FINAL REPORT

Biological Surveys for Fries Hydroelectric Project in the Upper New River, Grayson County, Virginia

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INTRODUCTION

Study Requests

Operated by Aquenergy Systems, LLC (the Licensee; a subsidiary of Enel Green Power North America, Inc.) and licensed by the Federal Energy Regulatory Commission (FERC), the Fries Hydroelectric Project (the Project; FERC No. 2883) is currently undergoing relicensing using FERC's Traditional Licensing Process (TLP). The current license for the Project was issued June 10th, 1980 and is set to expire May 31st, 2020. In compliance with the first stage of FERC's TLP, the Licensee filed its Notice of Intent (NOI) and Pre-Application Document (PAD) with FERC (May 2015; Aquenergy Systems, LLC 2015), conducted a joint meeting and site visit with resource agencies and members of the public to solicit input on information needs and study plans (September 2015), and received written comments from stakeholders identifying information gaps and necessary studies to be performed. Pursuant to input provided from resource agencies and the public, the Licensee prepared and distributed a draft outline of proposed studies and methodology to agencies on March 18, 2016. The Licensee held a follow-up joint agency conference call (March 24th, 2016) to receive feedback on the proposed study plans and to reach an agreement on all reasonable and necessary studies as requested by the agencies. Agency comments and changes were incorporated into study plans and a revised outline was distributed to the agencies on April 15th, 2016.

During TLP consultations, several agencies and stakeholders recommended that the Licensee perform biological studies to assess aquatic species assemblages and distributions within the Project vicinity and in immediately adjacent reaches. In particular, the U.S. Fish and Wildlife Service (USFWS) and the Virginia Department of Game and Inland Fisheries (VDGIF) requested surveys be conducted for several species with historical distributions from the upper New River. Aquatic species of particular interest to this region of the upper New River included the pygmy snaketail dragonfly (*Ophiogomphus howei*), New River crayfish (*Cambarus chasmodactylus*), Virginia spiraea (*Spiraea virginiana*), eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*), and imperiled mussel species pistolgrip (*Tritogonia verrucosa*), elktoe (*Alasmidonta marginata*), and green floater (*Lasmigona subviridis*). In addition, a fish community survey was requested. Initially, agencies had suggested targeted surveys for bog turtle (*Glyptemys muhlenbergii*); however, during consultations on study plans, the USFWS and VDGIF agreed that no separate bog turtle survey be required due to the extremely limited potential for bog turtle habitat to occur within the Project study area.

Upon final consultations with state and federal agencies and other stakeholders regarding study plans and methodology, it was requested that species surveys and instream habitat assessments be conducted within the Project vicinity, to include the impoundment, bypass, and tailwaters to 800 m downstream from the powerhouses (downstream impact area). In addition, it was requested that assessments be conducted at two reference sites (one upstream and one downstream) beyond the influence of the Project to provide additional information about Project influence on community assemblages and distributions.

Background

Located in the Appalachian Mountains and part of the Ohio Drainage, the New River is one of the oldest rivers in the world and flows in a northern direction, from North Carolina through Virginia and West Virginia where it drains into the Ohio River. In Virginia, the upper portion of the New River is divided by four hydropower dams as it flows northward 135 river kilometers (RKM) from the North Carolina border into Claytor Lake. Built in 1902, the Fries Project is the oldest of these four hydropower dams and is located near the town of Fries in Grayson County, Virginia. The Fries Project is a 41-foot high, rock masonry dam that was initially constructed to provide power to a textile mill. Although no longer used to support textile mill operations, this run-of-river dam now continues to operate as a hydroelectric facility.

Currently, there are no minimum flow requirements for the Fries Project. Since its construction over a century ago, the Project has altered the aquatic environment—both upstream and downstream of the structure—through modifications to the natural hydrological and geomorphologic processes found along this portion of the upper New River. What was once a free-flowing section of the upper New River is now characterized by a shallow, sediment-filled impoundment and a flow-altered bypass reach. The Project's downstream influence on habitat extends beyond the bypass to an undetermined distance downstream—becoming less pronounced with increasing distance from the structure. Study area boundaries of the Project extend approximately 2.4 km upstream through the impoundment, 150 m downstream through the bypass, and 800 m downstream from the powerhouses (Figure 1).

Through an extensive review of historical collection data, and published and grey literature, we found that there have been no extensive assessments of the biological resources within the vicinity of the Project area for fish, freshwater mussels, crayfish, or other rare biota. Although the initial licensing (1979) of the Project addressed environmental impacts to several taxa (fish, plants, herptiles, mammals, birds, aquatic insects), this information was limited to a list of potential species to occur in the vicinity of the Project (based on a literature review and personal communications) rather than targeted species surveys and lacked data on mussel and crayfish. Furthermore, knowledge on community assemblages and distributions within reaches immediately adjacent to the Project study area are limited and patchy in spatial coverage. Taxa-specific backgrounds and historical data in the upper New River are reviewed within their respective report sections.

To meet stakeholder requests made during Project relicensing consultations, surveys were needed to gather current information on the occurrence and distribution of species within the Project vicinity. As such, the goal of this study is to fill these gaps in knowledge through species surveys designed to assess longitudinal patterns in assemblages and distributions surrounding the Project. The data presented in this Final Report are results from species surveys conducted by Virginia Tech (Conservation Management Institute and Department of Fish and Wildlife Conservation) from mid-July 2016 through late September 2017.

Study Reaches

Species surveys were conducted across five distinct Study Reaches (as outlined in Aquenergy’s study plans) surrounding the Project (Figure 1) and are hereby defined (and referred to in this report) as follows:

Reach 1) the 400-m upstream reference reach in the first riffle/shoal habitat identified upstream from the Project impoundment,

Reach 2) the 2.3-km impoundment reach,

Reach 3) the 150-m bypass reach,

Reach 4) an 800-m impact reach extending downstream from the powerhouse to the New River Trail State Park boat landing, and

Reach 5) a 400-m downstream reference reach found approximately 1.5 km below Fries Dam and 500 m below the New River Trail State Park boat landing (upstream of the Byllesby Dam Project impoundment).

Study Reaches were delineated prior to species surveys in a geographic information systems (GIS) platform (ArcMap 10.3) using aerial imagery, on-site qualitative habitat evaluations, and reservoir and lentic habitat classification criteria. To help ensure systematic and thorough coverage of Study Reaches, we divided each Study Reach of interest into 200-m sections by establishing equally-spaced transects along the length of the river (Figure 1). The establishment of defined sampling units within Study Reaches provided further insight to the longitudinal gradient of the Project's influence on habitat and species distributions and will allow for repeatable and comparable future assessments.

Wadable- and partially-wadable Study Reach Sections 1–7 and 20–21 were sampled as independent units. Due to the size, non-wadeable conditions, and general homogenous habitat that characterized Reach 2, we determined that allocating and documenting survey efforts at a relative fine spatial scale (i.e., 200-m sections) would not have been effective or efficient in the impoundment. Notable observations and specific locations (e.g., if a target species were encountered) were documented; however, sampling efforts and results were collectively summarized across the impounded Reach 2. While not a Study Reach of interest identified by stakeholders, the powerhouse canal (diverted flow running parallel to the bypass) was sampled opportunistically (Section 8).

INSTREAM HABITAT ASSESSMENTS

Background

In conjunction with observations made during species surveys, instream habitat assessments were conducted. Habitat assessments provided insight to the longitudinal gradient of the Project's influence on habitat, and to factors driving species distributions. These assessments, along with visual inspection of habitat characteristics during species surveys, also provided data to evaluate the potential habitat for eastern hellbender within the Study Reaches.

Objectives

(1) Conduct instream habitat assessments to characterize the physical habitat within each Study Reach
(2) Collect basic water quality spot-samples within each Study Reach Section

Methods

To characterize the physical habitat within each Study Reach, instream habitat features were measured along each established, equally-spaced transect (i.e., channel cross-sections) from bank to bank. Measurements included several metrics, such as bankfull and wetted width, mesohabitat composition (e.g., pool, riffle, run), and canopy cover. In addition, substrate particle size (pebble counts to characterize particle size distribution) and depth were sampled at systematic intervals along each established study-reach transect. To ensure a representative pebble count in Study Reaches not dominated by a single channel feature (i.e., pool, riffle, run), additional cross-sectional transects were sampled using a stratified, systematic method.

Basic water quality spot-samples were taken within each Section using a multiparameter meter (YSI Professional Plus). Physiochemical metrics included dissolved oxygen (DO), temperature, pH, and conductivity. The multiparameter meter was calibrated using standard solutions regularly throughout the field season. Additional temperature and conductivity measurements were recorded during species surveys using a standard, steel cased, field thermometer and handheld conductivity meter (Oakton Instruments).

Results

Particle-size frequency distribution histograms and cumulative particle distribution curves for each Study Reach are shown in Figures 2–4. Summary of spot-sample water quality measurements are shown in Table 1. Figures 5–11 document habitat conditions and characteristics.

Reach 1—The widest part of the river in this study was located in the upper reference reach where it extended 290 m in width, bank-to-bank. Wetted widths ranged from 195–273 m in the main channel (average = 234 m, median = 244 m) and 19–50 m (25 m, 35 m) in side channels. Depth measurements ranged from 0.01–1.4 m, with an average and median depth of 0.34 and 0.30 m, respectively. The substrate composition within the upper reference reach was predominately gravel and sand (D_{50} = 4.5 mm, D_{84} = 130 mm), and contained approximately 10% cobble and 14% bedrock substrates. Reach 1 contained a diversity of habitat types (e.g., riffles, runs, glides, pools, eddies, side channels) and slow to moderately–fast flows. A significant portion of the substrate surface found within 75 m of the right-descending bank (RDB) was covered by submerged aquatic vegetation (SAV); which gradually increased in density over the spring–fall field season (Figures 5a, 5b).

Reach 2—We estimated the influence of the impoundment (i.e., the reservoir) extended upstream approximately 2.3 river km from the dam structure. The physical habitat within the impoundment was characterized by sediment accumulations with observed depths ranging from 0.05–4.0 m (average = 1.4 m). Accumulations of sediment have formed several islands, and ensuing side channel habitats, within the impoundment since dam construction. The substrate composition within Reach 2 was dominated by sand (D_{90} < 2 mm). Habitats containing large boulders, bedrock, and large woody debris were also present. Submerged aquatic vegetation covered large portions of the substrate surface in the lower half of the Study Reach (Sections 9–14) from mid-summer through early fall. Wetted widths ranged from 74–224 m in the main channel (average = 122 m, median = 120 m) and 26–46 m (39 m, 42 m) in side channels (Figure 6).

Reach 3—The bypass reach, an area extending downstream 150 m from the dam structure, was characterized by sediment scour and armoring with observed depths ranging from 0.05–3.0 m (average = 1.1 m). Frequently, little to no—and even backwards—flows were observed during habitat evaluations and species surveys in the summer–fall. The substrate composition was dominated by very large boulders and slabs of bedrock (particles >4 m; D_{50} = 5500 mm), although smaller substrates (very fine gravel–large cobble) occurred along shallower edge habitat found in the lower half of the reach. Silt covered substrates along the left descending bank (LDB) extensively, extending instream over bedrock and large boulders—particular when dam spillage was minimal. In addition, we observed filamentous algae and other unidentified vegetation occurring along the LDB and instream. Wetted width extended 154 m at the base of the dam and averaged 135 m across the bypass (Figure 7).

Reach 4—The tailwater habitat just below the powerhouse, Section 6, was >90% non-wadeable and characterized by pools and glides composed largely by bedrock, boulder, sand, and silt substrates. Apart from habitat found immediately below the powerhouse outflow during operations, surface velocities were moderately slow across Section 6. Depths ranged from 0.2–2.7 m and wetted width increased in a downstream direction, ranging from 116–233 m. A transition towards riffle and run habitat with an increased availability of diversity substrate sizes occurred towards the downstream boundary of Section 6 into Section 5. (Figure 8).

Generally, habitat characteristics were similar along Sections 3–5 (Figure 8). Conditions were wadeable along the LDB and to a distance instream approximately 1/3 of the width of the river (~70m). Wadeable conditions along the right descending bank (RDB) were less evenly distributed along the length of the river, ranging from 0–100 m instream from the bank and generally decreasing in a downstream direction. These sections contained a diversity of habitat types (e.g., riffles, runs, glides, pools, eddies, side channel) and slow to fast flows. Wetted widths ranged from 198–270 m in the main channel (average = 229 m, median = 233 m) and 8–38 m in side channels. At its widest part found, at the downstream boundary of Section 5, the river measured 280 m bank-to-bank. Habitat was composed predominately by a mixture of sand–gravel (64%), and bedrock (21%; $D_{50} \approx 18$ mm, $D_{84} \approx 4300$ mm) and depths that ranged from 0.02–1.5 m (average = 0.43 m, median = 0.35 m).

Reach 5—The downstream reference reach was characterized by the main channel (wetted width range = 190–227 m) and a side channel (15–18 m) flowing along the LDB. An island, extending approximately 500 m in length and ranging from 15–105 m in width, separated the side channel from the mainstem (Figure 9). The physical habitat within the main channel was characterized by riffles, runs, and glides, with depths generally increasing along the cross-section from the LDB to RDB, ranging from 0.07–1.1 m (average = 0.48 m, median = 0.46 m). The substrate within the main channel was predominantly composed of medium–coarse gravel (56%) and sand–fine gravel (32%; $D_{50} \approx 19$ mm, $D_{84} \approx 46$ mm).

The side channel (Figure 10) was characterized by slow–moderate flowing glides, riffles, and runs, with depths ranging from 0.09–0.5 m (average = 0.27 m, median = 0.26 m). The substrate within the side channel was composed of sand–fine gravel (46%), medium–coarse gravel (56%), and cobble (10%; $D_{50} \approx 12$ mm, $D_{84} \approx 50$ mm). Large woody debris (LWD) was a common instream feature. Effectively blocking the channel and creating a pool on the upstream side, a considerable amount of large woody debris had accumulated around a fallen tree that lay across the transect (perpendicular to flow) dividing side channel Sections 1 and 2. In addition, a notable difference in particle size distributions was qualitatively observed, and later supported by pebble counts, upstream (Section 2_SC; $D_{50} \approx 23$ mm, $D_{84} \approx 67$ mm) and downstream (Section 1_SC; $D_{50} \approx 4.5$ mm, $D_{84} \approx 25$ mm) of the log jam (Figure 10).

Extremely low flow conditions were observed in this reach in July 2017 following a disruption in flow connectivity from upstream of the dam event; consequently, exposing large portions of substrate and aquatic vegetation along the LDB to instream ~1/3 river width in Reaches 4 and 5 (Figure 11). As such, flow was cut off from entering the downstream reference Reach 5 side channel. Several days later, sediment deposition was observed along the LDB of Reach 4 extending downstream through Reach 5 (Figure 12).

FRESHWATER FISHES

Background

The New River upstream from Claytor Lake supports a fish assemblage characterized by notable absences of large catostomid fishes and lower species richness compared with rivers of similar size. Eight cool-water adapted endemic fishes occur in the New River drainage as the upper elevations were an important refugia during the most recent ice age. Rivers with depauperate fish faunas are hypothesized to be more susceptible to invasion and major community impacts such as decline and extirpation of native species (Buckwalter et al. 2017). Today, the New River has the highest proportion of introduced to native fishes of any eastern USA drainage as at least 57 introduced fishes persist in the New River alongside 44 native fishes (Easton et al. 1993; Easton and Orth 1994; Angermeier and Pinder 2015; Hilling in press). Knowledge on species assemblages and distributions in the upper New River is often limited or patchy in spatial extent, as relatively few whole community collections have been conducted. The fish fauna in the reaches near the Fries Hydroelectric Dam have seldom been examined. In one report, Masnik et al. (1978) reported 36 fish species across the upper New River during their comparison of techniques for fish collection following rotenone applications. The native fish fauna in the upper New River has few catostomid fishes and is dominated by species of minnows (Cyprinidae). Three of the minnows, Kanawha Minnow (*Phenacobius teretulus*), Bigmouth Chub (*Nocomis platyrhynchus*), and New River Shiner (*Notropis scabriceps*), are endemic to the New River drainage. In addition, the *Notropis rubellus* form is currently considered an undescribed species *Notropis* sp. cf. *rubellus* Kanawha Rosyface Shiner (Berendzen et al. 2008). Endemic darters include the Candy Darter (*Etheostoma osburni*), Kanawha Darter (*Etheostoma kanawhae*), and the Appalachia Darter (*Percina gymnocephala*). Endemic sculpins include the Kanawha sculpin (*Cottus kanawhae*) and Bluestone sculpin *Cottus* sp.

Game fishes include Redbreast Sunfish (*Lepomis auritus*), Smallmouth Bass (*Micropterus dolomieu)*, Muskellunge (*Esox masquinongy*), and the Walleye (*Sander vitreus*)*.* The Walleye is a genetically unique walleye which was discovered in the New River, and is the basis for current restoration effort (Palmer et al. 2007).

Objectives

(1) Conduct qualitative surveys for fishes within each Study Reach using a combination of sampling methods to maximize likelihood of detections in a large river.

Methods

Fish surveys were conducted across all five reaches by biologists (C. Carey, H. Kim, S. Wolf, H. Hatcher, M. St. Germain, J. Emmel, Dr. D. Orth, S. Kurtzman, B. Stuart, and C. Hilling) affiliated with the Conservation Management Institute, Fluvial Fishes Lab, and Department of Fish and Wildlife Conservation at Virginia Tech. Biologists from the VDGIF (M. Pinder, D. Wheaton, J. Copeland, G. Palmer, T. Young, and R. Mowery) provided additional field support and technical assistance. To assess fish community assemblages, standardized qualitative and semi-quantitative surveys were conducted using active and passive fish sampling techniques. These techniques included backpack, raft, and boat electrofishing, snorkel observations, cast netting, angling, night observations, set lines, gillnetting, and minnow traps. Fish sampling began in July and continued through October (2016) and supplemental sampling was conducted from May to July (2017). Incidental fish observations were documented during other taxa surveys. Since no previous fish surveys were conducted in the immediate vicinity of the Project, we combined data from multiple survey methods to provide a first comparison among the sampling locations without statistical comparisons or relative abundance. All fish species encountered were identified to species, with exception of some juvenile Cyprinids. Voucher specimens were retained and deposited in the Fisheries and Wildlife Conservation teaching collection, housed in the College of Natural Resources and Environment at Virginia Tech. Collections were made under Scientific Collection Permit No. 056929 issued by the VDGIF.

Results

Fish sampling techniques differed among the Study Reaches and the amount of effort is reported in Table 2. We encountered 43 fish species collectively across all five Study Reaches and sampling techniques (Table 2). Native and endemic fishes comprised 57% and introduced fish comprised 43% of the total fish assemblage (Figure 13). Fish photos are shown in Figures 14–20.

Four endemic species were encountered and these included bigmouth chub (*Nocomis platyrhynchus*), Kanawha minnow (*Phenacobius teretulus*), New River shiner (*Notropis scabriceps*), and Appalachia darter (*Percina gymnocephala*). Bigmouth chub, New River shiner, and Appalachia darter were most commonly encountered endemic species. We observed only one Kanawha minnow, at the bottom end of the 800-m impact reach.

Reach 1.—Seventeen fish species were collected in the upstream reference reach, including 2 (12%) endemic, 9 (53%) native, and 6 (35%) introduced species (Figure 13). Bigmouth Chub were most abundant in both sections of this reach, followed by Smallmouth Bass, Fantail Darter, and Rock Bass, Redbreast Sunfish, and Whitetail Shiner. New River Shiner and Kanawha Minnow were not present in this reach. Spottail Shiner was only collected in Reach 1.

Reach 2.—Twenty-three fish species were collected in the impoundment, including 1 endemic (4%), 9 native (39%), and 13 introduced (57%) species (Figure 13). The impoundment supported a different fish assemblage with more lentic adaptive species, such as Largemouth Bass, Carp, Bluegill, Channel Catfish, and Black Crappie. The 1 endemic species was represented by 1 individual (Bigmouth Chub) and was encountered in the upper Section 19 of the impoundment. In addition, 4 species (Pumpkinseed, Gizzard Shad, Golden Shiner, and Swallowtail Shiner) collected in Reach 2 were not detected in any other Study Reaches.

Reach 3.—Nineteen fish species were collected in the bypass, including 1 endemic (5%), 8 native (42%), and 10 introduced (53%) species (Figure 13). Samples were dominated by Redbreast Sunfish, Smallmouth Bass, Rock Bass, and Bluegill. Spring 2017 sampling revealed the presence of adult Walleye (1 individual) during the spawning run. No Walleye were collected during fall 2016 sampling or above the dam 2016–2017.

Reach 4.—Thirty fish species were collected in the 800-m impact reach, including 4 endemic (13%), 16 native (53%), and 10 introduced (33%) species (Figure 13). Whitetail Shiner were the most abundant species encountered. Two of the top four most common fishes were the endemic

Bigmouth Chub and Mimic Shiner. Rock bass, Redbreast Sunfish, and Smallmouth Bass were the most common game species. Three Walleye were collected in the tailwaters (Section 6) during spring 2017 sampling, but not during summer and fall sampling. One individual of the endemic Kanawha Minnow was collected in the lower Section 3 of the reach and was the only individual of this species encounter across all five project Study Reaches. Other species unique to Reach 4 included Saffron Shiner, Bluehead Chub, and Sharpnose Darter. This reach was also an important site for the endemic New River Shiner and the endemic and rare Appalachia Darter.

Reach 5 (mainstem)—Eleven fish species were collected in the downstream reference reach mainstem, including 3 endemic (20%), 8 native (53%), and 4 introduced (27%) species (Figure 13). This reach was an important site for New River endemics Mimic Shiner and Bigmouth Chub and rare-endemic Appalachia Darter—the three most common species in Reach 5. Rock Bass and Smallmouth Bass were the most common game species encountered.

Reach 5 (side channel)—Sixteen fish species were collected in the downstream reference reach side channel, including 3 endemic (14%), 13 native (62%), and 5 introduced (24%) species (Figure 13). Across the Study Area, Warpaint Shiner and Longnose Dace were only encountered in this side channel.

In summary, a total of 43 species comprised of both native and introduced were collected across all five Study Reaches. Fish assemblage composition was most distinctive in the impounded Reach 2, which contained more lentic-adaptive fishes. Similar numbers of fish species were collected from the impounded Reach 2 (23 species), bypassed Reach 3 (19), and downstream reference Reach 5 (mainstem and side channel combined, 22). The 800-m impact Reach 4 had the highest species richness detected (30), which were largely represented in the tailwater habitat of Section 6.

Discussion

The fish assemblages of the New River were influenced by a high percentage of introduced fishes. Collectively across our study reaches, the fish community assemblage was composed by 60% native and endemic species and 40% introduced species, which is not unexpected given the high numbers of introduced fishes in other parts of the New River (Easton and Orth 1993; Jenkins and Burkhead 1994; Hilling et al. in press). Introduced fishes includes species that are sought by anglers, including Rock Bass and Redbreast Sunfish. Redbreast Sunfish were the most common species collected in the impounded reach and commonly encountered at every site sampled. Rock Bass were also common across all, but one (downstream reference), of our study reaches.

Bigmouth Chub were the most dominant species in both the upstream and downstream reference sites, which contained more of the riffle-run habitat characteristics preferred by the species (Lobb and Orth 1988; Lobb and Orth 1991). Bigmouth Chub use habitats characterized by an abundance of small to large gravel (3–64 mm) substrates in moderate velocities and shallow depths for constructing spawning mounds; several of which we observed in the upstream reference (Figure 20). These habitat characteristics were uncommon in the reaches impacted by the Dam.

The impoundment supported a different fish assemblage compared with the other reaches. Not only did the impoundment yield more White Sucker, Common Carp, Largemouth Bass, Bluegill, Channel Catfish, and Black Crappie, it was the only Study Reach in which Gizzard Shad and Golden Shiner were encountered. This is the first reported collection of Gizzard Shad above Buck Dam. Gizzard Shad were first documented in the New River in 1988, from presumptive angler introductions (Easton and Orth 1994).

The bypassed Reach 3, though devoid of smaller gravel and cobble substrates, did yield a similar number of fish species compared to reference sites. However, the composition of species differed where the bypass contained more Centrachids and less Cyprinids (Centrachids = 9 species, Cyprinids = 3 species) than the upstream (5, 7) and downstream (4, 12) reference reaches. These differences in species composition most likely reflect differences in habitat conditions and species-associated habitat preferences.

The 800-m impact Reach 4 had the highest species richness (30 species) detected, many of which were found in the tailwater habitat of Section 6 (26 species). This high species richness was most likely due the habitat complexity of the section which contained transitional habitat types from the bypass, through the tailwaters, and into the free-flowing mainstem, and may reflect an attraction under the low flow conditions sampled. It is possible that the spill over the dam and powerhouse tailwaters provide an attraction flow and/or food source for drift feeding fishes. Following Whitetail Shiner, New River endemic Bigmouth chub were the second most commonly encountered species in Reach 4. Other common species collected included introduced Redbreast Sunfish, Rock Bass, and Smallmouth Bass with highest numbers in the tailwater habitat of Section 6. The impact reach also supported several native and endemic species, to include Mimic Shiner, Appalachia Darter (endemic), Central Stoneroller, Greenside Darter, and New River Shiner (endemic).

The Appalachia Darter and the Kanawha Minnow collections are important findings. The Appalachia Darter occurred above and below the Fries Dam while the Kanawha Minnow was only collected downstream of the dam. The Kanawha Minnow was collected by Masnik et al. (1978) in the upper New River in good numbers. However, and similar to our findings, the vast majority of collections of the Kanawha Minnow consist of fewer than 10 specimens (Hambrick et al. 1975; Jenkins and Burkhead 1994). Masnik et al. (1978) also captured the Appalachia Darter (identified at the time as the Blackside Darter *Percina maculata*) in rare numbers in their collections. A notable absence from our collections were Kanawha Darter, which were collected in nearby reaches by Masnik et al. (1978).

In rivers impounded by large dams, fish assemblages can be influenced by impoundments for many kilometers downstream (Kinsolving and Bain 1993; Travnichek and Maceina 1994). In the case of Fries Dam, the notable differences in fish assemblages appears to be more localized to habitat alteration immediately upstream and downstream of the dam (Gillette et al. 2005).

AQUATIC MACROINVERTEBRATES

Background

Mussels, crayfish, dragonflies, and other rare macroinvertebrates in the upper New River have been poorly sampled with regional publications and resource agency databases providing the majority of the historical taxonomic and distributional information (Kennedy and White 1979; Carle 1982; Jezerinac et al. 1995; Loughman et al. 2009; Simmons and Fraley 2010; Russ et al. 2016). Mussel collections in the New River date back to 1913; however, historical survey efforts have generally been focused in the lower reaches of the river below Claytor Lake. The most recent mussel survey work from across the upper New River was conducted two decades ago (Pinder et al. 2002). In total, five mussel species have historical records above Claytor Lake in Virginia, including the rare elktoe, Virginia state threatened species green floater (under federal review) and pistolgrip, and the more common spike (*Eurynia dilitata*), pocketbook (*Lampsilis ovata*), and purple wartyback (*Cyclonaias tuberculata*; Dillion 1977; Jirka and Neves 1985, 1992; Pinder et al. 2002). The closest mussel records in proximity to the Project study area consist of purple wartyback that were collected below the New River Trail State Park boat landing in the late 1990s (Pinder et al. 2002). Additional collections have been made within 6 river km of the dam structure, to include live green floater, elktoe, spike and relic evidence of pistolgrip (Dillion 1977; Pinder et al. 2002).

Other macroinvertebrates of interest at the Fries Project that were identified during consultations included the New River crayfish (Tier IV Species of Greatest Conservation Need [SGCN] in Virginia's State Wildlife Action Plan [SWAP], New River endemic species) and pygmy snaketail dragonfly (Virginia Tier II SGCN). While both species have been described from this section of the upper New River surrounding the Project (Kennedy and White 1979; Carle 1982; Russ et al. 2016), their distributions within the vicinity of the Project are unknown. The closest (in proximity to the Project) historical collection record for New River crayfish occurred below the New River Trail State Park boat landing in 1997 (Pinder et al. 2002). In a recent range-wide conservation status assessment of the New River crayfish, Russ et al. (2016) concluded that although the species is stable at this time, its geographical range is restricted—making them more vulnerable to threats. Furthermore, this assessment noted that data on New

River crayfish distributions in Virginia were limited and recommended additional surveys in the state to fill these gaps in knowledge.

In 1976, Kennedy and White (1979) collected pygmy snaketail dragonfly approximately 4 km downstream of the Project at the St. Rte. 721 bridge. It is the smallest species within its genus (mature larvae 19–23 mm, adults 31–34 mm) with an emergence window ranging from April 30–May 23 (available records indicate 19°C water temperatures) in Virginia (Carle 1982; Kennedy and White 1979). Pygmy snaketail dragonfly larvae inhabit medium–large rivers (>10 m) within forested watersheds, and prefer areas of fast flow composed of fine sand or gravel substrates (Michigan DNR, Kennedy and White 1979). The current conservation status of the pygmy snaketail dragonfly in the New River drainage is unknown (Kennedy and White 1979; Virginia SWAP 2015; VaFWIS 2016). This uncertainty in conservation status extends across the pygmy snaketail dragonfly’s range of occurrences. While the distribution of pygmy snaketail extends from North Carolina to Canada, populations are rare or localized throughout its range. When last reviewed by the NatureServe (2006), it was given a globally vulnerable species (G3) conservation status.

To date, no federally listed endangered mussels, crayfish, dragonflies, or other listed macroinvertebrates have been identified within the upper New River, Virginia. However, given the potential for listed species to occur within the vicinity of the Project, multispecies (Unionidae, Decapoda, Odonata) surveys were initiated to address knowledge gaps in macroinvertebrate distributions and assess potential Project impact on macroinvertebrate communities in the upper New River.

Objectives

(1) Conduct standardized, qualitative surveys for freshwater mussels and crayfish within each Study Reach.
(2) Conduct crayfish, dragonfly larvae, and benthic macroinvertebrate surveys using a combination of sampling methods to maximize likelihood of detection within a large river.
(3) Conduct opportunistic searches and collect incidental observations for all taxa.

Methods

Survey efforts—Areas of suitable habitat within the Study Reaches to target survey efforts were identified prior to sampling based on visual assessments during preliminary site visits and instream habitat assessments. Species-specific suitable habitat characteristics were based on preferences reported in Pinder et al. (2002) and Russ et al. (2016), and communications with biologists (B.Watson, T. Lane, M. Pinder, Z. Loughman, personal communication). Surveys were conducted by biologists affiliated with Virginia Tech (C. Carey, H. Kim, S. Wolf, H. Hatcher, M. St. Germain, S. Kurtzman, B. Stuart) and West Liberty University (Z. Loughman) in late summer–early fall 2016, and in the late spring–early fall 2017, when river conditions were optimal and accessible for sampling (i.e., low flows and warmer temperatures). Biologists from the VDGIF provided additional field support and technical guidance (M. Pinder, D. Wheaton, T. Lane, B. Watson, and R. Mowery). Collections were made under Scientific Collection Permit Nos. 054376 and 059587, and Threatened and Endangered Species Permit Nos. 057004 and 059585, issued by the VDGIF.

Freshwater mussels—To assess mussel distributions and determine if protected species were present, we employed qualitative (timed) searches within each Study Reach, focusing on areas of suitable habitat (if present). Preferred mussel streambed habitats were searched (visual and tactile) for live individuals and shell material by snorkeling, using viewscopes, hand-turning rocks, and waving gently over the surface to displace finer substrates. Dive searches were required for sampling deeper habitats found in impounded Reach 4. River banks and exposed areas were searched for fresh dead and relic mussel shells. Opportunistic sampling coincided with boat electrofishing, night spotting (i.e., spotlighting at night), and fish and crayfish snorkel sampling efforts. Any live mussels or shell material (fresh dead, relic, or fragments) encountered were collected, identified to species, and then returned (if live) to the substrate. Search efforts (person-hours) for taxa-specific and opportunistic sampling were recorded. Incidental encounters made during other taxa-targeted surveys were documented. Shell material retained was brought back and deposited at Virginia Tech.

Crayfish, dragonflies, and other rare macroinvertebrates—To assess New River crayfish and pygmy snaketail dragonfly distributions, we conducted qualitative searches within wadeable habitats using a combination of snorkeling, kick-net, and seine-haul sampling methods. D-frame dip nets were used to collect samples in wadeable and non-wadeable areas, and across multiple habitats, such as riffles, sand, vegetation, leaf packs, and woody debris. A log peavey was used to lift larger slab rocks during seine-haul and kick-net sampling. Snorkel surveys for crayfish coincided with freshwater mussel and fish snorkel sampling efforts.

In addition to sampling odonates during the (aquatic) nymph stage, visual searches for exuviae (i.e., the cast skin remaining after a molt into the adult life stage) in mud and grassy vegetation along river banks, and opportunistic sampling by physical capture or photography of adults, were conducted in spring 2017. Other opportunistic sampling efforts coincided with boat electrofishing, night spotting, and fish snorkel surveys, and included underwater photography and video techniques. Search efforts (person-hours) for taxa-specific and opportunistic sampling were recorded. Crayfish were identified in the field with the assistance of Dr. Zachary Loughman (West Liberty) and voucher specimens were collected for validation as needed. Odonate larvae were sorted from other macroinvertebrates collected in the field, preserved in a 70% ethanol solution, and retained at Virginia Tech for identification in the lab. Dragonfly nymphal characteristics described by Kennedy and White (1979), Carle (1982), and Needham et al. (2000) were used to identify pygmy snaketail and other odonates.

Results

Survey efforts—Survey efforts and results are summarized in Tables 4–6. Photos of species encountered are shown in Figures 21–24.

Freshwater mussels—A total of 61 live mussels represented by 2 species were collected from Study Reaches 1, 4, and 5 (Table 3). Green floater (10 live, 2 shells, 3 fragments; Figure 21) were collected upstream of the dam in reference Reach 1, whereas purple wartyback (Figure 22) were collected downstream of the dam in the 800-m impact Reach 4 (50 live, 15 shells) and reference Reach 5 (21 live, 19 shells). Recent and relic shell material for a third species, spike, were collected from reference Reach 1. No live mussels or shell material were observed in the impounded Reach 2 or bypassed Reach 3. One relic shell fragment (unknown species) was obtained from an old pile of dredged sand material that lay within a property adjacent to the impoundment (i.e., dredged sand from the impoundment pre-2000s).

Crayfish, dragonflies, and other rare macroinvertebrates—Over 800 live crayfish, representing one species, were encountered from Study Reaches 1, 3, 4, and 5. The spiny stream crayfish (*Orconectes cristavarius*; Figure 23), a native to the New River, was abundant in Reaches 1, 4, and 5. Only one live individual was encountered in the bypassed Reach 3 by video, and no crayfish were encountered in the impounded Reach 2. We did not detect New River crayfish, a target species, within any of the Study Reaches.

Odonate nymphs, representing 4 families and 17 species, were encountered across Study Reaches 1, 2, 4, and 5 (Table 4). No odonates were identified from the bypassed Reach 3. The target dragonfly species, pygmy snaketail, was collected downstream of the dam in Reaches 4 and 5 (Figure 24). Three additional Virginia SWAP SGCN species were identified during this study: Allegheny river cruiser (*Macromia alleghanensis*), spine-crowned clubtail (*Gomphus abbreviatus*), and green-faced clubtail (*Gomphus viridifrons*).

Discussion

This project filled gaps in knowledge on aquatic macroinvertebrate community assemblages and distributions within Upper New River reaches surrounding, and in the vicinity, of the Fries Project. We encountered Purple Wartyback in habitat below the dam and outside the bypassed reach and documented a new occurrence record for state threatened Green Floater in the upstream reference reach. Crayfish were common in all reaches outside the bypass and impoundment; however, our extensive collections did not reveal the presence of our targeted species, the New River Crayfish, and were represented by only one species, the Spiny Stream Crayfish. In addition to detecting the targeted dragonfly SGCN, pygmy snaketail, we documented three other dragonfly SGCNs not previous documented within the Project Area.

Similar to findings of a 1997 survey (Pinder et al. 2002), a population of purple wartyback were identified from the mainstem of the New River below Fries Dam and the New River Trail State Park boat landing (Study Reach 5). In addition, we found purple wartyback to be patchily distributed across the width of the river in the lower sections of the 800-m impact Reach 4, with largest aggregations occurring along the RDB. There was no evidence of recent recruitment given the absence of smaller individuals (smallest individual = 73 mm; both live or as shell material) in our collections indicating that this may represent a relict population of aging adults. Comparisons of catch-per-unit effort in 1997 (115 live individuals in 4.5 person-hours; Pinder et al. 2002) to our 2016–2017 efforts (89 live individuals in 42 person-hours of snorkeling and diving) from below the dam which suggest a local decline in purple wartyback abundance. Pinder et al. (2002) also reported spike below the boat landing; a species which we did not detect in our collections. While these semi-quantitative comparisons can provide insight to population trends, they should be interpreted with caution given that the survey protocols and search area were not identical between 1997 and 2016–2017 surveys. A quantitative assessment would be required to obtain reliable population size estimates for mussels. Host fishes for purple wartyback (Flathead and Channel Catfish) were detected in all Study Reaches except the upstream reference Reach 1.

State threatened pistolgrip, live or shell material, were not encountered during our searches. Additional anecdotal accounts from local residents (i.e., recreational anglers, private citizens, dredging contractor) suggest that pistolgrip were once abundant in the upstream reaches of the dam (Reaches 1–2), but that it has declined to undetectable levels, if not have been extirpated, from the impoundment over the last 2–3 decades. Flathead Catfish, a known host fish for pistolgrip, were present in all Study Reaches except the upstream reference Reach 1.

A new occurrence locality for state threatened green floater, a species not previously reported from the Study Area and last documented 30 km upstream of the dam in the 1990s, was discovered in our upstream reference Reach 1. Across the 134 sites sampled for mussels in the New River above and below Claytor Lake in 1997–1998, Pinder et al. (2002) found green floater to occur in 3 sites. Collections of green floater in Reach 1 represent a significant find given the rarity of the species in occurrences and numbers (within a locality) across the New River and as a species Under Review for federal listing. A quantitative assessment would be required to obtain reliable population size estimates for this local population.

While our search efforts revealed the presence of one crayfish species (spiny stream crayfish), historical collection records from the Upper New River indicate that the mainstem once supported at least five different species of crayfish. Loughman et al. (2013) reported New River crayfish habitat preferences to include areas with slab boulders and moderate depths (0.25–0.75 m) and flows. Although we did not detect the New River crayfish it may be present at very low, undetectable densities within Study Reaches 1, 4, and 5 which contained areas of preferred habitat as identified by Loughman et al. (2013).

No crayfish or freshwater mussels were encountered in the impounded Reach 2; however, we did identify five species of dragonfly from the impoundment, including Tier II SGCN green-faced clubtail. Except for one Spiny Stream Crayfish, we did not detect freshwater mussels or dragonflies within the bypassed Reach 3. It is unlikely that we failed to detect freshwater mussels in the bypassed Study Reach 3 given our search efforts and the unsuitable habitat conditions within the bypass.

VIRGINIA SPIRAEA

Background

Virginia spiraea (*Spiraea virginiana*) is a federally threatened clonal shrub endemic to the Blue Ridge and Appalachian Plateau physiographic provinces with small populations occurring in seven southeastern, Midwest and mid-Atlantic states: Georgia, North Carolina, Ohio, Tennessee, Virginia and West Virginia (Horton et al. 2015). Virginia spiraea has erect or arching stems and typically grows to between 0.4–2.5 meters tall, often-forming dense thickets along rivers and streams. Leaves are lance-shaped, elliptic or oval, 3–5 cm long and toothed above the middle with the lower surfaces powdery white. Flowering from late May–July, Virginia spiraea flowers range from white to a greenish-yellow disk and occur in 5–7 cm wide rounded to flat-topped clusters. Reproduction is primarily vegetative, spreading through clonal growth, with dispersal occurring through the fragmentation of rhizomes and subsequent dislodgment and transport downstream via flooding events (Ogle 1991a). Fruiting occurs from August–September with the small pods borne in clusters (Weakley et al. 2012). However, seed viability is very low likely due to the presence of a single genotype in most populations (Ogle 1991b)

Virginia spiraea occurs along riparian corridors and is dependent upon scouring floods and other disturbances to control competition and to maintain suitable habitat conditions. Virginia spiraea is typically found in high gradient reaches of second and third order streams where periodic, scouring flooding occurs (Ogle 1991a). The dependence upon the flooding disturbance benefits the plant by reducing competing vegetation and allowing dispersed rhizomes to gain purchase and root in suitable substrate (e.g. cobble and boulders). Furthermore, periodic disturbance restricts the growth of surrounding woody vegetation that would overtop the shade intolerant Virginia spiraea (Horton et al. 2015). Ogle (1991b) identified six general habitat types for Virginia spiraea, which included (1) scoured banks of high gradient streams, (2) meander scrolls, (3) point bars, (4) natural levees, (5) braided features of lower stream reaches, and (6) disturbed right-of-ways. While several others have reported similar descriptive habitat preferences for Virginia spiraea to those described by Ogle (1991a,b; 1991b; Weakely et al. 2012, Rossell et al. 2013), Horton et al. (2015) identified several quantifiable—and significant—predictor habitat characteristics (Table 7). This rare flora species has been documented along the upper New River in Grayson (1986) and Carroll (1992) Counties and, more recently, in 2011 from upper North Carolina reaches (Ogle 1991; USFWS 1992; Horton et al. 2015). Hence, surveys were needed to determine its current distribution surrounding the Project.

Objectives

(1) Examine aerial imagery to identify sites with potential suitable Virginia spiraea habitat.
(2) Conduct timed searches at sites identified through aerial imagery.
(3) Opportunistically search stream bank habitats for Virginia spiraea presence during other taxa surveys.

Methods

The following general approach was used to efficiently survey the Study Area for Virginia spiraea:

(1) Review peer reviewed and agency literature to identify key habitat variables.
(2) Use aerial photos and GIS to identify potential habitat locations within the study area for field survey.
(3) Perform site visits (i.e., wading, canoe, kayak) at all potential habitat locations identified in step 2 throughout the growing season and under a variety of flow regimes.
(4) If Virginia spiraea was encountered, the extent of the site would be georeferenced, basic habitat data collected, and detailed photographs taken for taxonomic confirmation.

Following key habitat characteristics identified by Horton et al. (2015; Table 5) and general types described by Ogle (1991b), we used GIS (e.g., canopy cover, herbaceous cover) and instream habitat data (e.g., substrate composition, vine cover) to identify survey locations and guide field efforts for Virginia spiraea within the Study Area. This resulted in the identification of 37 sites that contained had at least one of the Virginia spiraea habitat characteristics. Field surveys were conducted periodically throughout the growing season (May–September 2017) and with a focus during the peak flowering period (May–June). Targeted-field surveys were conducted by wading, canoe, and kayak and each site was searched (including the surrounding area) for a minimum of 10 minutes for evidence of Virginia spiraea presence. Additional stretches of bank, and islands in Reach 1, were surveyed opportunistically while accessing and moving between sites. In addition, field crews conducting fish and aquatic macroinvertebrate surveys were given species (Virginia spiraea) and habitat identification guides, and instructed to document any potential locations for further investigation.

Results and Discussion

Virginia spiraea was not detected within any of the five Study Reaches across 33.5 hours of targeted field efforts (excludes GIS analysis) to locate the species. Many sites surveyed (both pre-identified and opportunistic) were downstream of the dam where scouring during flood events would most likely increase the likelihood of suitable habitat presence. Where many sites exhibited at least one suitable habitat characteristic (e.g., open canopy), others were considered unsuitable (e.g., dense tree and herbaceous cover). Nevertheless, we did not identify any locations that would constitute ideal habitat within the Study Reaches. While Virginia spiraea has been encountered elsewhere in the upper New River, the non-detection of this species within our surveys is likely due to limited suitable habitat with the Study Area.

OTHER RARE SPECIES

Background

Eastern hellbender.—The eastern hellbender is a rare, fully aquatic salamander that is patchily distributed across parts of the eastern United States, including collections within the New River drainage (Burgmeier et al. 2011; Jachowski and Hopkins 2014; VaFWIS 2016). It is a Tier I SWAP species of concern in Virginia (SWAP 2015). The most recent hellbender encounters in the upper New River within Grayson County have occurred periodically from 2013–2016 near the North Carolina border (VaFWIS 2016). At present, there are no known eastern hellbender occurrences reported from within the vicinity of the Project. Because of its potential to occur in this reach of the upper New River, an assessment of suitable habitat availability and current status within the Project vicinity were requested. The goal of this assessment was to determine if suitable habitat was present, and if so, to opportunistically investigate whether eastern hellbender occurred within the vicinity of the Project.

Bog turtle.—A semi-aquatic species, the bog turtle is a federally threatened and state (Virginia) endangered, Tier I species (SWAP 2015). Preferred bog turtle habitat is highly fragmented, often ephemeral due to vegetation succession, and includes stream-head sedge meadows, spring-fed sphagnum bogs, fens, and open shrubby swamps, and nearby small streams (Ernst and Lovich 2009). Availability of open, shade-free, wet areas are important for nesting bog turtles (Zappalorti et al. 2015). There have been no documented encounters of bog turtles within the vicinity of the Project (VaFWIS 2016). Although unlikely, there is a possibility for wetland areas to occur within the Project boundary that may serve as suitable bog turtle habitat. Therefore, visual inspection of aerial imagery and opportunistic searches for suitable habitat during other targeted-species site visits would provide data for Project Relicensing stakeholders to determine if further bog turtles studies were warranted.

Objectives

(1) To use information gathered from instream habitat assessments and species surveys to qualitatively assess the presence or absence of suitable hellbender and bog turtle habitat.

(2) Conduct qualitative and opportunistic searches for hellbender in habitat where the likelihood of detection is greatest (if suitable habitat is identified).
(3) Qualitatively and opportunistically search for suitable bog turtle habitat.

Methods

Eastern hellbender—Eastern hellbender site suitability was qualitatively assessed during instream habitat assessments and other species' sampling events. Favorable habitat characteristics were based on habitat use in the main stem of the New River findings of Jackowski and Hopkins (2014) and preferences reported in Nickerson and Mays (1973), Hutchison and Hill (1976), Nickerson et al. (2003), Keitzer (2007), and Pitt et al. (2017). Preferable characteristics included depth (0.5–1.0 m), presence of large, flat boulders (0.75–1.0 m length, 0.4–1.0 m^2 area), pH (7.6–9.0), conductivity (<278 µS/cm), and cooler water temperatures. While many have reported eastern hellbender water temperature preferences in the 10–23°C range, Jackowski and Hopkins (2014) collected upper New River mainstem residents in habitats as warm as 26.6°C.

If suitable habitat was observed in any of the five Study Reaches, we included these patches of habitat in our crayfish and mussel surveys. Because eastern hellbenders spend most of their time under large, flat rocks—a preference they share with New River crayfish—and are relatively sedentary during the day, monitoring for their presence was conducted in conjunction with crayfish and mussel surveys which overlapped in sampling techniques (i,e., snorkeling surveys, looking under rocks and in crevices). Biologists were mindful of the potential to encounter eastern hellbenders as they turned over rocks and boulders during other taxa-targeted surveys. Non-invasive underwater photography and video techniques to explore cavities under flat rocks for fish and crayfish provided an opportunistic means of detecting hellbender presence in deeper habitats (>1 m) where snorkeling has been found to be ineffective (Nickerson and Krysko 2003, Jackowski et al 2014). If an individual was observed, GPS coordinates would be recorded, and a photo taken if possible without disturbing the individual.

Bog turtle.—Opportunistic searches for preferred bog turtle habitat were conducted in conjunction with Virginia spiraea surveys with the assistance of Amy Roberts (bog turtle biologist). If potential suitable habitat was encountered, the site would be georeferenced and photo documented, and the Project relicensing parties would be notified.

Results & Discussion

Eastern hellbender—Across our site assessments, we identified several patches within Reaches 1, 4, and 5 that could (potentially) serve as suitable eastern hellbender habitat based on substrate composition (e.g., availability of large flat rocks in gravel and cobble substrates). We qualitatively searched these patches in conjunction with crayfish and mussel surveys; however, no eastern hellbenders were observed within Reaches 1, 4, or 5. Additional anecdotal evidence from residents suggests that eastern hellbender were once (>20 years ago) commonly encountered in both the mainstem and local tributaries within and surrounding the Project study area. Encounters by locals included incidental (and often frequent) captures while fishing, visual sightings, and reports of observing dead individuals along banks that clearly appeared to be intentional and human-caused. Although there is the potential for hellbender presence within Reaches 1, 4, and 5, as it has been documented elsewhere in the New River mainstem, the range of water temperatures (25–31°C) recorded during our assessments were well above hellbender preference for cooler water temperatures (typically 10–23°C), suggesting that these habitats are not optimally suitable for hellbenders.

Following our 2016–2017 surveys across the Study Area, an eastern hellbender was incidentally captured by angling in the impoundment (Reach 2) in late February 2018 (Figure 25). The individual was an adult measuring approximately 26" in length. Based on this one collection we cannot conclude whether this species is a resident of the mainstem or a transient individual that occupies the mainstem for shorter periods of time (Jachowski and Hopkins 2014). Until this collection, the last reported collections of eastern hellbender in the mainstem of the Upper New River (i.e., above Claytor Lake) between Fries and Fields Dam occurred in 2002 and 2014, over 30 RKM upstream of Fries Dam. To our knowledge, this encounter represents the furthest most collection site within the mainstem of the Upper New River, above Claytor Lake, over the last 20 years. This encounter represents a significant find given the rarity of the species in the Upper New River.

Bog turtle—Geospatial analysis of known bog turtle sites showed no nearby populations with hydrologic connections to the study area. No suitable habitat was found within the Project Study Area boundary, either through geospatial analysis or field observations.

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TABLES & FIGURES

Table 1. Summary statistics (average and range; rounded to the nearest tenth) for water quality spot-samples taken during site visits in Project Study Reaches, Grayson County, Virginia, 2016–2017. While samples provide snapshots of water quality conditions, note that parameter measurements should be interpreted with caution as they represent water quality samples taken during site visits and not continuous or random monitoring.

Reach	Water Temperature (˚C)		D.O. (mg/L)		Conductivity (µS/cm)		pH	
1	24.3	(20.9–28.4)	8.4	(7.8–9.0)	68.0	(57.0–76.0)	8.0	(8.0–8.0)
2	25.6	(15.8–29.1)	7.6	(7.1–7.8)	75.5	(66.5–79.7)	8.4	(8.2–8.6)
3	21.5	(13–30.6)	7.5	(7.4–7.6)	73.1	(64–89.7)	7.9	(7.9–7.9)
4	23.3	(17.2–27.6)	7.3	(6.7–7.8)	68.7	(65–75.1)	7.9	(7.6–8.2)
5	24.8	(23.9–30.1)	8.1	(7.1–8.4)	68.8	(67.1–71)	8.3	(7.9–8.6)
5_SC	24.0	(22.0–27.7)	7.6	(7.0–7.9)	71.7	(68.1–77.6)	8.0	(7.7–8.5)
Canal*	23.4	(23.3–23.4)	6.3	(6.2–6.4)	67.4	(66.6–67.6)	7.7	(7.6–7.8)

*Sampled once on 8/2/2017

Table 2. Fish sampling efforts broken down by collection method and Project Study Reaches, Grayson County, Virginia, 2016–2017. Study Reaches are presented along a longitudinal gradient, descending downstream from Reach 1 (Upstream Reference Reach) to Reach 5 (Downstream Reference Reach).

	Study Reaches						Other	
Collection Method	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 5 SC*	Canal (Sec. 8)	Effort Units
Active								
Electrofishing								
Boat		14,847						Electricity on-time (seconds)**
Raft			6,565	1,714				Electricity on-time (seconds)
Backpack	5,884		320	7,278	1,676	4,884		Electricity on-time (seconds)
	5,884	14,847	6,885	8,992	1,676	4,884		Electricity on-time (seconds)
Backpack	63		15	131	60	28		Seine-sets
Castnetting	4						10	Number casts
Passive								
Gillnetting		21						Soak-time (hours)
Trotlines		26						Soak-time (hours)
Minnow traps	27	10	8	39				
Visual								
Night spotting		22						person-hours
Snorkeling/diving	13		6	18	6	2		person-hours

*Reach 5 SC = side-channel along left-decending bank in Reach 5

**Electricity on-time = total time backpack unit is delivering a current to the water, includes seine-sets and dip-netting time

Table 3. Species collected within each Section of the Project Study Reaches. Study Reaches are presented along a longitudinal gradient, descending downstream from Reach 1 (Upstream Reference Reach) to Reach 5 (Downstream Reference Reach). Origin is the biogeographic origin based on Jenkins and Burkhead (1994). N=Native, I=Introduced, E=Endemic.

Species	Common Name	Origin	Study Reach of Interest (Sections)											
			Reach 1 Upstream Reference		Reach 2 Impoundment	Reach 3 Canal + Bypass		Reach 4 800-m Impact Reach				Reach 5 Downstream Reference Reach		
			21	20	9–19	8	7	6	5	4	3	2	1	1+2 SC
Hypentelium nigricans	Northern Hogsucker	N	6	1	77	0	19	3	4	2	1	0	0	13
Catostomus commersonii	White Sucker	N	0	0	20	0	2	0	0	0	0	0	0	0
Pomoxis nigromaculatus	Black Crappie	I	0	0	11	0	2	0	0	0	0	0	0	0
Lepomis macrochirus	Bluegill	I	0	0	29	0	37	3	0	0	0	0	0	0
Lepomis cyanellus	Green Sunfish	N	0	1	0	0	0	0	0	0	1	0	0	0
Micropterus salmoides	Largemouth Bass	I	0	0	47	0	8	3	0	0	0	0	0	0
Lepomis gibbosus	Pumpkinseed	I	0	0	1	0	0	0	0	0	0	0	0	0
Lepomis auritus	Redbreast Sunfish	I	2	18	181	1	122	51	3	9	0	0	0	37
Ambloplites rupestris	Rock Bass	I	18	5	15	0	61	38	8	16	5	9	0	8
Micropterus dolomieu	Smallmouth Bass	I	41	2	21	4	77	30	4	3	6	8	1	10
Micropterus punctulatus	Spotted Bass	I	0	0	2	0	7	0	0	0	0	0	0	0
Dorosoma cepedianum	Gizzard Shad	I	0	0	15	0	0	0	0	0	0	0	0	0
Nocomis platyrhynchus	Bigmouth Chub	E	42	27	1	0	2	22	23	25	7	4	16	19
Nocomis leptocephalus	Bluehead Chub	N	0	0	0	0	0	1	0	0	0	0	0	0
Pimephales notatus	Bluntnose minnow	N	1	1	0	0	0	0	0	0	0	0	0	2
Campostoma anomalum	Central Stoneroller	N	9	5	0	0	0	2	23	2	1	1	0	76
Cyprinus carpio	Common Carp	I	0	0	42	0	5	1	1	0	0	1	1	1
Notemigonus crysoleucas	Golden Shiner	I	0	0	2	0	0	0	0	0	0	0	0	0
Phenacobius teretulus	Kanawha Minnow	E	0	0	0	0	0	0	0	0	1	0	0	0
Rhinichthys cataractae	Longnose Dace	N	0	0	0	0	0	0	0	0	0	0	0	4
Notropis volucellus	Mimic Shiner	N	0	0	0	0	0	21	18	18	7	27	8	1
Notropis scabriceps	New River Shiner	E	0	0	0	0	0	1	16	4	1	0	6	12

Note: The total number of individuals collected does not represent abundance of fishes within a Study Reach

Table 3. Continued.

Species	Common Name	Origin	Study Reach of Interest (Sections)											
			Reach 1 Upstream Reference		Reach 2 Impoundment	Reach 3 Canal + Bypass		Reach 4 800-m Impact Reach				Reach 5 Downstream Reference Reach		
			21	20	9–19	8	7	6	5	4	3	2	1	1+2 SC
Notropis rubellus	Rosyface Shiner	N	7	7	1	0	0	3	2	3	3	7	5	0
Notropis rubricroceus	Saffron Shiner	I	0	0	0	0	0	0	1	0	0	0	0	0
Notropis photogenis	Silver Shiner	N	0	0	88	0	0	8	0	0	0	0	0	26
Cyprinella spiloptera	Spotfin Shiner	N	0	0	0	0	0	0	0	0	0	2	2	18
Notropis hudsonius	Spottail Shiner	I	0	1	0	0	0	0	0	0	0	0	0	0
Notropis procne	Swallowtail Shiner	N	0	0	1	0	0	0	0	0	0	0	0	0
Notropis telescopus	Telescope Shiner	I	0	1	0	0	0	0	1	2	0	0	0	0
Luxilus coccogenis	Warpaint Shiner	N	0	0	0	0	0	0	0	0	0	0	0	4
Luxilus albeolus	White Shiner	N	0	0	8	0	0	6	1	1	7	0	0	0
Cyprinella galactura	Whitetail Shiner	I	10	10	17	0	7	109	25	12	6	0	8	78
Esox masquinongy	Muskellunge	I	0	0	1	0	0	1	0	0	0	0	0	0
Ictalurus punctatus	Channel Catfish	N	0	0	16	0	2	1	0	0	0	0	1	2
Pylodictis olivaris	Flathead Catfish	N	0	0	10	0	2	5	2	1	0	1	1	2
Noturus insignis	Margined Madtom	N	4	8	0	0	0	1	3	0	0	0	0	3
Percina gymnocephala	Appalachia Darter	E	1	1	0	0	0	17	7	2	6	10	14	1
Etheostoma flabellare	Fantail Darter	N	20	8	0	0	1	4	10	2	0	6	12	2
Etheostoma blennioides	Greenside Darter	N	5	3	1	0	3	4	6	8	5	4	12	4
Sander vitreus	Walleye	N	0	0	0	0	1	3	0	0	0	3	14	3
Percina caprodes	Logperch	N	1	0	0	0	5	6	3	2	1	0	0	0
Percina oxyrhynchus	Sharpnose Darter	N	0	0	0	0	0	2	0	0	0	0	0	0
Perca flavescens	Yellow perch	I	0	0	0	0	12	0	0	0	0	0	0	0
		Total Collected	167	99	607	5	375	346	161	112	58	77	89	324
		Species Richness	14	16	23	2	19	26	20	17	15	12	13	21

Note: The total number of individuals collected does not represent abundance of fishes within a Study Reach

Table 4. Survey efforts (person-hours) summarized by taxa within Project Study Reaches in the upper New River, Grayson County, Virginia, 2016–2017.

			Total Effort (person-hours)		
Reach No.	Reach Name	Collection Method	Mussels[A]	Crayfish[B]	Benthic Macroinvertebrates[C]
1	Upstream Reference	All (Snorkeling)	36 (32)	43 (32)	16 (Opportunistically)
2	Impoundment	All (Snorkeling & diving)	26 (8)	35 (8)	8 (Opportunistically)
3	Bypass	All (Snorkeling)	8 (6)	8 (6)	8 (Opportunistically)
4	800-m Impact	All (Snorkeling & diving)	37 (34)	50 (34)	22 (Opportunistically)
5	Downstream Reference	All (Snorkeling)	16 (8)	16 (8)	6 (Opportunistically)

*Note that some sampling efforts overlapped between taxa. "All" collection methods includes snorkeling/diving efforts

[A]Mussel total sampling effort = snorkeling/diving + visual + night spotting

[B]Crayfish total sampling effort = snorkeling/diving + visual + night spotting + seine-hauls

[C]Benthic macroinvertebrate total sampling effort = all seine + dip-netting collections

Table 5. Freshwater mussel and crayfish collections by Section within Project Study Reaches, Grayson County, Virginia, 2016–2017. Study Reaches are presented along a longitudinal gradient, descending downstream from Reach 1 (Upstream Reference Reach) to Reach 5 (Downstream Reference Reach).

			Study Reaches (Sections)										
			Reach 1		Reach 2	Reach 3	Reach 4				Reach 5		
Family	Species	Common Name	(21)	(20)	(9-19)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(SC)
Unionidae	*Cyclonaias tuberculata*	Purple wartyback						L	L	L	L	L	
	Lasmigona subviridis [ST]	Green floater	L	L									
	Eurynia dilatata	Spike	S										
Cambaridae	*Orconectes cristavarius*	Spiny stream crayfish	L	L		L	L	L	L	L	L	L	L

S = Shell material L = Live individual ST = State Threatened SC = Side channel

Table 6. Benthic macroinvertebrates belonging to the Suborder Anisoptera (dragonflies) identified within the Project Study Reaches. Study Reaches are presented along a longitudinal gradient, descending downstream from Reach 1 (Upstream Reference Reach) to Reach 5 (Downstream Reference Reach). Species in bold are Species of Greatest Conservation Need (SGCNs) identified in Virginia's State Wildlife Action Plan (SWAP 2015).

Family	Species	Common Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	VA SWAP Tier
Aeshnidae	*Boyeria vinosa*	Fawn Darner	X			X	X	
Corduliidae	*Epitheca cynosura*	Common Baskettail		X				
	Epitheca princeps	Prince Baskettail				X		
	Macromia alleghanensis	**Allegheny River Cruiser**	**X**					**IV**
	Macromia illinoiensis	Swift River Cruiser	X			X	X	
Gomphidae	*Argiogomphus villosipes*	Unicorn Clubtail		X				
	Dromogomphus spinosus	Black-shouldered Spinyleg	X	X		X	X	
	Gomphus abbreviatus	**Spine-crowned Clubtail**				**X**		**III**
	Gomphus adelphus	Mustached Clubtail	X			X		
	Gomphus vastus	Cobra Clubtail					X	
	Gomphus viridifrons	**Green-faced Clubtail**		**X**				**II**
	Hagenius brevistylus	Dragonhunter					X	
	Ophiogomphus howei	**Pygmy Snaketail**				**X**	**X**	**II**
	Ophiogomphus rupinsulensis	Rusty Snaketail	X			X		
	Progomphus obscurus	Common Sanddragon				X		
	Stylurus spiniceps	Arrow Clubtail		X				
Libelludidae	*Neurocordulia obsoleta*	Umber Shadowdragon	X					

Table 7. Preferred habitat characteristics and predictor variables for Virginia spiraea identified in published research (Ogle 1991a,b; Weakely et al. 2012; Rossell et al. 2013; Horton et al. 2015).

Citation	Habitat Characteristics
Horton et al. (2015)	Small substrate: <54% of the substrate is <65mm
	Visible sky: 0.22
	Herbaceous cover: <50%
	Non-Virginia spiraea shrub density: >2.2 stems/m^2
	Vine cover: <25%
Ogle (1991a,b)	Scoured banks in high-gradient 2nd–3rd order systems
	Braided stream features
	Point bars
	Meander scrolls
	Disturbed right-of-ways
	Natural levees
	Floodplains
	Driftwood jams
Weakley et al. (2012)	Riverbanks and bars, often in gorges, that are rocky and frequently flood-scoured
Rossell et al. (2013)	Habitat characterized by periodic flooding
	2nd–3rd order streams
	Flood-scoured areas along high-gradient reaches
	Rock crevices along riverbanks, loose riverborne deposits along bars and shore

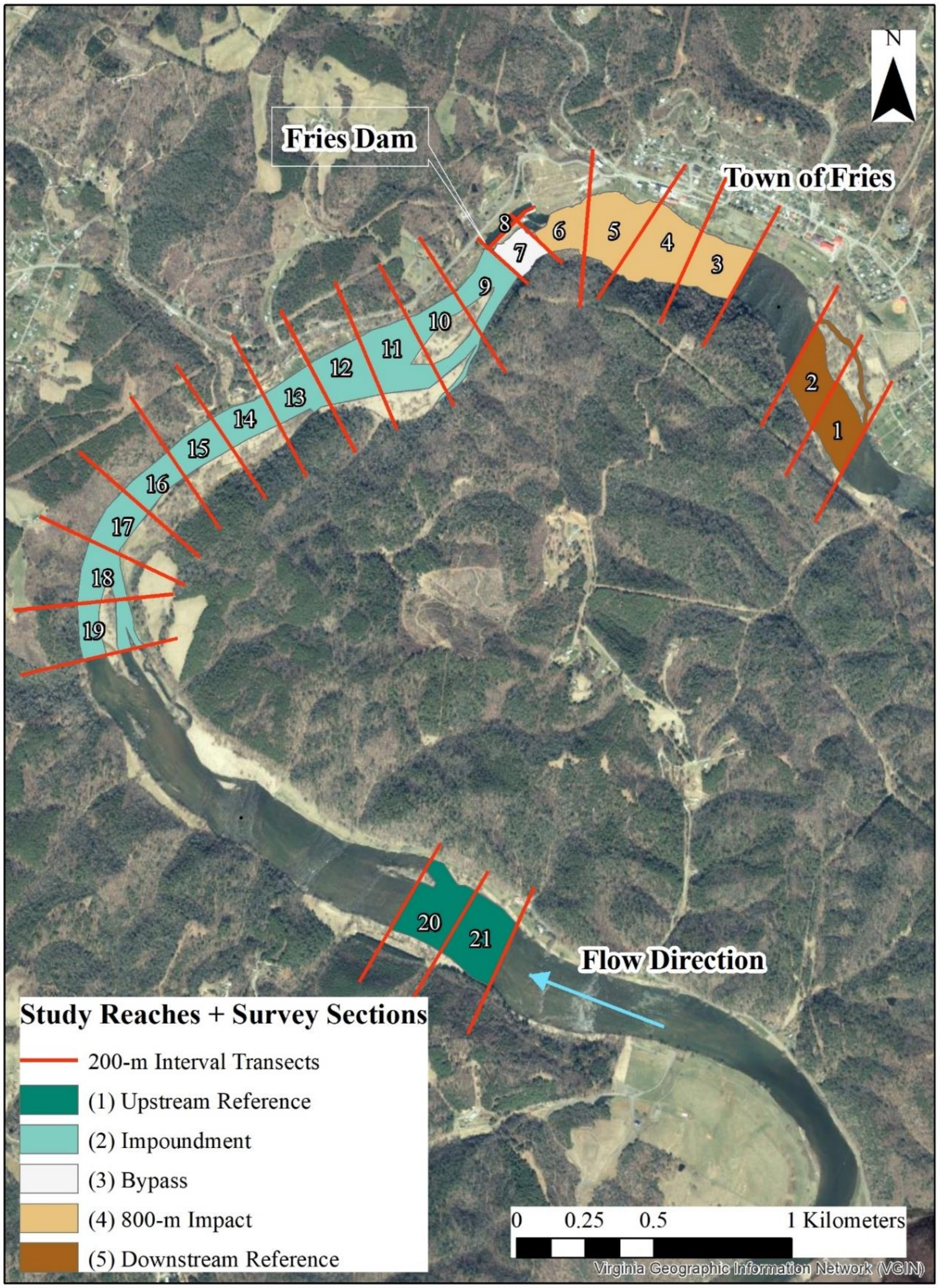

Figure 1. Study Reaches (5) and survey Sections (21) within the upper New River, Grayson County, Fries, Virginia, 2016–2017.

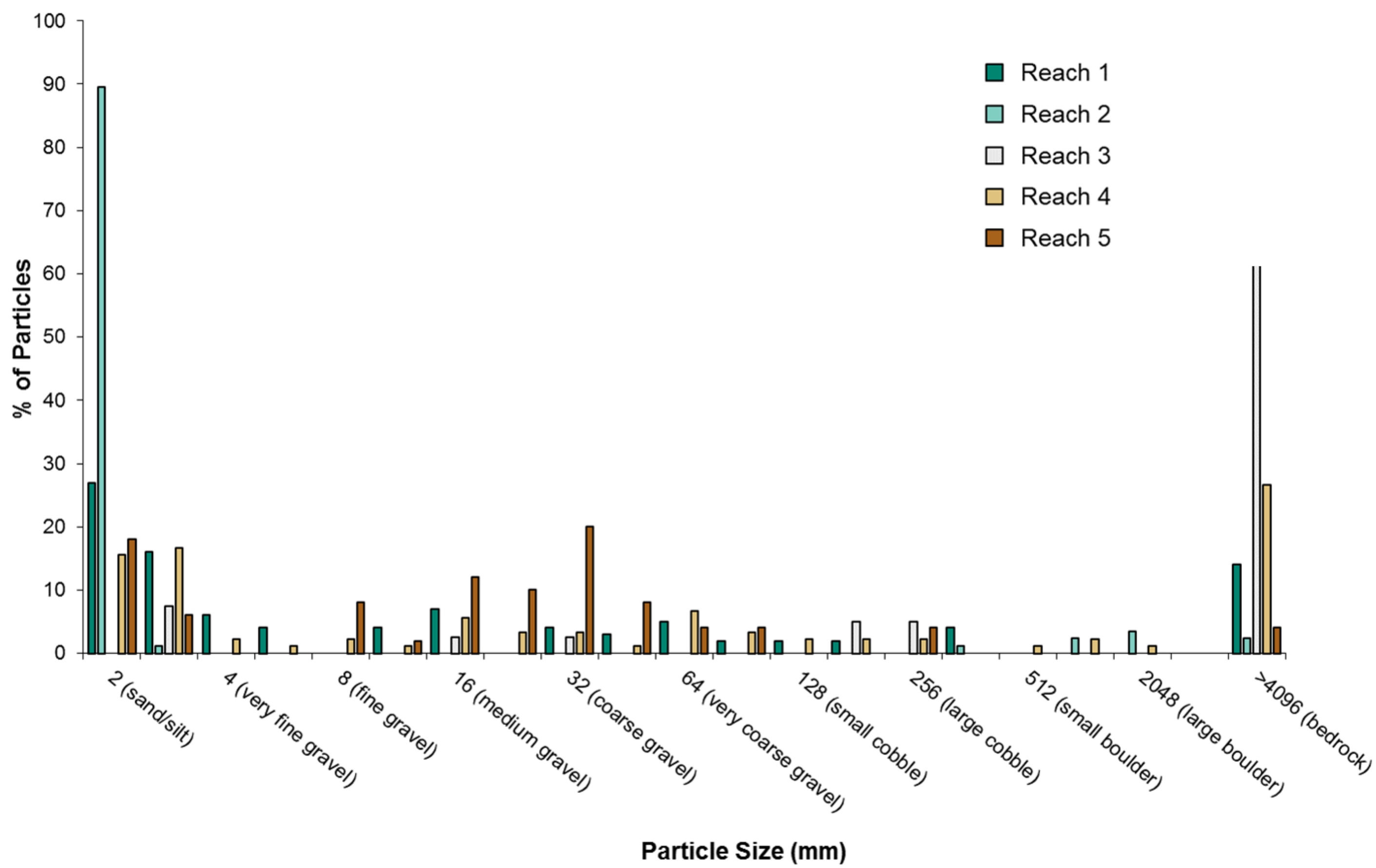

Figure 2. Particle-size frequency distribution histogram for Study Reaches surrounding the Project, Grayson County, Virginia, 2016–2017. Note that the histogram for Reach 5 represents the main stem particle-size frequency.

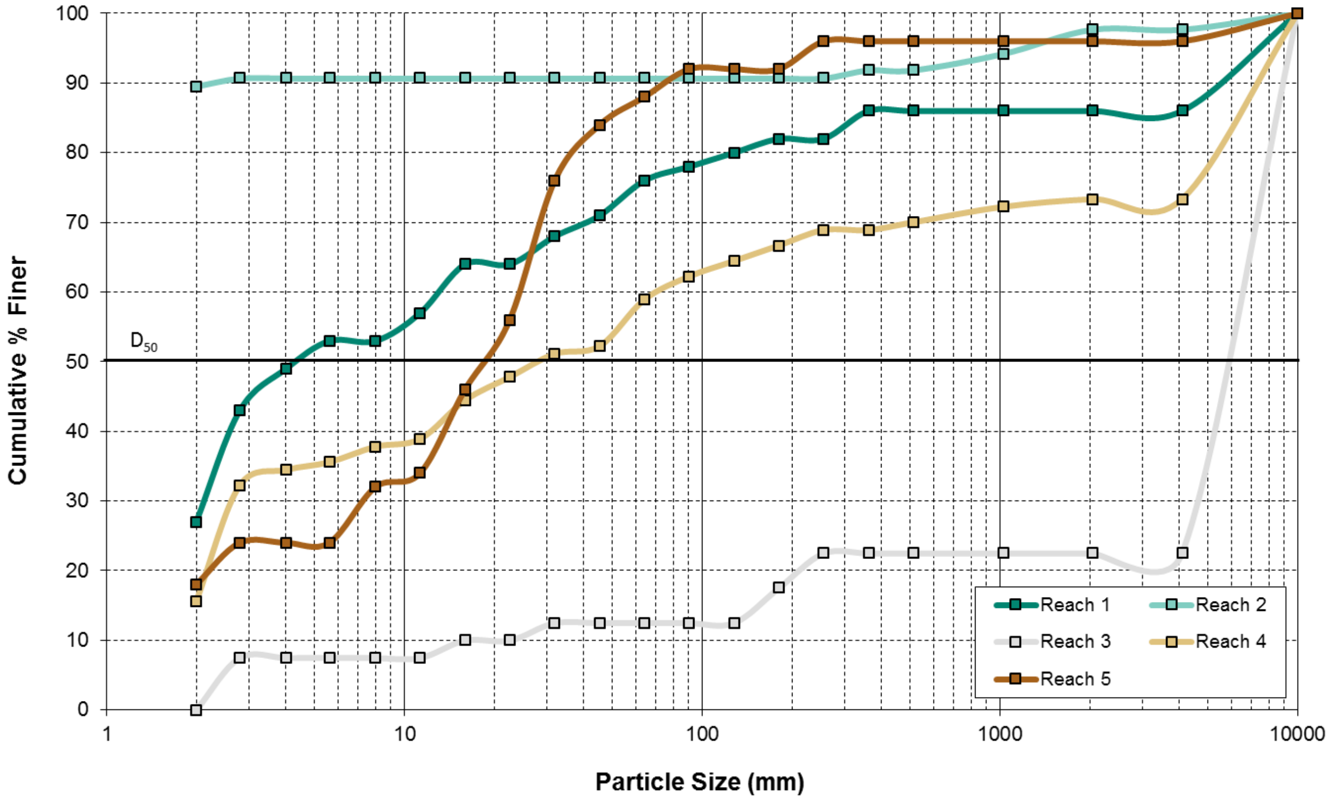

Figure 3. Particle-size cumulative distribution curves for Study Reaches surrounding the Project, Grayson County, Virginia, 2016–2017. Note that the curve for Reach 5 represents the main stem particle-size distribution.

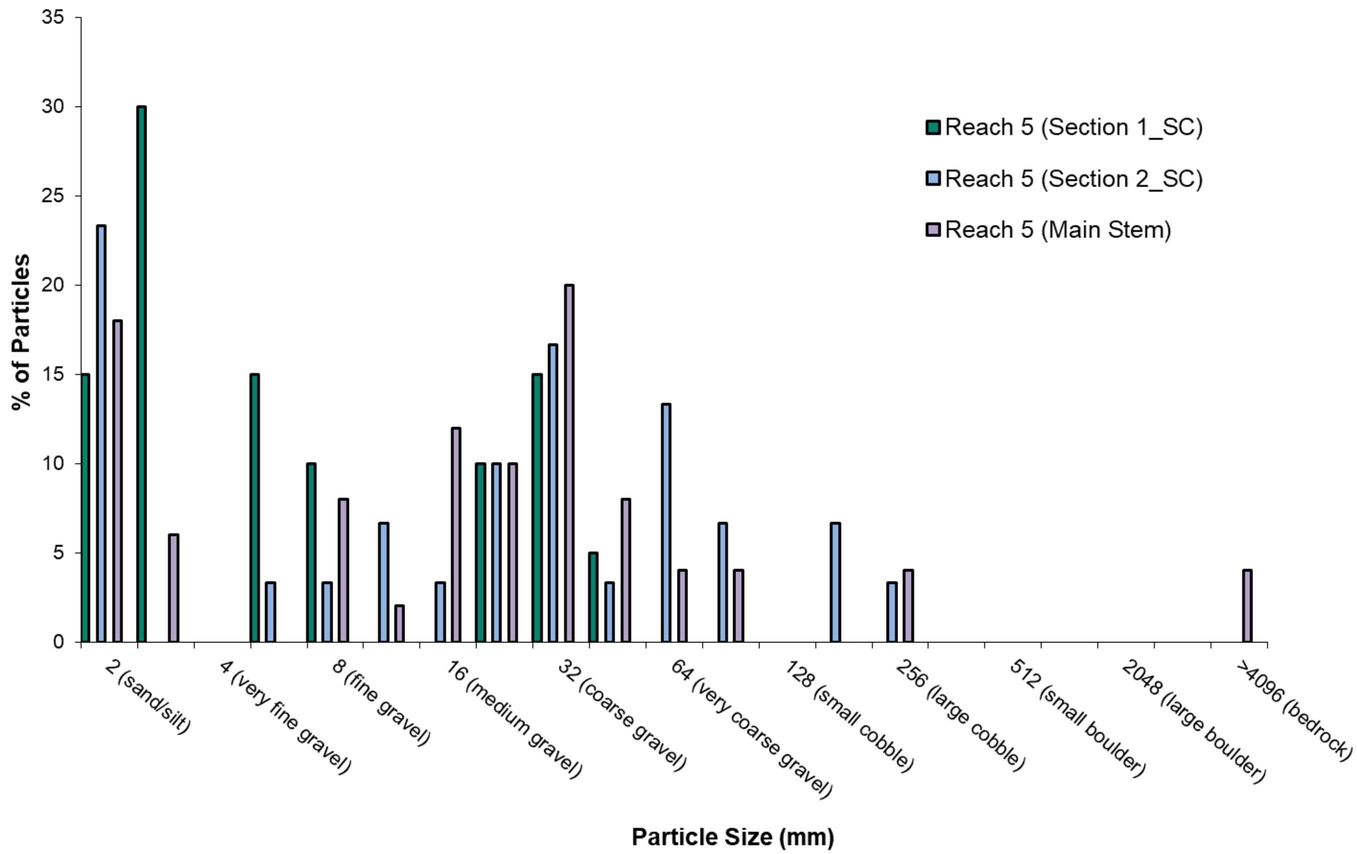

Figure 4. Particle-size histogram for downstream reference Reach 5 mainstem and lower and upper side-channel Sections (1, 2), Grayson County, Virginia, 2016–2017.

Late Spring | Mid-summer

Figure 5a. Photo depicting the temporal change in submerged aquatic vegetation (SAV) cover in upstream reference Reach 1 along the RDB. Photo taken in Section 21, facing upstream, in late spring and mid-summer 2016.

Figure 5b. Upstream reference Reach 1. Photo taken along right-descending bank, facing downstream through the side channel.

Figure 6. Habitat photos taken above the dam in the impoundment, Study Reach 2.

Figure 7. Habitat photos of the bypassed Reach 3.

Figure 8. Habitat photos of the 800-m impact Reach 4.

Figure 9. Habitat photos of the downstream reference Reach 5, mainstem.

Figure 10. Habitat photos of the downstream reference Reach 5, side channel.

Figure 11. Comparison photos of habitat conditions taken along the left-descending bank facing downstream, near the boat ramp below the Project (Reach 4), on the mornings of July 29th, 2016 and July 12th, 2017.

Figure 12. Increased sediment deposition observed downstream of the dam following July 12th, 2017 no flow event. Photo taken approximately 1 km downstream of dam, upstream of the island separating the mainstem from the side channel (Reach 5).

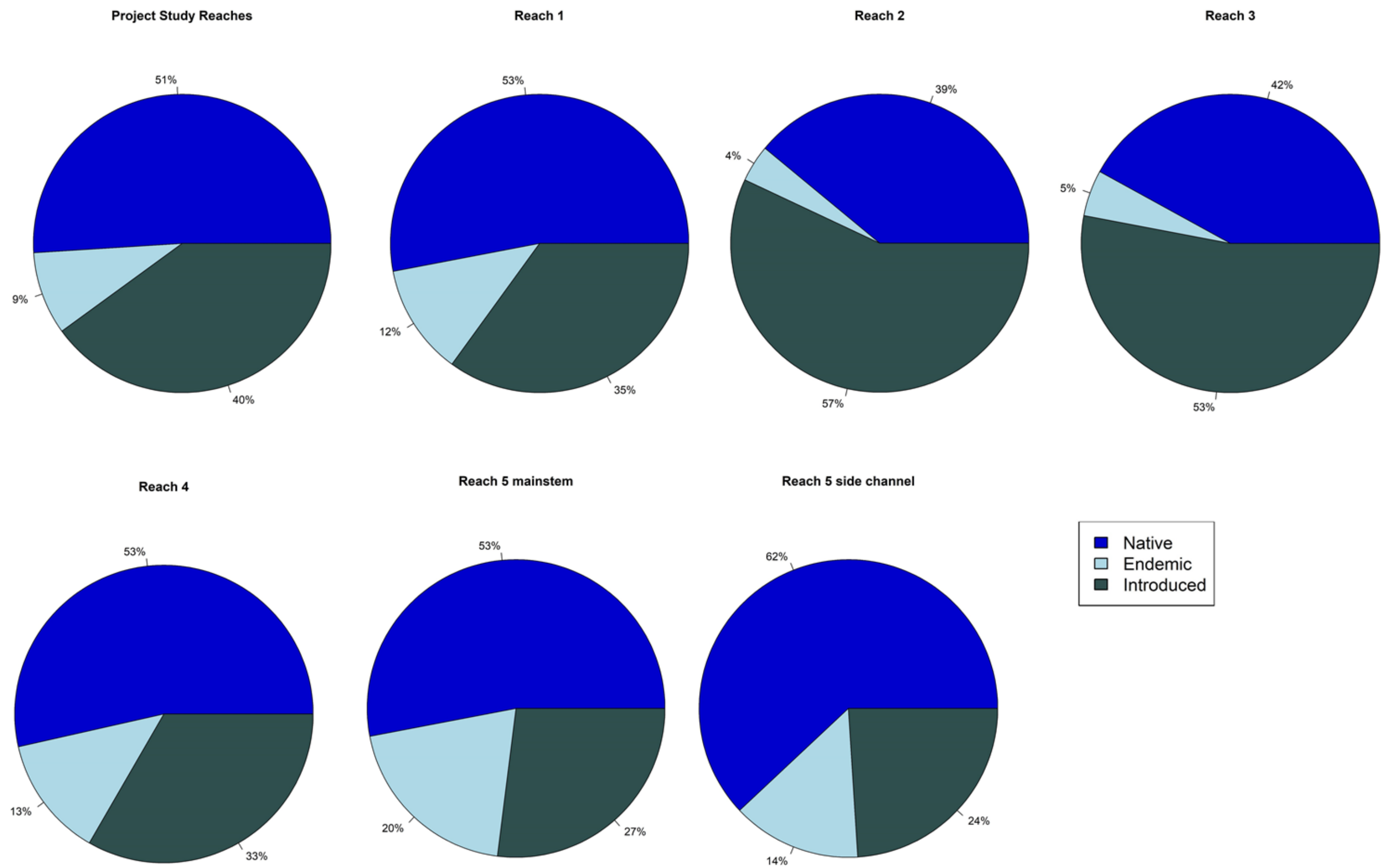

Figure 13. Composition (%) of species by biogeographic origin within Study Reaches 1–5 and collectively across Project Study Reaches. Origin based on Jenkins and Burkhead (1994).

Figures 14. Several fish species (top to bottom: Margined Madtom, Rosyface Shiner, Smallmouth Bass) collected within the upstream reference Reach 1, Grayson County, Fries, Virginia 2016–2017.

Figures 15. Several fish species (clockwise from top left: Black Crappie, White Sucker, Common Carp, Redbreast Sunfish) collected within the impounded Reach 2, Grayson County, Fries, Virginia 2016–2017.

Figures 16. Several fish species (clockwise from top left: Flathead Catfish, Yellow Perch, Walleye) collected within the bypassed Reach 3, Grayson County, Fries, Virginia 2016–2017.

Figures 17. Several fish species (clockwise from top left: Sharpnose Darter, Kanawha Minnow, Logperch) collected within the 800-m impact Reach 4, Grayson County, Fries, Virginia 2016–2017.

Figures 18. Several fish species (top to bottom: Appalachia Darter, Bigmouth Chub, Mimic Shiner) collected within the downstream reference Reach 5 mainstem, Grayson County, Fries, Virginia 2016–2017.

Figures 19. Several fish species (clockwise from top left: Silver Shiner, Whitetail Shiner, Channel Catfish) collected within the downstream reference Reach 5 side channel, Grayson County, Fries, Virginia 2016–2017.

Figure 20. Bigmouth Chub mounds (red arrows in top image) found in the upstream reference Reach 1.

Figure 21. Green floater collected in the upstream reference Reach 1, Grayson County, Fries, Virginia 2016–2017.

Figure 22. Purple wartyback collected in the downstream reference Reach 5, Grayson County, Fries, Virginia 2016–2017.

Figure 23. Spiny stream crayfish collected in the 800-m impact Reach 4, Grayson County, Fries, Virginia 2016–2017.

Figure 24. Pygmy snaketail nymph collected in the upstream reference Reach 1, Grayson County, Fries, Virginia 2016–2017.

Figure 25. Eastern hellbender collected in Fries impoundment (Study Reach 2) of the Upper New River mainstem, Grayson County, Virginia, 2018.