
No live mussels encountered.		
3. Island shoreline near the Norman Wood Bridge ³ . Total search time - 180 biologist-minutes		
eastern elliptio	5	127 - 146 (5.0 - 5.75)
yellow lampmussel	1	114 (4.5)
4. Channel between the downstream end of Piney Island and the upstream end of another island. ⁴ Total search time - 50 biologist-minutes.		
No live mussels encountered.		
5. East shoreline of the tailrace. ⁵ Total search time - 20 biologist-minutes.		
No live mussels encountered.		
<i>Upstream of Dam (in Lake Aldred)</i>		
1. TM2. Total search time - 30 biologist-minutes.		
eastern floater	2	64 and 76 (2.5 and 3.0)
2. TM3. Total search time - 10 biologist-minutes.		
eastern floater	2	38 and 51 (1.5 and 2.0)
3. TM4. Total search time - 20 biologist-minutes.		
eastern floater	1	51 (2.0)

Table 3. Continued.

Search Area / Species	Total Number	Range of Shell Length millimeters (inches)
<i>Upstream of Dam (in Lake Aldred) (continued)</i>		
4. TM5. Total search time - 10 biologist-minutes.		
No live mussels encountered.		
5. TM6. Total search time - 20 biologist-minutes.		
eastern floater	2	51 and 64 (2.0 and 2.5)
6. TM7. Total search time - 20 biologist-minutes.		
eastern floater	30	38 - 127 (1.5 - 5.0)
7. TM11. Total search time - 60 biologist-minutes		
eastern elliptio	1	102 (4.0)
eastern floater	10	51 - 127 (2.0 - 5.0)
8. TM16. Total search time - 145 biologist-minutes		
eastern elliptio	8	76 - 127 (3.0 - 5.0)
eastern floater	50	70 - 127 (2.75 - 5.0)
yellow lampmussel	3	114 - 127 (4.5 - 5.0)
9. TM17. Total search time - 45 biologist-minutes.		
eastern floater	1	76 (3.0)
10. TM18. Total search time - 40 biologist-minutes.		
eastern floater	1	76 (3.0)
yellow lampmussel	1	114 (4.5)
11. TM19. Total search time - 40 biologist-minutes.		
eastern floater	6	76 - 127 (3.0 - 5.0)

Table 3. Continued.

Search Area / Species	Total Number	Range of Shell Length millimeters (inches)
<i>Upstream of Dam (in Lake Aldred) (continued)</i>		
12. TM20. Total search time - 135 biologist-minutes.		
eastern floater	3	25 - 51 (1.0 - 2.0)
triangle floater	1	37 (1.5)
13. TM21. Total search time - 10 biologist-minutes.		
No live mussels encountered.		
14. TM23. Total search time - 100 biologist-minutes.		
eastern elliptio	2	114 and 127 (4.5 and 5.0)
eastern floater	3	19 - 114 (0.75 - 4.5)
15. TM26. Total search time - 10 biologist-minutes.		
No live mussels encountered.		
16. TM27. Total search time - 30 biologist-minutes.		
eastern floater	1	70 (2.75)
17. TM29. Total search time - 30 biologist-minutes.		
eastern floater	20	64 - 102 (2.5 - 4.0)
18. TM30. Total search time - 100 biologist-minutes.		
eastern floater	5	19 - 64 (0.75 - 2.5)

¹ 375 feet downstream of Holtwood Dam

² 0.25 mile upstream of the Norman Wood Bridge.

³ 0.25 miles downstream of the bridge and 330 feet from the Lancaster County (east) shoreline.

⁴ 300 feet upstream of the Norman Wood Bridge.

⁵ 800 feet downstream of the Project powerhouse.

Table 4. Selected life history information for the live mussels encountered in survey of the Susquehanna River near Holtwood Dam in September 2005.

Species	Known Fish Hosts ^{1,2}	Breeding Season ⁵
eastern elliptio	<i>banded killifish, green sunfish, orange-spotted sunfish, largemouth bass, white crappie, yellow perch</i>	Short-term brooder ⁶
eastern floater	<i>carp, pumpkinseed, threespine stickleback, white sucker, rock bass</i> ³	Long-term brooder ⁷
triangle floater	central stoneroller, slimy sculpin, fantail darter, <i>northern hogsucker, pumpkinseed, common shiner, largemouth bass</i> , rosyface shiner, <i>blacknose dace, longnose dace</i> ⁴	Long-term brooder
yellow lampmussel	white perch, <i>yellow perch</i> ⁴	Long-term brooder

¹ Unless specified otherwise, the source of information is: Watters, G.T. 1994. An annotated bibliography of the reproduction and propagation of the Unionoidea (Primarily of North America). Ohio Biological Survey, Miscellaneous Monograph No. 1. 158 pp.

² Fish captured in electrofishing and seine survey of Lake Aldred and the spillway and tailrace areas in 2005 are bold and italicized.

³ List supplemented with species from: Gray, E.S., W.A. Lellis, J.C. Cole, and C.S. Johnson. 1999. Hosts of *Pyganodon cataracta* (eastern floater) and *Strophitus undulatus* [squawfoot (= creeper)] from the Upper Susquehanna River Basin, Pennsylvania. Triannual Unionid Report 18: 6.

⁴ Cordeiro, J. and J. Bowers-Altman. 2004. Freshwater Mussels of the New York Metropolitan Region and New Jersey. A Guide to Their Identification, Biology, and Conservation. <http://cbc.amnh.org/mussel/>

⁵ Source: Nedeau, E.J., et. al. 2000. The Freshwater Mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine. 118 pp.

⁶ Short-term brooder - eggs are fertilized in early spring and glochidia are released later in the summer.

⁷ Long-term brooder - eggs are fertilized in August and glochidia are released the following spring.