Stantec Consulting Services Inc.
1011 Boulder Springs Drive, Suite 225, Richmond, VA 23225

January 27, 2020
File: 203401138

Attention: Stuart Tyler
Mr. Stuart Tyler
Parsons
2101 Wilson Boulevard, Suite 900
Arlington, Virginia 22201

Dear Mr. Tyler,

Reference: Route 28 Environmental Assessment Support Services, Supplement 1 -Threatened and Endangered Species Survey

Per your request, Stantec Consulting Services Inc. (Stantec) coordinated surveys for the federally and state endangered dwarf wedgemussel (*Alasmidonta heterodon*) and harperella (*Ptilimnium nodosum*), and the state endangered brook floater (*Alasmidonta varicosa*) on the above-referenced project. Stantec also conducted an assessment of three bridges that occur within the project to determine if bats are utilizing the bridges as day and/or night roosts. The project area consists of three (3) current alternatives, designated as 2A, 2B, and 4, associated with the proposed improvements in the Route 28 corridor between Sudley Road (Business Route 234) in Prince William County and Compton Road (Route 658) in Fairfax County, all located within the Bull Run drainage basin (Figures 1 & 2). The study limits associated with these project corridors were established during the Route 28 Corridor Feasibility Study completed in 2018 in support of the Environmental Assessment (EA) for the project. The following sections discuss the methods and results of each survey.

Mussels

Mussel surveys for the dwarf wedgemussel and brook floater were conducted from September 19 to 21, 2019, with additional assessments and brief surveys being conducted on the morning of September 24, 2019. Surveys were conducted by Brett J. K. Ostby and Braven B. Beaty (Daguna Consulting), both of whom are listed as approved mussel surveyors in Virginia by the U.S. Fish and Wildlife Service (USFWS). All surveys were conducted utilizing “abbreviated survey” protocols, as defined within the Virginia Department of Game and Inland Fisheries (VDGIF) Freshwater Mussel Guidelines for Virginia (Last Updated: 6-22-15). A series of surveys were conducted extending from 400 meters (m) downstream to 100 m upstream of potential project footprints where suitable habitat was present. These surveys covered 2200 m of Bull Run, 100 m of Cub Run, 3900 m of Flat Branch, and 500 m of the Upper Occoquan Service Authority (UOSA) impoundment tailwater. Smaller perennial tributaries to Flat Branch were assessed as well.

No listed mussels were detected during the survey. A total of four (4) live native mussel species (*Elliptio lanceolata*; *Elliptio fisheriana*; *Strophitus undulata*; and *Utterbackia imbecillis)* and the shell of one other native species (*Alasmidonta undulata*) were identified. An additional shell of a species not native to the Atlantic slope (*Pyganadon grandis*) was also identified and likely was displaced from the UOSA

impoundment upstream of the site. The invasive Asian clam (*Corbicula fluminea*) was present in the majority of stream reaches, in large numbers at certain locations. Further details on the study are included in the mussel survey report prepared by Daguna Consulting, included in Appendix A. Per USFWS and VDGIF guidelines, mussel surveys are valid for a period of two (2) years.

Harperella

Surveys for harperella were conducted on September 18, 2019, within the optimal survey timeframe established by USFWS (July 1 – September 30 in periods of low water). The field work was conducted by Garrie Rouse (Rouse Environmental Services), a botanist recognized by the USFWS as qualified to conduct surveys for the target plant. Surveys were conducted within areas of suitable habitat previously determined by Stantec in 2018[1]. Water levels at the time of the survey were suitable to detect the presence of the plant.

No populations of harperella were observed within the study area during the survey. Further details on the survey are included in the report prepared by Rouse Environmental Services, included in Appendix B. Due to equipment damaged during the survey, no photos are included in the attached report. Per USFWS guidelines, harperella surveys are required annually.

Bridge Surveys

Stantec conducted a bridge assessment within the Route 28 project area for signs of use by bats as day and/or night roosts, due to the potential presence of the state and federally threatened Northern long-eared bat (*Myotis septentrionalis*) being identified within the project area. The assessments followed the Federal Transportation Agency/State Department of Transportation (DOT) Preliminary Bat Assessment Guidelines for Bridges/Structures. The guidelines are outlined in Appendix D of the User's Guide for the Range-wide Programmatic Consultation for Indiana Bat and Northern Long-eared Bat (Version 5.0, February 2018). A total of three (3) bridges were assessed on September 28, 2019. Assessments were conducted in the field from accessible points on the ground beneath the bridges and at suitable vantage points with the assistance of binoculars, spotting scopes and spotlights to determine the potential presence of bats utilizing the bridges. Bridges were not inspected from the road for reasons of safety. Bridge 1 is located within the study area at the Route 28 (Centreville Road) crossing of Bull Run. Bridge 2 is located within the study area at the crossing of Route 616 (Ordway Road) over Bull Run. Bridge 3 is located within the study area at the crossing of Lomond Drive over Flat Branch. The location and identification of the bridges is depicted on Figure 2.

The bridge assessment revealed no signs of bats roosting within the three (3) bridges. Bridge 1, constructed in 1980, appears to provide suitable roosting potential for bats. Significant staining was observed on the piers of Bridge 1, but it appears to be related to drainage from the road above through exposed expansion joints. No guano was observed on the piers, beams, abutments or the ground. Piles of crumbled concrete, gravel and debris washed from the road above were observed on most structures of the bridge. Areas that are exposed to the road above and are experiencing runoff provide unsuitable roosts for bats. Discrete areas may be located within the bridge that are not exposed to these conditions, but this could not be ascertained from available vantage points. Though no clear signs of bat roosting were

[1] Threatened and Endangered Species Technical Report. Environmental Documentation for Route 28 Corridor. August 2018.

observed, absence of roosting bats at Bridge 1 cannot be definitively confirmed. Once an alternative has been selected additional survey methods may need to be considered to confirm the presence/absence of bats roosting on the bridge.

Neither Bridge 2 nor 3 appeared to have any signs of use by bats. Actively roosting pigeons, old nests and significant bird droppings were observed at both bridges. Some debris and mouse droppings were present at the abutments of the bridges. Bridge 2 was reconstructed in 2017 and Bridge 3 was constructed in 1998. Both bridges have corrugated steel decking and no exposed expansion joints. Both bridges generally lack suitable characteristics for bat roosting.

Results of the bridge surveys were recorded on the USFWS Bridge/Structure Assessment Form (Revised June 2017) (Appendix C). Representative photographs of the bridges are included in Appendix D. Per USFWS guidelines, bridge assessments are required annually to determine the use of bridges by bats prior to construction activities.

Discussion

Based upon the results of the surveys for threatened and endangered species for the Route 28 EA project, no listed species were confirmed within the study area, or the offsite survey area for mussels. None of the three (3) assessed bridges were found to have signs of actively roosting bats. Based upon the conditions observed at Bridge 1 during the bridge inspection, an inspection of areas not visible from suitable vantage points on the ground and/or an emergence survey is recommended as the project progresses to determine if roosting is occurring. As previously noted, surveys for harperella and the bridge surveys are valid for one (1) year and mussel surveys are valid for two (2) years.

Please let me know if you have any questions about the results of the threatened and endangered species surveys for the Route 28 project.

Regards,

Stantec Consulting Services Inc.

Sean Wender, PWD
Senior Ecologist
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Fax: 804 267 3470
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Attachment: Figure 1, 2
Appendix A, B, C, D

c. Surbhi Ashton, Parsons
Carolyn Keeler, Stantec

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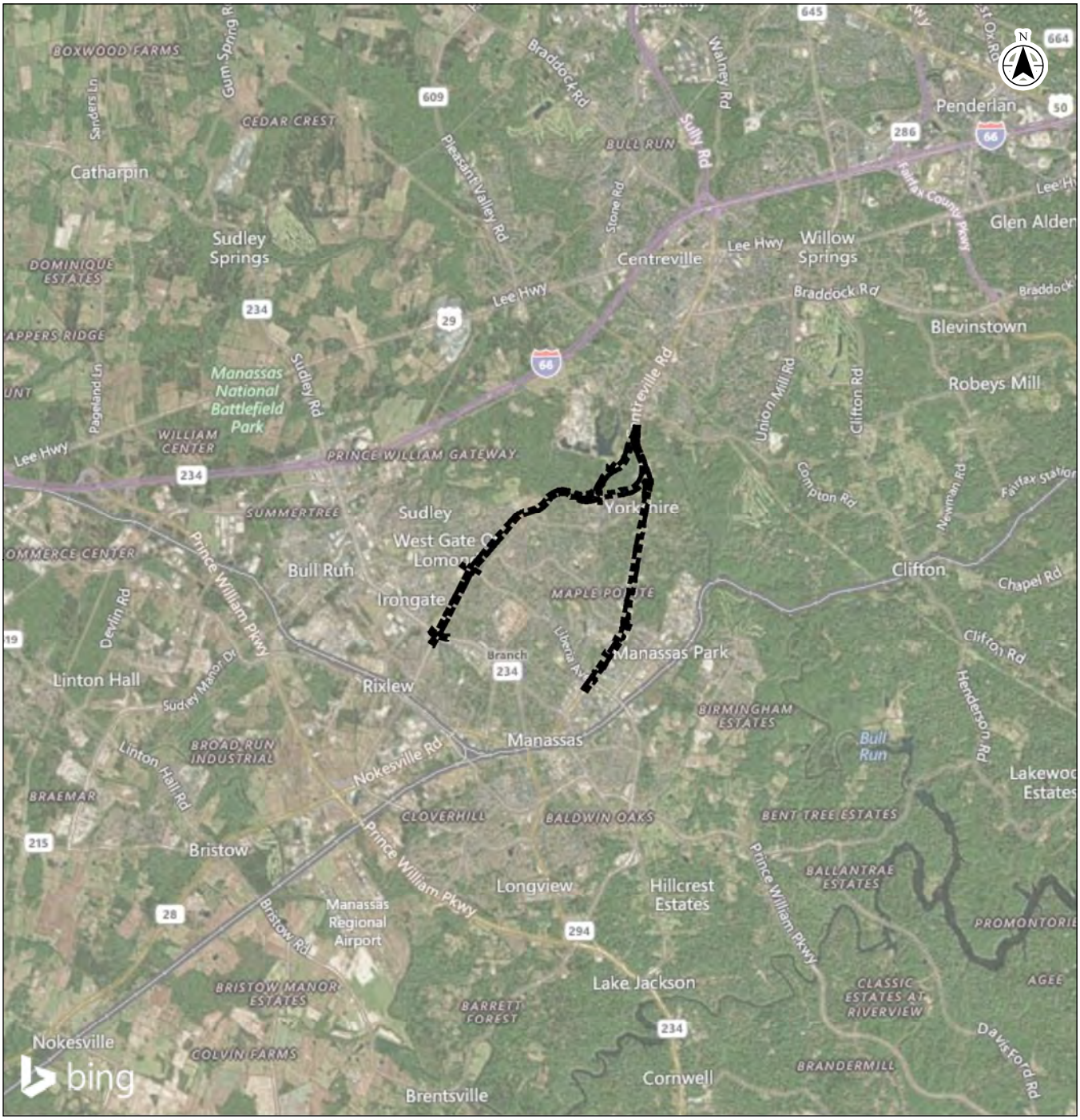
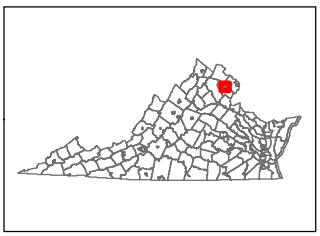
U:\203401138\03_data\gis_cad\gis\01138_e_vic.mxd Revised: 2018-07-20 By: ejlko





Project Limits

0 5,000 10,000 Feet

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Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
2. Project limits provided by Parsons Transportation Group, Inc.
3. Orthoimagery © Bing Maps
4. Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Stantec

Project Location
Fairfax, Prince William, and Manassas Counties and City of Manassas Park, Virginia

203401138
Prepared by ECL on 2018-07-09
Technical Review by TPS on 2018-07-20
Independent Review by JMM on 2018-07-19

Client/Project
Parsons
Route 28 Environmental Assessment

Figure No.
1

Title
Project Vicinity Map

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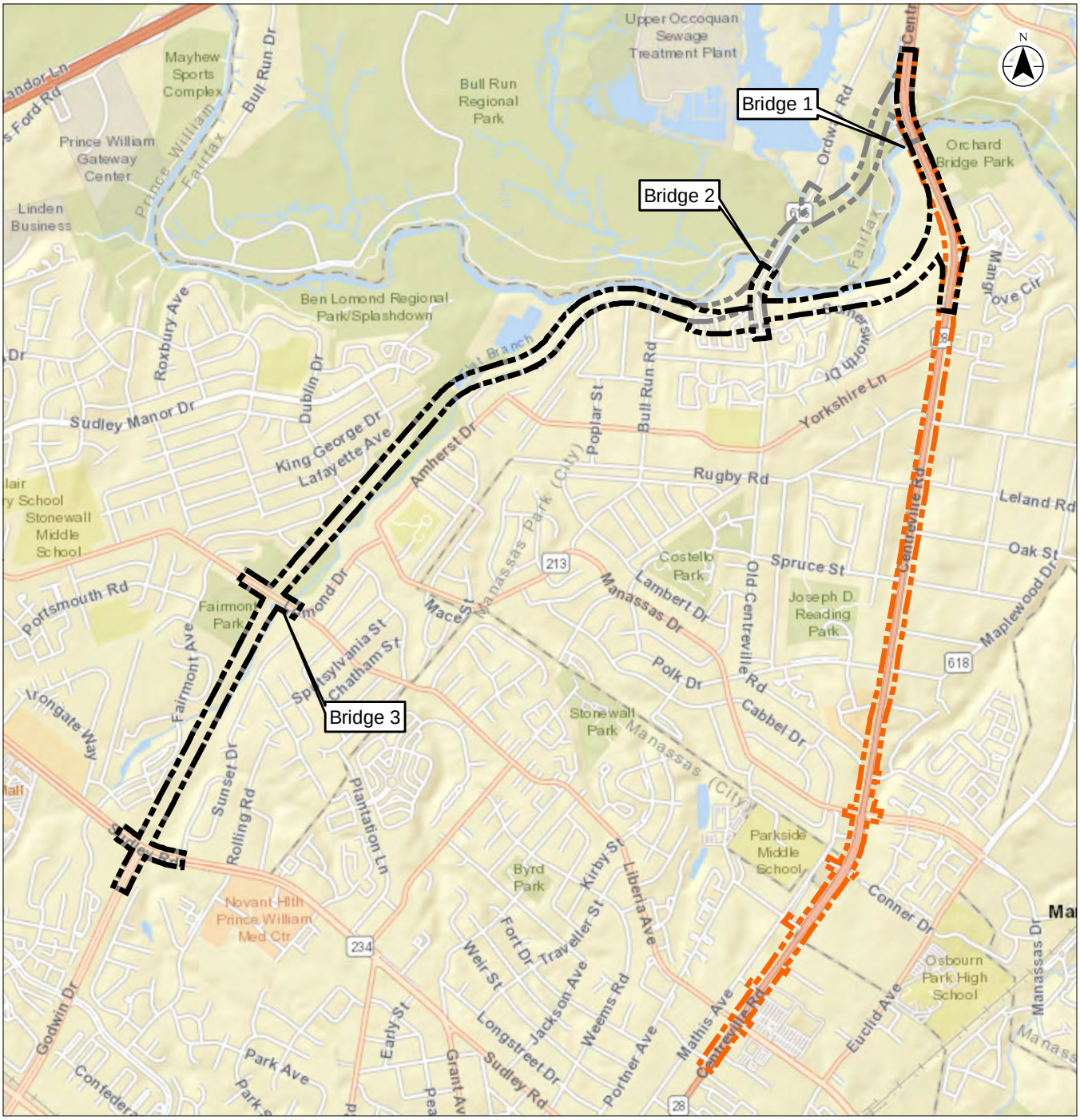

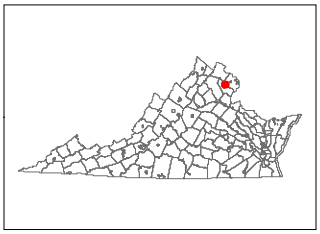

Alternative 2A Limits
Alternative 2B Limits
Alternative 4 Limits

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1:31,200 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 StatePlane Virginia North FIPS 4501 Feet
2. Project limits provided by Parsons Transportation Group, Inc.
3. Orthoimagery © ESRI

Stantec

Project Location
Fairfax, Prince William, and Manassas Counties and City of Manassas Park, Virginia

203401138
Prepared by MGS on 2019-11-26
Technical Review by TPS on 2019-11-26
Independent Review by SMW on 2019-11-26

Client/Project
Parsons
Route 28 Environmental Assessment

Figure No.
2

Title
Bridge Assessment Map

APPENDIX A
MUSSEL SURVEY REPORT
DAGUNA CONSULTING

FINAL REPORT

Survey for Protected Mollusks in Bull Run and Its Tributaries along the Proposed Alternative Routes of Virginia Highway 28

by

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for

Stantec
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October 27th, 2019
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INTRODUCTION

The Prince William County Department of Transportation (PWC DOT), in coordination with the Virginia Department of Transportation (VDOT) and the Federal Highway Administration (FHWA), has prepared an Environmental Assessment (EA) to evaluate the potential social, economic, and environmental effects associated with proposed improvements in the Virginia Route 28 corridor between Sudley Road in Prince William County and Compton Road in Fairfax County. The EA evaluated three alternatives developed in the December 2017 Route 28 Corridor Feasibility Study—a long-term corridor feasibility study funded by the Northern Virginia Transportation Authority (NVTA)—to address the issues along the corridor. The three alternative routes (2A, 2B and 4) proposed for VA Rte 28 in Prince William and Fairfax Counties would cross or parallel Bull Run and its tributaries.

Two mussel species were identified in the VA Rte 28 Threatened and Endangered Species Technical Report prepared by Stantec (November 2018) as potentially occurring within the project area; the state and federally endangered Dwarf Wedgemussel (*Alasmidonta heterodon*) and state-endangered Brook Floater (*Alasmidonta varicosa*). These species were identified through a search of the U.S. Fish and Wildlife Service's (USFWS) Information for Planning and Consultation database (IPaC) and the Virginia Department of Game and Inland Fisheries (VDGIF) Virginia Fish and Wildlife Information Service database (VaFWIS). Potential habitat was identified by Stantec for both species within streams in the project area including Bull Run and Flat Branch.

Because the federally listed species *A. heterodon* and state-listed species *A. varicosa* were identified as potentially occurring within the study area, we, Daguna Consulting, LLC were contracted to conducted a series of "Abbreviated Surveys" extending from 400 meters (m) downstream to 100 m upstream of potential project footprints. These surveys covered 2200 m of Bull Run, 100 m of Cub Run, 3900 m of Flat Branch, and 500 m of the Upper Occoquan Service Authority (UOSA) impoundment tailwater (Figure 1 and Table 1). The primary goal of the "Abbreviated Surveys" were to detect the presence or absence of protected freshwater mussels. Smaller tributaries to Flat Branch were assessed to determine whether suitable habitat for mussels was present.

METHODS

Brett J. K. Ostby and Braven B. Beaty conducted surveys and assessments from September 19th through the 21st, 2019, with additional assessments and brief surveys being conducted on the morning of September 24th, 2019. We used mask and snorkel and water scopes to aid visual searches of the streambed. However, we mostly used water scopes and unaided visual inspection due to safety concerns (discussed in the Results section). All stream reaches were surveyed unless the habitat was deemed "unsuitable" for mussels based on the site visit. The "unsuitability" of any stream reach(es) as habitat for mussels was fully documented. Stream banks and exposed shoals were surveyed for mussel shells. If present, we searched muskrat/raccoon middens. Surveys were conducted when water level and clarity were suitable to locate shells and live individuals with ease. Sufficient effort was expended to visually inspect all suitable habitat so that we could state with reasonable confidence that endangered and/or threatened species do or do not occur in the reach sampled. Representative

specimens of each species detected were photographed. Dead shell material was retained for confirmation.

Geographical Information System (GIS) programs and Geographic Positioning System (GPS) devices were used to georeference the boundaries of surveys, location of protected species, and location of other pertinent features. We provided a list of latitudes and longitudes for all georeferenced points in Table 1. We listed survey reaches and assessments in order from downstream to upstream. These numbers did not match the order in which they were visited. Figures also followed this order, so many not match the order in which they are addressed in the Results section.

RESULTS

Weather and Stream Conditions

Weather was ideal for conducting surveys on all days we were onsite. Skies were clear and air temperature was seasonally warm (Table 2). No gage data was available for Bull Run or its tributaries; however, the nearby gage on Cedar Run, USGS 01656000 near Catlett, VA, approximately 19 km away and within the Occoquan watershed, was one third of median flow for mid-September. The surrounding landscape was dry. Both observations suggested streams were at baseflow. The singular exception was the stream flowing out of the UOSA impoundment, which had high and warm flow. All flowing streams had exceptionally clear water, with the streambed visible to all depths from the surface where flow was laminar. Some areas with stagnant flow had clarity issues. Specific conditions limiting surveys are listed for warrant reaches.

Surrounding Land Cover and Land Use

The surveyed reach of Bull Run and its tributaries flowed through suburban Prince William and Fairfax Counties (Figures 2-9). Surrounding lands were mostly residential and commercial to the south and predominantly forested parkland to the north. All of Bull Run was buffered by at least 20 m of mostly contiguous forest, interrupted only by 2 road crossings (VA Routes 28 and 616) and 1 powerline crossing. To the north, forested buffers were contiguous with parklands that were a mix of open greenspaces and forest. Flat Branch flowed through a utility corridor that was a mix of grasslands, shrub and forest. Parts of the corridor were bound by levees, and some surrounding neighborhoods to the east may have been built on wetlands. This corridor was 50 to 200 m wide and a de facto park. It was surrounded by moderately dense residential neighborhoods and some developed parklands. Major impacts included storm drains and impervious surfaces in the Bull Run drainage and a wastewater treatment outfall emptying via the UOSA tailwater. Human refuse was observed along the banks and in streams themselves.

Survey Reach 1: Bull Run

Survey Reach 1 of Bull Run extended from 400 m downstream to 100 m upstream of the existing VA Rte 28 bridge (see Figures 2-3). Alternatives 2A and 4 would impact this reach. This reach had a bankfull width of 25 to 30 m. Due to low flows, water only covered 70-80% of the bankfull width downstream of the bridge, leaving extensive point bars exposed (Figure 10). Side channels visible from aerial images were dry during the September 20th survey. Bankfull height was typically 2 m but tended to be higher and less stable near the bridge. The reach was 2% rapid, 8% riffle, 60% run, and

30% pool habitat. It had a diverse streambed that was 5% exposed bedrock, 10% boulder, 20% cobble, 25% gravel, 30% sand, and 10% silt. Most of the streambed was stable and good habitat for mussels (Figure 11). Except in the rapid, larger particles tended to be moderately to heavily embedded by small particles, leaving little habitat for aquatic insects. Downstream of the bridge, most habitats were less than 0.5 m deep, with a maximum depth of 1.6 m. Upstream of a boulder rapid at the bridge, tbere was pool habitat, mostly greater than 1 m deep (Figure 12). Large woody debris was common throughout the surveyed reach, contributing to habitat complexity.

Table 3 listed the results of survey efforts, including catch-per-unit effort as live mussels observed by hour. *Elliptio complanata* were scattered throughout the reach from the rapid downstream (Figure 13). We also detected *E. fisheriana* (Figure 14) and *S. undulata* live (Figure 15). *Alasmidonta undulata* was only represented by a singular pair of valves collected below the rapid (Figure 16). We detected no mussel upstream of the rapid. We observed bullhead, channel catfish, madtoms, darters, largemouth bass and small mouth bass in Reach 1. Fish densities were moderate. We found caddisflies and mayflies on larger substrate particles, though densities were lower than expected. The native snail *Pleurocera* (=*Elimia*) *virginica* was common. We observed 2 invasive mollusk species in the reach. The Chinese Mystery Snail (*Cipangopaludina chinensis malleata*) was present but uncommon (Figure 17). The Asian Clam (*Corbicula fluminea*) was abundant throughout (Figure 18).

Survey Reach 2: Bull Run

Survey Reach 2 of Bull Run started 500 m downstream of the existing VA Rte 616 bridge (Figures 2-3). Alternative 2 A and B would impact this reach. This reach was vastly different downstream of the bridge compared to upstream. We divided the description of this reach accordingly. To access the downstream reach, we walked along a powerline corridor from an apartment building parking lot located to the south of the bridge. The area where the powerline corridor met the stream was an itinerant campsite. This area was also an unmaintained access point for fishing and other activities. There was a lean-to and tent in the area, trash piles were common, and there was evidence of untreated human sewage (Figures 19-20). For safety reasons we did not use mask and snorkels in this reach. The 400 m reach downstream of the bridge was 10% low-gradient riffle, 60% run, and 30% pool. The streambed was not as stable as observed downstream in Reach 1, as evidenced by our feet sinking into gravel shoals downstream of the Rte 616 bridge (Figure 21). The streambed was 5% bed, 5% boulder, 10% cobble, 50% gravel, 15% sand, and 15% silt in the 400 m reach downstream of the bridge. A considerable proportion of the gravel-sized particle category that dominated the streambed material was live *C. fluminea* and shell material, which may have accounted for our feet sinking into the shoals. This invasive species was the top layer of the streambed in depositional areas, including a mussel bed (Figures 22 and 23). In over 20 years of sampling streams in Virginia, we have never observed such high densities of this species. We estimated density to be greater than 1,000 m^{-2} in many habitats downstream of the bridge.

As previously mentioned, this reach supported a mussel bed. It was located along the left ascending (south) bank of Bull Run some 150 m downstream of the bridge (see Table 2 for boundaries). This mussel bed was occupied by 4 species (Figure 24), including *Utterbackia imbecillis* (Figure 25). Almost all mussels detected in Reach 2 were found in this area. Specimens in the mussel bed

demonstrated faster growth and larger size then observed elsewhere in Bull Run (see Figure 24). Several *E. complanata* with 5-6 annuli were around 90 mm. Average size for *E. complanata* downstream of the bridge in Reach 2 was 120 mm (SD = 16.2) with the largest being 144 mm. The mussel bed habitat was composed of depositional material including small gravel, sand, silt and *C. fluminea* (see Figure 23). This depositional material appeared to have buried the boulder and cobble that may have comprised the historical streambed. The bed was also at the mouth of an unnamed tributary gully feeding Bull Run from the south. The single most important factor influencing the biota of Reach 2, including the mussel bed, was the tailwater of the Upper Occoquan Service Authority polishing impoundment. This tailwater contributed approximately a third of the flow volume to Bull Run, entering from the north, just downstream of the bridge. The tailwater also changed the water temperature of Bull Run. Temperature rose 3°C from downstream to upstream of its mouth (see Table 2). This tailwater entered Bull Run on the opposite side of the channel, but because of gravel bars in the area, its flow power likely dissipated in the mussel bed along the opposite bank. The Chinese Mystery Snail (*Cipangopaludina chinensis malleata*) was common and *C. fluminea* excessively abundant downstream of the bridge and UOSA tailwater.

Upstream of the UOSA tailwater and Rte 616 bridge, *C. fluminea* were uncommon and *C. c. malleata* were absent. The 100 m of Bull Run upstream of the bridge was pool habitat with a streambed that was 60% bedrock (Figure 30). Other particles comprising the streambed were boulder (composing 5%), cobble (10%), gravel (10%), sand (10%), and silt (5%). Maximum depth reached 2 m. No mussels were detected in the 100 m reach upstream of the bridge.

Survey Reach 3: UOSA Tailwater

We surveyed an approximately 500 m reach of the UOSA tailwater extending from its mouth to upstream of the Rte 616 culvert crossing (see Figures 2 and 3). Proposed Route 2B would cross and border this stream. Survey efforts were mostly focused on the reach extending from its mouth to the current Rte 616 crossing (September 21st). We conducted a brief search of the area upstream of Rte 616 on September 24th. Surveying this tailwater was difficult due to the high volume of flow exiting the UOSA impoundment (Figure 26). For most of its length, flow was confined to a well-defined rectangular channel that was 5-6 m wide. Flow was almost always bank-to-bank and banks were steep and stable, being usually 1 m above the water surface. Flow depth was usually 0.4 m or shallower. The channel ran straight from the UOSA impoundment to the Rte 616 culvert, then turned sharply to parallel 616. Flow was mostly turbulent over a stream bed that was 20% exposed bedrock, 50% gravel, 15% sand and 15% *C. fluminea* (live and shell, Figure 27). This stream was 70% riffle, 25% run and 5% glide (Figure 28). The singular exception to fast flow habitats in a rectangular channel was a deep, wide plunge pool downstream of the culvert, which comprised 5% of the reach (Figure 29). At 23°C, water temperature in the tailwater was warmer than observed in Bull Run. We frequently encountered large shells of *E. complanata* but found none live. We detected a single Giant Floater (*Pyganodon grandis*) shell near the tailwater mouth. Both *C. fluminea* and *C. c. malleata* were abundant in the tailwater, the former so much so that it was a significant proportion of the streambed itself (see Figure 27).

Survey Reach 4: Bull Run

Survey Reach 4 of Bull Run was a 1,200 m reach extending from 100 m upstream of the VA Rte 616 bridge to 100 m upstream of the Flat Branch confluence (see Figures 4 and 5). Proposed Routes 2A and 2B would border this reach of Bull Run. Cub Run entered Reach 3 approximately 320 m downstream of Flat Branch and contributed 20% of the flow to Bull Run from there downstream. The stream morphology of Bull Run changed at the Cub Run confluence.

From the survey reach start point (upstream of the Rte 616 bridge) to a bend in the channel where a gravel bar had formed (approximately 200 m upstream of the bridge), Bull Run was a sluggish pool (Figure 30). Maximum depth was 2 m, with most of the pool 1 m or deeper. From that gravel bar, upstream to a riffle approximately 550 m from the bridge, Bull Run was run habitat at most 1 m deep. Bankfull width was 18 m with wetted width usually 90% of bankfull width. This reach was isolated from the floodplain with the water surface usually 2 m below steep banks. Several banks exhibited signs of recent erosion (Figure 31). As much as 50% of the streambed was exposed bedrock from the bridge to the first riffle. This bedrock had fragmented in some areas forming slab rocks that would fit into the small boulder particle size category. Otherwise, smaller substrate particles (gravel, sand and silt) were mostly located within 2-3 m of each bank. A few *E. complanata* were observed in this reach, none of which were within the first 200 m upstream of the Rte 616 bridge where Bull Run was mostly pool.

The first riffle in an approximately 550 m reach of Bull Run was located at 38.79554, -77.46223. The next riffle was at the mouth of Cub Run, approximately 350 m upstream. The habitat between these riffles was considerably different from areas upstream and downstream. Here Bull Run was shallower, with flows usually 0.3 to 0.5 m deep and 20% of the streambed exposed (Figure 32). This reach had a bankfull width of 20 m. The streambed was an equal mix of cobble, gravel, sand and exposed bedrock. Slab rocks, cleaved from bedrock, were also noted. We flipped some of these slab rocks to search for mussels. This habitat supported more mussels than observed elsewhere in Reach 4. None were found under slab rock.

From Cub Run upstream, the stream morphology changed. Here Bull Run meandered with point bars and riffles at expected frequencies (Figure 33). This reach was 15-20 m wide with a wetted width generally 50-75% of the channel width at point bars. Lower banks had formed within the wider channel and were most noticeable as high points on exposed point bars. Mussels were rare in this area.

The upstream-most 100 m of the survey reach was mostly pool habitat that transitioned into a riffle at the survey end point. A few mussels were found in the riffle at the survey endpoint.

Overall, *E. complanata* was rare in Reach 4. Mean length of *E. complanata* in this reach was 89.3 mm (SD = 15.5) and they exhibited a slower growth rate than observed in Reaches 1 and 2. Figure 34 demonstrates the slower growth of this species. Most *E. complanata* were found downstream of Cub Run along the right ascending (north) margin of the stream. Only 2 *E. fisheriana* and a single *S. undulatus* were found in Reach 4. *Corbicula fluminea* were present but were far less common than

observed downstream in Reaches 1 and 2. Fish were less frequently observed than they were in Reaches 1 and 2.

Survey Reach 5: Cub Run

Cub Run was directly upstream from Alternatives 2A and 2B so it fell within the upstream requirements for surveys. The 100 m reach of Cub Run that we surveyed was geomorphcially active (Figure 35). It may have been in the process of cutting new channels and abandoning others as it worked through the Bull Run floodplain. It was also a deposition zone for a considerable bedload. During recent high flows, some of its flows had been diverted into a longer, now dry channel near its mouth which entered Bull Run 50 m downstream of the currently wetted mouth. Depth varied greatly from bank to bank and the streambed was mostly unstable sand and gravel in the wetted channel of Cub Run. The channel was cluttered with large woody debris. This reach was deeply incised into the Bull Run flood plain, with unstable banks. The singular exception to the habitat description provided above, was a pile of boulders laid atop a sewer line paralleling Bull Run and crossing Cub Creek; this anthropogenic habitat was divergent from all other habitats in Cub Run and reach 4 of Bull Run. We found mussel shells on exposed gravel/sand bars in Cub Run, which suggested mussels were often displaced to this habitat along with bed material. We did not find any live mussels in Cub Run.

Survey Reach 6: Flat Branch

The lower 850 m reach of Flat Branch, which we defined as Reach 6, was confined by substantial levees on each side (see Figures 4 and 5). This reach would be impacted by Routes 2A and 2B. Flat Branch had been straightened and a new channel formed decades earlier (Figure 36). The stream was overly wide at 6 m, no more than 0.3 m deep, and had been scoured by flow or mechanically scraped down to bedrock. Most of the channel remained exposed bedrock, with some cobble and gravel noted. The substratum near its mouth was composed of an unusually uniform gravel particle size. The water was extremely warm; it was 28ºC when we surveyed it around 4 pm on September 21st. This reach was also nutrient enriched. It was only shaded by a few shrubs and had low, stable banks ($\leq$ 0.5 m above the water surface). This area has been maintained as a floodway and not an ecosystem, and thus provided almost no habitat for freshwater mussels. There was evidence that all-terrain vehicles (ATVs) frequently impacted the reach. We found no evidence of freshwater mussels. No *C. fluminea* were noted. Schools of Threadfin Shad (Figure 37) and Green Sunfish were also observed. The survey reach ended at a boulder dam that buried pipelines (Figure 38). We assessed an unnamed stream entering Flat Branch downstream of the boulder dam (Assessment 1) as well.

Assessment 1

We surveyed the downstream reach of this unnamed stream and assessed it from Amherst Drive. From Amherst Drive downstream to Flat Branch, this stream had been straightened and was confined by levees on both sides (Figures 39 and 40). It had little discernable flow when we visited it on September 21st, though it was wetted. The channel was dry upstream of the Amherst Drive culvert crossing when we assessed it on September 24th (Figure 41). This stream did not provide sufficient flow for freshwater mussels.

Survey Reach 7: Flat Branch

This survey reach extended from the pool formed by the rock dam (see Figure 38) to the Lomond Drive crossing (See Figures 6 and 7). This reach would be impacted by Routes 2A and 2B. At the downstream end of this reach there were 2 channels in the corridor of Flat Branch. Both were unnaturally straight and deep. The channel to the west was stagnant for its entire 190 m length. Its surface was covered with thick mats of algae (Figure 42). This habitat was suspected to be anoxic and was not searched. The fluvial channel to the east was impounded for 100 m by the rock dam. This pool was 1.5 m deep at the dam and was also stagnant (Figure 43). Shallow areas of the pool with gravel and sand streambed were searched. In many places, Reach 7 was affected by the urban environment through which it flowed. Refuse and large woody debris clogged flow in some places (Figure 44). Some parts of the channel abutted residential yards. Banks were generally higher and steeper than we observed in survey reaches downstream and upstream. This channel was incised 1.5 to 2 m into the floodplain, so it was relatively isolated from the floodplain given its size. Bankfull width was 4-5 m with wetted width usually reaching bank to bank downstream. Despite being relatively high, most banks were stable, being held in place by tree roots (reference Figure 44). Other areas, as pictured in Figure 45, provided suitable habitat for mussels, with ample gravel and sand into which mussels could easily burrow. This reach was 40% pool, 50% run and 10% riffle. Upstream of the pool, flow in Flat Branch was usually 0.5 m or shallower. The stream bed provided sufficient cobble, gravel and sand for mussels. Stream conditions improved between Assessment 2 and Lomond Drive, where the stream had started to meander, actively working through its floodplain. Here wetted width was narrower where point bars were more frequent.

We observed some fish (minnows, dace, sunfish and largemouth bass) in this reach but found no evidence of freshwater mussels. Fish densities were lower than we would expect for a stream this size. We noted live *C. fluminea*. We also observed crayfish actively crawling in some run habitats.

We assessed 2 apparently perennial tributaries that entered Flat Branch within this reach; Assessment 2 was a stream that entered from the southeast and Assessment 3 was a stream that entered from the west.

Assessment 2

We surveyed the downstream reach of this unnamed stream and assessed it from Lomond Drive. The upstream reach was wetted and 1-2 m wide. Its stream bottom was mostly bedrock. The stream was incised 2m below lawns (Figure 46 and 47). We found no evidence to suggest mussels inhabited the stream. This stream may have once drained a wetland and we found evidence that neighborhoods to the east may have once been a wetland (Figure 48).

Assessment 3

We surveyed an unnamed tributary to Flat Branch that flowed from the west, entering Flat Branch approximately 250 m downstream of the Lomond Drive Bridge. This stream was wetted and 1-2 m wide. This stream had some streambed habitat for mussels and supported fish (Figures 49 and 50). We surveyed the stream up to where it bordered lawns of a residential neighborhood, finding no evidence of mussels.

Survey Reach 8: Flat Branch

This survey reach extended from the Lomond Drive crossing to 100 m upstream of the Rte 234 (Sudley Road) crossing (See Figures 8 and 9). This reach would be affected by proposed routes 2A and 2B. The 1,600 m reach of Flat Branch we surveyed on September 19th had a wide variety of instream habitats; including pools formed by beaver dams (Figure 53), runs with suitable streambed habitat (Figure 54), riffles over anthropogenic boulders (Figure 55), and extremely shallow reaches gliding over exposed bedrock (Figure 56). Flat Branch directly upstream of Lomond Drive had formed at least 2 channels and in some places 3 channels; these channels braided though a corridor of trees, shrubs and grasses, bound by residential neighborhoods (Figure 52). Only a single channel was wetted at a time. Dry channels were often clogged by large woody debris. These channels had remarkably low banks and had likely formed following massive disturbance and establishment of a low-lying floodplain in the corridor (Figure 54 was an example of this more natural channel form). Flat Branch was reverting to a more natural form in a corridor of Reach 8. In general Reach 8 provided the best habitat for mussels and fish observed in the entirety of Flat Branch that we visited. Fish were more common, most notably dace and young largemouth bass. We were able to photograph a habitat where fish had schooled (Figure 59). We found no evidence to suggest that mussels inhabited this reach and *C. fluminea* were rare.

We assessed one stream entering from the west (**Assessment 4**) which was mostly dry, providing no habitat for mussels (Figure 58).

DISCUSSION

We documented live specimens of 4 native mussel species in Bull Run; they were *E. complanata, E. fisheriana, S. undulatus* and *U. imbecillis.* A fifth native species, *A. undulata*, was represented by a single pair of valves. We also detected a large shell of *P. grandis* in the UOSA tailwater. Its shell was destroyed by handling, so we were unable to provide a photograph. This species was not native to Atlantic Slope streams of Virginia; it was common and native in the interior basins of North America, including the Mississippi and Ohio. It likely inhabited the UOSA impoundment and was displaced to its tailwater. We found shells of *E. complanata* in Cub Run and the UOSA tailwater. Flat Branch did not support native mussels. We did not detect any listed mussel species within any of the survey reaches.

We achieved a high probability to detect rare species in Bull Run and Flat Branch. Using a sampling equation from Smith (2006), we calculated post hoc detection probabilities based on total area searched and assumed detection of an individual mussel when present (or search efficacy, Table 4). Generally, detection probability of an individual mussel (search efficacy) was 0.2 on a scale from 0 to 1, where "0" means an individual was present but not detected and "1" means an individual was present and detected.

Through an independent review of records found in a database maintained by the Virginia State Mussel Biologist, Brian Watson, we found that the piedmont streams of the Occoquan Watershed had been frequently surveyed for freshwater mussels in recent decades due to urbanization, which had increased the number of road and utility crossings of its major tributaries (Broad Run, Cedar Run, Bull

Run, Cub Run). Previous studies demonstrated Bull Run supported patchy but moderate densities of Eastern Elliptio (*E. complanata*) and that other native mussel species persist at lower densities; including Creeper (*Strophitus undulata*), Triangle Floater (*Alasmidonta undulata*), Eastern Floater (*Pyganodon cataracta*), and lances belonging to the *Elliptio* genus (Table 5). Our survey results appear typical for Bull Run. During the review, we found survey information for the VA Rte 28 Bridge from August 29th, 1991, which described a similar assemblage to that we observed in the 2019 survey of Reach 1. Another survey from 1991 at the mouth of Cub Run, including part of Bull Run, found considerably greater abundances then we documented (see Table 5). Recent surveys suggest Cub Run may support a more abundant mussel fauna than Bull Run (EA Engineering, Science, and Technology 2006, 2008, 2010).

Our database review also revealed that the federally threatened Yellow Lance (*Elliptio lanceolata*) had been documented near the study area. *Elliptio lanceolata* had been documented in Cub Run, a tributary to Bull Run in Fairfax County, during a survey conducted over 20 years ago (Beaty and Neves 1997). The validity of this identification has been questioned, so it may not have appeared in IPaC and VaFWIS database searches. Lances belonging to the *Elliptio* genus, including *E. lanceolata,* have an uncertain taxonomy in Atlantic slope streams, including Bull Run (Bogan et al. 2009, Fagundo 2016). Much confusion arose from the seminal work of Johnson (1970), who lumped all elongated species presumed to belong to the *Elliptio* genus into a singular taxon, *E. lanceolata*. Recent and ongoing work has sought to assign this complex into more valid taxa. Several species once clumped into *E. lanceolata*, included *E. angustata, E. fisheriana, E. lanceolata* and *E. producta*. We found no evidence to suggest the Federally Threatened *E. lanceolata sensu stricto* occupied Bull Run. Beaty and Neves (1997) documented it well upstream of this project, but it was not documented in other surveys of Cub Run that we reviewed (see Table 5). This species had been most recently documented in another Occoquan tributary, Broad Run; however, based on later genetic analysis, that identification was not supported (Bogan et al. 2009). Our recent sampling of Broad Run (Ostby and Beaty 2019), where those records originated, provided further support that elongated lances were not *E. lanceolata.* Currently, *E. lanceolata* are known to persist in only a few places in Virginia, mostly in the Rappahannock River Basin. We identified the elongated *Elliptio* detected in Bull Run as *E. fisheriana*. Previous surveys had identified it as *E. angustata, E. producta, E. lanceolata* in the Bull Run and its tributaries.

The UOSA impoundment and tailwater appeared to be an important ecological driver in Bull Run. The most important habitat for native mussels we observed in this study was a depositional area where flows from the tailwater settled. This tailwater provided food and warmth to support many native mussels. Coincidentally, this habitat also supported the highest densities of *C. fluminea* that we have ever observed in Virginia. We also documented *C. c. malleata* there. Bull Run was 3ºC warmer downstream of the tailwater than upstream. Mussels grew faster downstream of the tailwater and reached a greater size (compare Figures 24 and 34). Upstream of the tailwater, *C. fluminea* were less dense, by at least an order of magnitude, and *C. c. malleata* absent.

All equipment exposed to reaches supporting *C. c. malleata* were cleaned using a >10% bleach solution.

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Table 1. Latitude and longitude in WGS84 for survey boundaries, landmarks and photographs.

Stream	Survey Reach	Label	Lattitude	Longitude
Bull Run	1	Downstream Start	38.803671	-77.44459
Bull Run	1	Figure 10: Downstream Route 28	38.803867	-77.44704
Bull Run	1	Figure 12: Upstream Route 28	38.802875	-77.44945
Bull Run	1	Upstream End	38.802393	-77.45039
Bull Run	1	Figure 18: C. fluminea shells on streambed	38.803647	-77.44501
Bull Run	2	Figures 19&20: Campsite and garbage on south bank	38.796386	-77.45759
Bull Run	2	Downstream Start	38.796109	-77.45321
Bull Run	2	Figure 21: Unstable gravel shoal	38.796036	-77.45407
Bull Run	2	Downstream Boundary Bed	38.795843	-77.45671
Bull Run	2	Figure 22&23: Upstream Boundary Bed	38.795897	-77.45715
Bull Run	2,4	Figure 30: Photo at Reach 2&4 boundary	38.797657	-77.45890
UOSA Tailwater	3	Figure 26: Downstream Start, Mouth	38.797246	-77.45743
UOSA Tailwater	3	Figure 27: *C. fluminea* streambed material	38.798027	-77.45682
UOSA Tailwater	3	Figure 29: Plungepool below 616	38.800088	-77.45532
UOSA Tailwater	3	Upstream End	38.800991	-77.45624
Bull Run	4	Downstream Start	38.797657	-77.4589
Bull Run	4	Figure 31: Unstable bank	38.795728	-77.46121
Bull Run	4	First riffle upstream of 616	38.79554	-77.46223
Bull Run	4	Figure 32: Shallow habitat	38.796503	-77.46528
Bull Run	4	Figure 33: Pointbars, habitat upstream of Cub Run	38.796543	-77.46663
Bull Run/Cub Run	4	Mouth of Cub and upstream riffle	38.796612	-77.46597
Cub Run	5	Figure 35: 100 m upstream of mouth	38.797578	-77.46551
Bull Run	4	100 m upstream of Flat Branch	38.795719	-77.47067
Flat Branch	6	Figure 36: Downstream start, mouth	38.795876	-77.46941
Flat Branch	6	Figure 37: Shad	38.791317	-77.47631
Flat Branch	6	Figure 38: Boulder dam	38.790847	-77.47657
Flat Branch	6	Upstream End	38.790749	-77.47668
Flat Branch	6	Assessment 1, Figure 39	38.790876	-77.47643
Flat Branch	6	Assessment 1, Figure 40	38.789878	-77.47585

Table 1. Continued.

Stream	Survey Reach	Label	Lattitude	Longitude
Flat Branch	7	Figure 42: Western isolated channel	38.789958	-77.47749
Flat Branch	7	Figure 43: Pool habitat	38.790392	-77.47683
Flat Branch	7	Figure 44: Large Woody Debris and Refuse in Flat Branch	38.787177	-77.48011
Flat Branch	7	Figure 45: Run habitat with gravel bed	38.785287	-77.48247
Flat Branch	7	Figure 46: Assessment 2	38.784578	-77.48203
Flat Branch	7	Figure 47: Assessment 2, Upstream of Lomond Drive	38.784242	-77.48161
Flat Branch	7	Assessment 3 downstream	38.783108	-77.48486
Flat Branch	7	Figure 49: Assessment 3	38.783522	-77.48618
Flat Branch	7	Figure 50: Assessment 3 upstream	38.784144	-77.48683
Flat Branch	7	Figure 51: Habitat downstream of Lomond Drive Bridge	38.782014	-77.48644
Flat Branch	7	Upstream End	38.795876	-77.46941
Flat Branch	8	Figure 52: Reach 8 corridor	38.782100	-77.48758
Flat Branch	8	Figure 53: Beaver dam	38.780069	-77.48838
Flat Branch	8	Figure 54: Excellent mussel habitat	38.778382	-77.48932
Flat Branch	8	Figure 56: Erroding bank	38.771767	-77.49351
Flat Branch	8	Figure 57: Pool habitat downstream of Rte 234 crossing	38.770697	-77.49426
Flat Branch	8	Assessment 4 upstream	38.776769	-77.49168
Flat Branch	8	Figure 58: Assessment 4	38.776931	-77.49095
Flat Branch	8	Upstream End Reach 8	38.769083	-77.49492

Table 2. Relevant survey conditions for each reach. Flow in Cubic Feet Per Second (CFS) was from a nearby gage on Cedar Run, USGS 01656000 near Catlett, VA. This gage was approximately 19 km away and within the Occoquan watershed.

Date	Survey Reach	Water Temperature (C)	Water Temperature (F)	Flow @ Cedar Run (CFS)	Weather	Air Temperature (C)	Air Temperature (F)
9/19/2019	Flat Branch (Reach 8)	21	70	1.66	Clear and Sunny	23	74
9/20/2019	Flat Branch (Reach 7)	21	70	1.64	Clear and Sunny	23	74
9/20/2019	Reach 1: Bull Run @ VA 28	22	72	1.64	Clear and Sunny	24	76
9/21/2019	Reach 2: Bull Run downstream of VA 616	22	72	1.64	Clear and Sunny	27	80
9/21/2019	UOSA Impoundment Tailwater (Reach 3)	23	73	1.64	Clear and Sunny	28	82
9/21/2019	Survey Reach 3 &4: Bull Run upstream of Rte 616	18	64	1.46	Clear early, with scatter clouds later	29	84
9/21/2019	Flat Branch (Reach 6&7)	28	82	1.46	Clear and Sunny	30	86
9/24/2019	Flat Branch (Reach 7)	18	64	1.11	Overcast	22	72
9/24/2019	UOSA Impoundment Tailwater (Reach 3)	23	73	1.11	Overcast	22	72

Table 3. Survey results by stream. Effort was person-hour in active survey in a reach, catch-per-unit-effort (CPUE) was the total number of mussels per person-hour of survey. S=shell only.

Date	Stream Reach	Effort (Person-hours)	Reach Length (m)	*A. undulata*	*E. complanata*	*E. fisheriana*	*P. grandis*	*S. undulatus*	*U. imbecillus*	Total	CPUE
9/20	Bull Run Reach 1	7	540	S	19	2	0	1	0	22	3.14
9/20-9/21	Bull Run Reach 2	5.5	650	0	31	5	0	4	3	43	7.82
9/21&9/24	UOSA Tailwater Reach 3	1.5	500	0	S	0	S	0	0	0	0
9/21	Bull Run Reach 4	6	1,200	0	26	2	0	1	0	29	4.83
9/21	Cub Run Reach 5	0.5	100	0	S	0	0	0	0	0	0
9/19 - 9/21, & 9/24	Flat Branch (Reaches 6-8)	7	3,900	0	0	0	0	0	0	0	0

Table 4. Probability of detecting a species (p) using Smith (2006) equation, $p = 1 - e^{-\beta\alpha\mu}$, given search efficacy (β), actual area covered in a survey (α), and a theoretical density (μ). We also present a theoretical population size for a survey reach for a given density (0.01 or 0.005 individuals per meter square). Area covered (α) was a minimal estimate.

	p	**β**	**α**	**μ**	
Stream & Reach	Probability of population detection	Probability of Individual Detection	Area Visually Searched	Poulation Density	Population Size in Survey Reach
Bull Run Reach 1	0.9985	0.2	3240	0.01	32.4
	0.9608	0.1	3240	0.01	32.4
	0.9608	0.2	3240	0.005	16.2
	0.8021	0.1	3240	0.005	16.2
Bull Run Reach 2	0.9993	0.2	3600	0.01	36
	0.9727	0.1	3600	0.01	36
	0.9727	0.2	3600	0.005	18
	0.8347	0.1	3600	0.005	18
UOSA Tailwater Reach 3	0.9093	0.2	1200	0.01	12
	0.6988	0.1	1200	0.01	12
	0.6988	0.2	1200	0.005	6
	0.4512	0.1	1200	0.005	6
Bull Run Reach 4	1.0000	0.2	7800	0.01	78
	0.9996	0.1	7800	0.01	78
	0.9996	0.2	7800	0.005	39
	0.9798	0.1	7800	0.005	39
Cub Run Reach 5	0.5507	0.2	400	0.01	4
	0.3297	0.1	400	0.01	4
	0.3297	0.2	400	0.005	2
	0.1813	0.1	400	0.005	2
Flat Branch Reaches 6-8	1.0000	0.2	7000	0.01	70
	0.9991	0.1	7000	0.01	70
	0.9991	0.2	7000	0.005	35
	0.9698	0.1	7000	0.005	35

Table 5. Summary results compiled from reports we reviewed (Literature Cited) and from a database maintained by VDGIF mussel biologist, Brian Watson. Data reviewed was limited to Bull Run and its tributaries. FD = Fresh Dead, S = Shell Material.

Study/Source	Stream	Year	Lattitude	Longitude	*A. undulata*	*E. angustata*	*E. complanata*	*E. fisheriana*	*E. lanceolata*	*E. producta*	*P. cataracta*	*S. undulatus*	Effort
DNH	Bull Run	1990	38.88962	-77.57032	0	0	1	0	0	0	1	2	n/a
DNH	Bull Run	1990	38.84919	-77.54613	0	0	Common	0	0	0	1	0	2
DNH	Bull Run	1990	38.88961	-77.57031	0	0	1	0	0	0	1	2	n/a
DNH	Bull Run	1991	38.79892	-77.48016	S	0	15	0	0	0	S	9	n/a
DNH	Bull Run	1991	38.79666	-77.46610	0	0	20	0	0	0	0	0	n/a
DNH	Bull Run	1991	38.80326	-77.44914	1	0	18	1	0	10	0	0	n/a
DNH*	Bull Run	1991	38.76981	-77.41501	0	0	18	0	0	0	0	S	n/a
DNH	Bull Run	1991	38.79946	-77.49454	S	0	15	0	0	0	S	9	n/a
DNH	Bull Run	1991	38.79663	-77.46626	0	0	20	0	0	0	0	0	n/a
DNH**	Bull Run	1991	38.80330	-77.44913	1	1	18	0	0	0	0	10	n/a
DNH	Bull Run	1991	38.76639	-77.41481	0	0	18	0	0	0	0	S	n/a
DNH	Bull Run	1991	38.84258	-77.53694	0	6	28	0	0	0	1	1	n/a
DNH	Bull Run	1991	38.82411	-77.50405	0	0	25	0	0	0	0	0	n/a
DNH	Bull Run	1991	38.82407	-77.50390	0	0	8	0	0	0	0	S	n/a
DNH	Bull Run	1991	38.84264	-77.53725	0	0	28	6	0	0	1	1	n/a
DNH	Bull Run	1991	38.82413	-77.50412	0	0	25	0	0	0	0	0	n/a
VDGIF	Bull Run	1991	38.82499	-77.45783	0	0	2	0	0	1	0	1	1.75
DNH	Bull Run	1996	38.84247	-77.53888	5	0	50	20	0	0	1 FD	2	4
DNH	Bull Run	1996	38.84919	-77.54613	0	0	125 (2 FD)	0	0	0	0	2	4
DNH	Bull Run	1997	38.82407	-77.50390	1	0	Abundant	5	0	0	S	0	8
Creek Lab (2015)	Bull Run	2015	38.80544	-77.48972	0	0	2	0	0	0	0	0	3
Three Oaks (2017)	Bull Run	2017	38.81011	-77.49021	0	0	63	0	0	0	0	3	6.37
DNH	Catharpin Creek	1991	38.84946	-77.63800	0	0	0	0	0	0	0	0	n/a
DNH	Catharpin Creek	1991	38.83036	-77.59785	0	11	19	0	0	0	0	26	n/a
DNH	Cub Run	1991	38.80367	-77.47066	0	2	113	0	0	0	0	0	n/a
DNH	Cub Run	1991	38.82120	-77.46606	1	7	90	0	0	0	S	0	n/a
DNH+	Cub Run	1991	38.79663	-77.46614	S	12	100	0	0	0	0	0	n/a
Beaty & Neves (1997)	Cub Run	1997	38.88232	-77.46986	2	0	63	17	5	0	0	0	6
EA (2006)	Cub Run	2006	38.83901	-77.46416	0	0	386	4	0	0	0	0	n/a
EA (2006)	Cub Run	2006	38.84229	-77.46349	0	0	150	1	0	0	0	0	n/a
EA (2007)	Cub Run	2007	38.83904	-77.46313	0	0	450	4	0	0	0	0	14
EA (2007)	Cub Run	2007	38.84229	-77.46349	0	0	184	2	0	0	0	0	3.5
EA (2007)	Cub Run	2007	38.83901	-77.46416	0	0	207	3	0	0	0	0	12.5
VDGIF	Cub Run	2007	38.87549	-77.47192	0	0	10	0	0	1	0	0	1.75
EA (2008)	Cub Run	2008	38.84237	-77.46360	0	0	248	0	0	2	0	0	n/a
EA (2008)	Cub Run	2008	38.84237	-77.46360	1	0	409	0	0	1	0	0	n/a
EA (2008)	Cub Run	2008	38.82527	-77.45890	0	0	0	0	0	0	0	0	n/a
EA (2008)	Cub Run	2008	38.83037	-77.46070	0	0	16	0	0	1	0	0	n/a
EA (2008)	Cub Run	2008	38.83346	-77.46420	0	0	114	0	0	3	0	0	n/a
EA (2008)	Cub Run	2008	38.84717	-77.46840	1	0	568	0	0	12	0	0	n/a
EA (2008)	Cub Run	2008	38.86287	-77.47540	1	0	302	0	0	20	3	0	n/a
EA (2010)	Cub Run	2010	38.83454	-77.46569	1	0	154	0	0	8	0	0	18
EA (2010)	Cub Run	2010	38.84034	-77.46374	1	0	274	0	0	1	0	0	16
Three Oaks (2016)	Cub Run	2016	38.81525	-77.47716	1	0	20	S	0	S	0	0	6.6
Three Oaks (2016)	Cub Run	2016	38.81013	-77.49017	0	0	73	1	0	0	0	5	6.9
ESI (2017)	Cub Run	2017	38.81519	-77.47725	0	0	10	S	0	0	0	0	5.25
Creek Lab (2005)	Elklick Run	2005			0	17	136	0	0	0	0	0	n/a
Creek Lab (2005)	Elklick Run	2005			0	1	164	0	0	0	S	0	n/a
Creek Lab (2005)	Elklick Run	2005			0	0	233	0	0	0	3	0	n/a
DNH	Little Bull Run	1991	38.84267	-77.538943	0	0	5 (8 FD)	2 (4 FD)	0	0	0	1	n/a
DNH	Little Bull Run	1995	38.84249	-77.53881	1 FD	0	50 (10 FD)	30 (3 FD)	0	0	3 (1 FD)	S	5
VDGIF	Little Bull Run	2007	38.84204	-77.539427	0	0	3	0	0	10	0	0	0.33

* Assumed based on description

** Survey Reach 1

+ Survey Reach 4 & 5

Figure 1. Road map demonstrating survey reach boundaries and assessment locations. Maps in Figures 2-9 are referenced here.

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DagunaConsulting@gmail.com

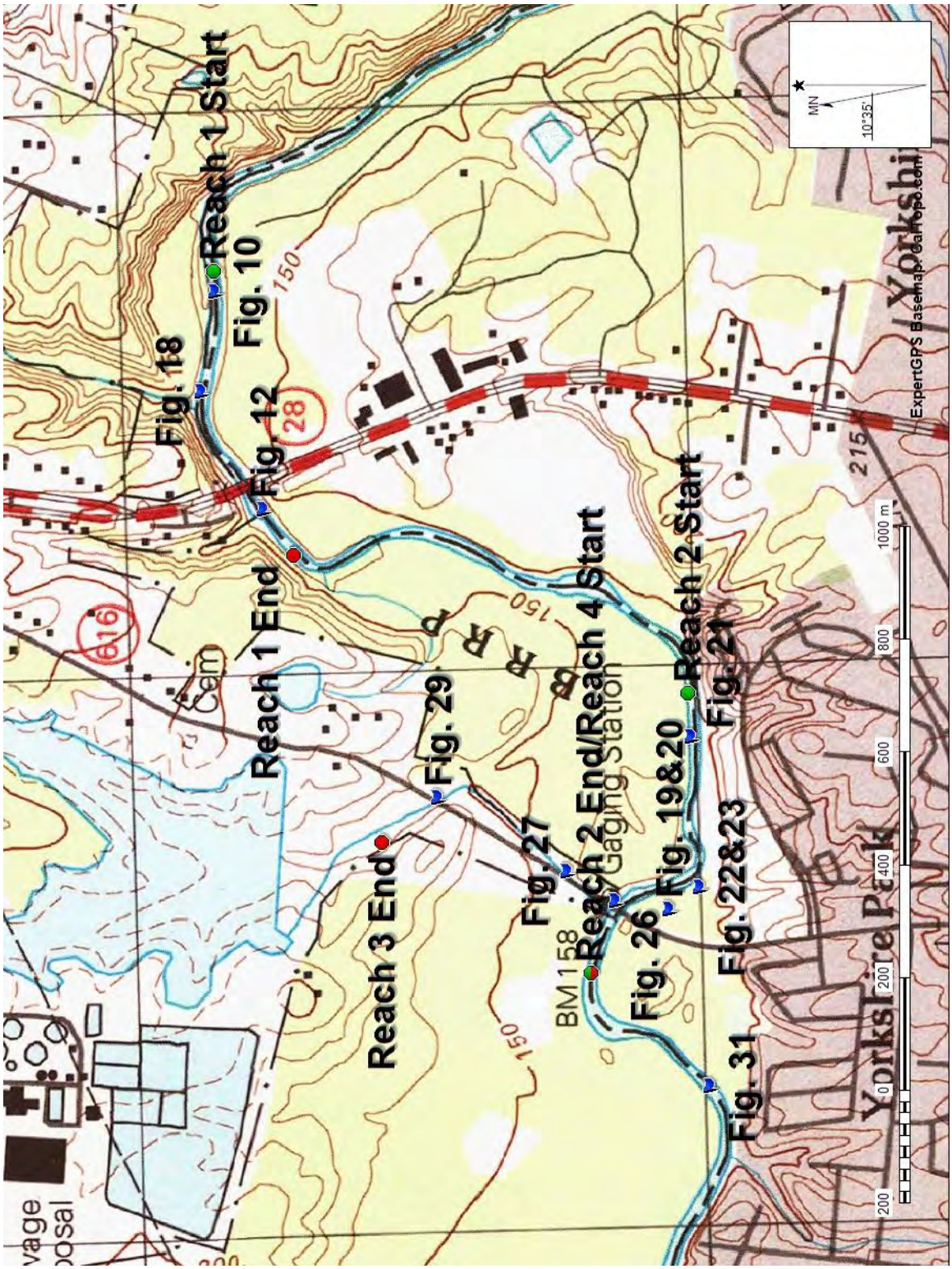

Figure 2. Detailed topographic map demonstrating the survey boundaries and photograph locations for reaches 1-3.

Figure 3. Aerial map of survey reaches 1-3.

Figure 4. Detailed topographic map demonstrating the survey boundaries and photograph locations for reaches 4-6.

Figure 5. Aerial map of survey reaches 4-6.

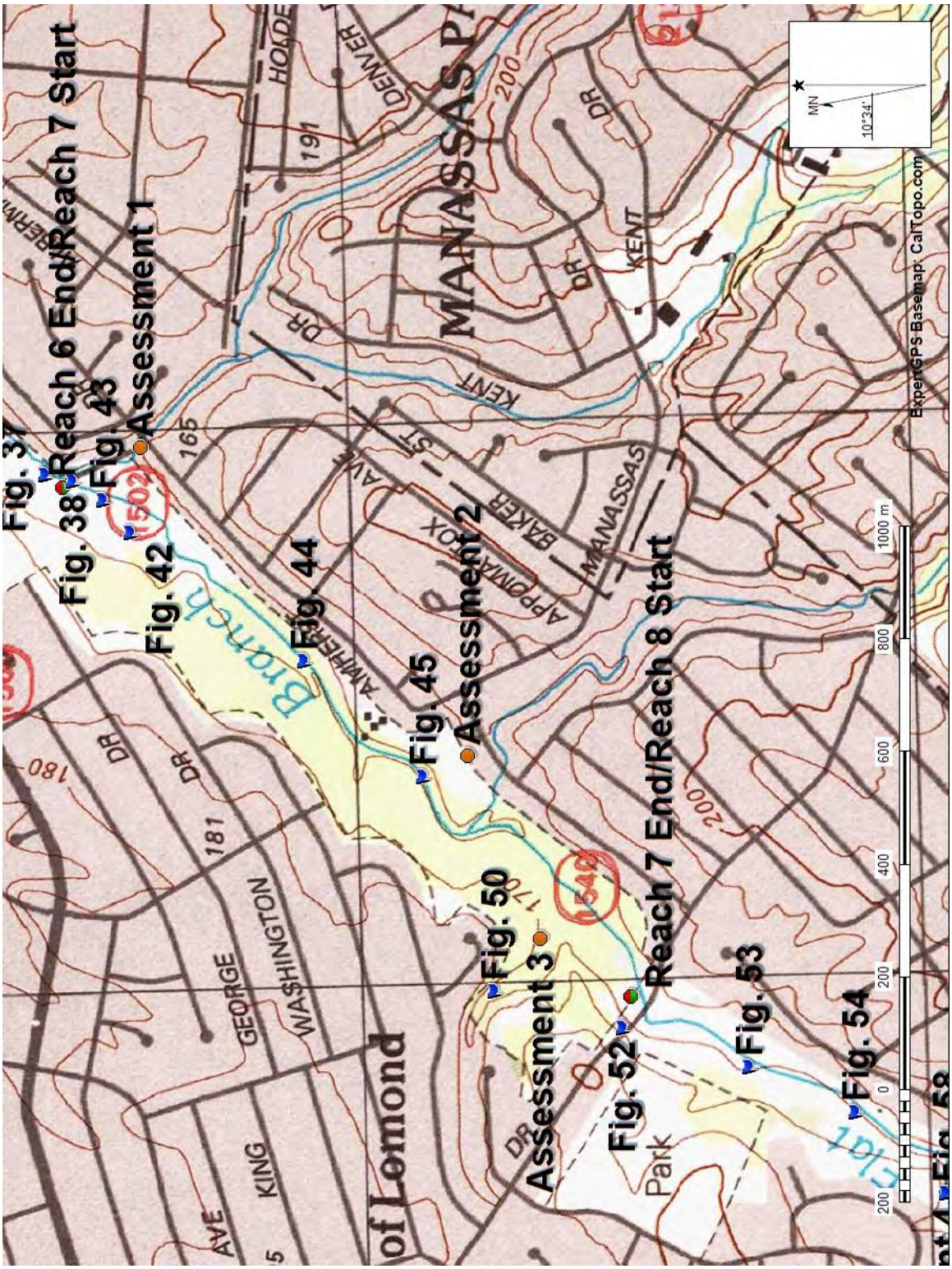

Figure 6. Detailed topographic map demonstrating the survey boundaries and photograph locations for reaches 6-7 and Assessments 1-3.

Figure 7. Aerial map of survey reaches 6-7 and assessments 1-3.

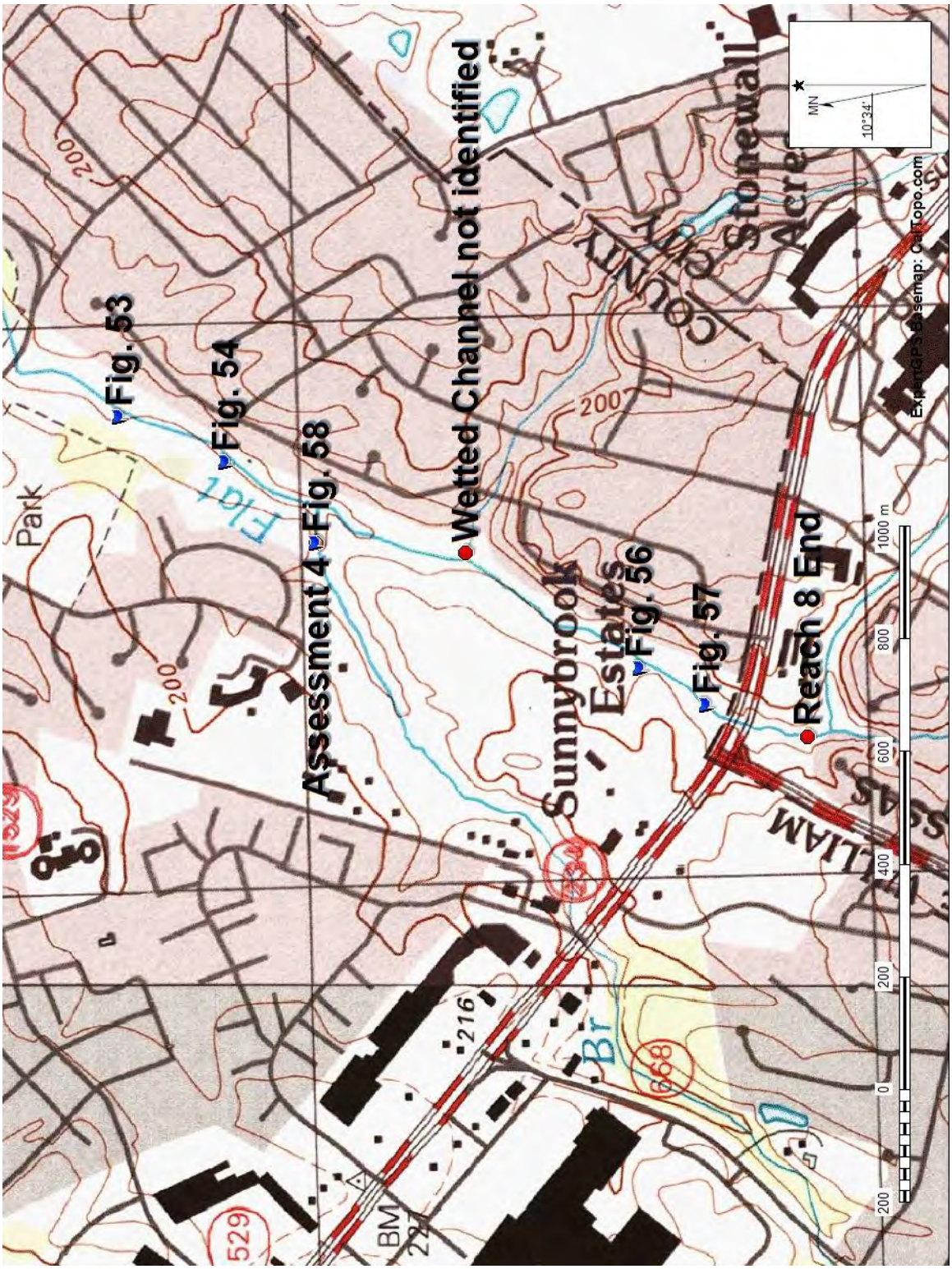

Figure 8. Detailed topographic map demonstrating the survey boundaries and photograph locations for reaches 8 and Assessment 4.

Figure 9. Aerial map of survey reache 8 and assessment 4.

Figure 10. This shallow run habitat downstream of the Virginia Rte 28 was typical for Survey Reach 1. Mussels were scattered throughout this habitat with dead shells on exposed bars.

Figure 11. Typical streambed inhabited by mussel downstream of the Rte 28 bridge in Survey Reach 1

Figure 12. Pool and rapid habitat upstream of the VA Route 28 bridge (38.802875, -77.449447).

Figure 13. Young *E. complanata* observed in Reach 1 of Bull Run.

Figure 14. *Elliptio fisheriana* observed in Reach 1 of Bull Run.

Figure 15. *Strophitus undulatus* observed live in Bull Run Reach 1.

Figure 16. We only found a single pair of valves of *A. undulata* in Bull Run Reach 1.

Figure 17. The Chinese Mystery Snail (*Cipangopaludina chinensis malleata*) was present by uncommon.

Figure 18. Asian Clam (*C. fluminea*) shells in shallows downstream of the VA 28 bridge.

Figure 19. The itinerate camp downstream of the Virginia Rte 616 bridge.

Figure 20. Refuse on an exposed bar downstream of Rte 616 bridge.

Figure 21. Unstable gravel shoal approximately 400 m downstream of the Rte 616 bridge. We pictured typical habitat for Reach 2.

Figure 22. This depositional area was the only mussel bed we detected in this study.

Figure 23. Live *C. fluminea* and shell made up much of the stream bed in the mussel bed we documented in Survey Reach 2. This underwater photograph was taken at the same location shown in Figure 22. A live *E. complanata* was pictured center.

Figure 24. Mussels observed in a bed in Reach 2. Note the large size *E. complanata* at top (144 mm).

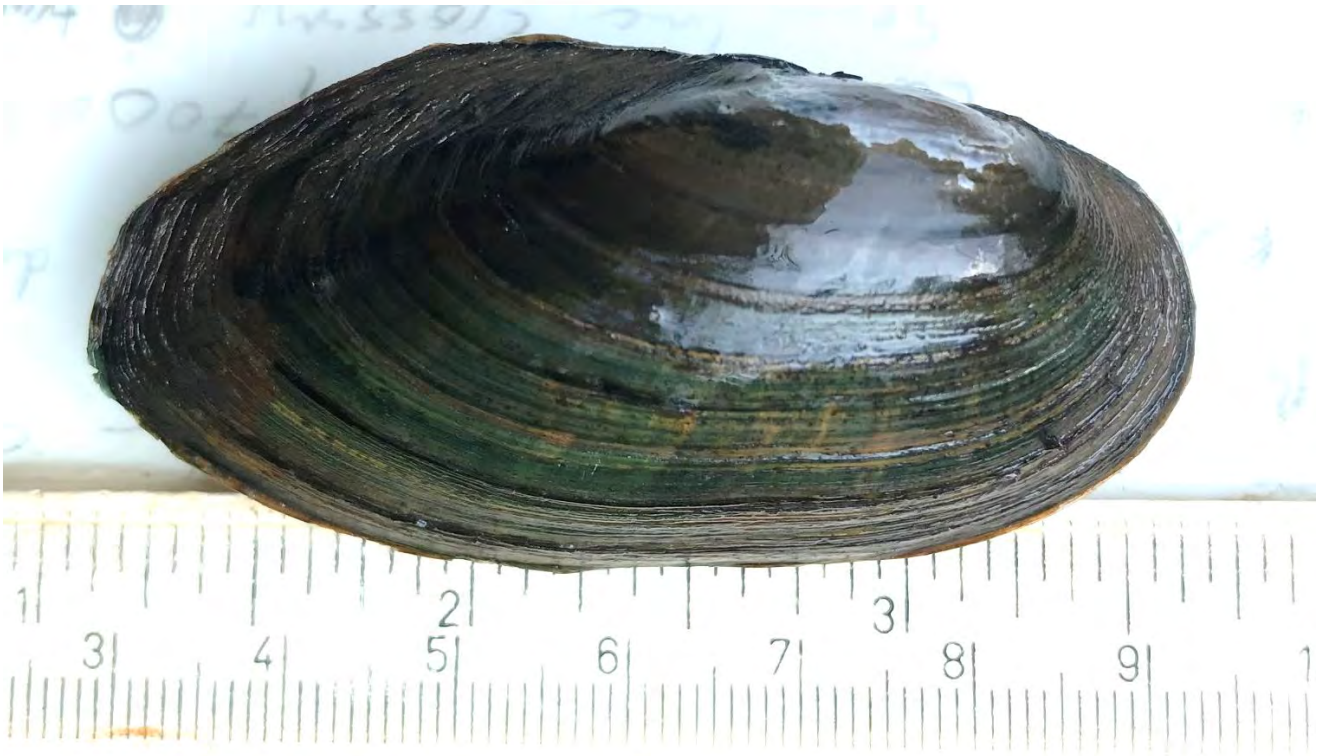

Figure 25. Detailed image of *U. imbecillis* detected in Bull Run.

Figure 26. The UOSA tailwater (Reach 3) can be best described as a long riffle habitat with a gravel dominated streambed, as pictured at its mouth.

Figure 27. *Corbicula fluminea* live and shell were the top layer of streambed material in this depositional area of the UOSA tailwater (Reach 3; 38.798027, -77.456815).

Figure 28. Typical habit in the UOSA tailwater (Reach 3).

Figure 29. Plunge pool below Rte 616 culvert crossing (38.800088, -77.455316).

Figure 30. Pool habitat in at the boundary of Reach 2 and 4 (38.797657, -77.458904). Habitat pictured here was representative of 200 m long area upsteam of the Rte 616 bridge.

Figure 31. Unstable bank in Bull Run, Reach 4 (38.795728, -77.461206). Some slab rock that had broken off the bed ledge can be seen in photograph center. These slab rocks were common in Reach 4 downstream of Cub Run.

Figure 32. Shallower habits downstream of Cub Run in Reach 4 (38.796503, -77.465275). Exposed streambed and bank conditions pictured here were typical for Reach 4 downstream of Cub Run.

Figure 33. Reach 4 upstream of Cub Run was a narrower meandering stream within a larger channel that had point bars and riffles at regular frequencies (38.796543, -77.466628).

Figure 34. Slower growing *E. complanata* observed in Reach 4.

Figure 35. Cub Run approximately 100 m upstream from its mouth was littered with large woody debris and was cut at least 2.5 m into the Bull Run floodplain (38.797578, -77.465508).

Figure 36. Nutrient rich, warm waters of lower Flat Branch was confined by levees on both sides (38.795876, -77.469409).

Figure 37. Threadfin Shad (*Dorosoma petenence*) detected in Reach 6 of Flat Branch (38.791317, -77.476311). These schools were frequently encountered in Reaches 6 and 7.

Figure 38. Anthropogenic boulders atop sewer crossing in Flat Branch approximately 850 m upstream from the mouth (38.790847, -77.476570). The pool formed by the rock dam can be seen in the background.

Figure 39. The stream feeding Flat Branch form the southeast (Assessment 1) had flow no more than 5 cm deep filling only half the channel.

Figure 40. Assessment 1 of stream flowing under Amherst Drive (38.789878, -77.475853).

Figure 41. Assessment 1 upstream of Amherst Drive was dry.

Figure 42. The western channel was isolated from the flowing channel of Flat Branch. It was covered with a thick mat of algae.

Figure 43. Pool habitat in Reach 7 upstream of the rock dam in Reach 7.

Figure 44. Run habitat in Survey Reach 7 where refuse had been trapped by large woody debris (38.787177, -77.480112).

Figure 45. Some shallow runs with gravel streambeds in Flat Branch provided potential habitat for mussels. None were detected (38.785287, -77.482472).

Figure 46. We assessed a tributary flowing from the east, under Lomond Drive (Assessment 2). We found no evidence of mussels and the stream seemed extremely flashy (38.784578, -77.482033).

Figure 47. Habitat in an unnamed tributary upstream of Lomond Drive had a mostly bedrock streambed (38.784242, -77.481606).

Figure 48. This lawn near assessment 2 was wetland (38.783622, -77.482269), this and other features suggested areas around Flat Branch had once been low lying wetlands.

Figure 49. Assessment Reach 3 had at most 5 cm of flow over cobble and gravel just upstream of the utility corridor (38.783522, -77.486183).

Figure 50. Pool habitat at residential neighborhood in Assessment 3.

Figure 51. Flat Branch flowed through anthropogenic boulders downstream of the Lomond Drive Bridge (38.782014, -77.486442).

Figure 52. Utility corridor through which Reach 8 of Flat Branch flowed (38.782100, -77.487581). Flat Branch was shaded by the tree line pictured left. Flat Branch Reach 8 has been allowed to rework itself in this floodway, unlike Reach 6 where it was confined by levees and straightened.

Figure 53. Beaver dam in Flat Branch (38.780069, -77.488378).

Figure 54. Flat Branch had probably re-worked a fluvial channel with at least 2 meandering channels through a corridor between residential areas (38.778382, -77.489316). Banks were low and the streambed provided excellent habitat for mussels.

Figure 55. Anthropogenic boulders in a widened section of Flat Branch in Reach 8.

Figure 56. Banks like the one pictured here had provided much of the streambed. This specific location provided no habitat for mussels as it was exposed bedrock (38.771767, -77.493514).

Figure 57. Pool habitat downstream of the Rte 234 crossing of Flat Branch (38.770697, -77.494256).

Figure 58. Assessment 4 off Reach 8 (Flat Branch) was dry during the September 19th visit (38.776931, -77.490953).

Figure 59. Fish were more common in the upper reaches of Flat Branch. We photographed black nose dace and a minnow belonging to the *Notropis* genus.

Survey Record #1

Site #: DAGUNA09202019.2

Stream: Bull Run, Reach 1

County: Prince William and Fairfax Counties

Description: 550 m of Bull Run from 400 m downstream to 100 m upstream of the VA Rte 28 Bridge

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.803671, -77.444594

Survey End: 38.802393, -77.450389

Survey Date: 9/20/2019

Survey Effort: 7 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
19 Live *Elliptio complanata*
2 Live *E. fisheriana*
1 Live *Strophitus undulatus*
Alasmidonta undulata (shell, rare)
Live *Corbicula fluminea* (extremely abundant)
Live *Cipangopaludina chinensis malleata* (common)
Live *Pleurocera virginica*

Survey Record #2

Site #: DAGUNA09202019.1

Stream: Bull Run, Reach 2

County: Prince William and Fairfax Counties

Description: 650 m of Bull Run from 475 m downstream to 100 m upstream of the Rte 616 Bridge

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.796109, -77.453209

Survey End: 38.797657, -77.458904

Survey Date: 9/20/2019, 9/21/2019

Survey Effort: 5.5 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
31 Live *Elliptio complanata*
5 Live *E. fisheriana*
4 Live *Strophitus undulatus*
3 Live *Utterbackia imbecillis*
Live *Corbicula fluminea* (extremely abundant)
Live *Cipangopaludina chinensis malleata* (common)
Live *Pleurocera virginica* (uncommon)

Survey Record #3

Site #: DAGUNA09212019.1

Stream: Upper Occoquan Service Authority Polishing Pond Tailwater, Reach 3

County: Fairfax County

Description: 500 m reach from its mouth to 100 m upstream of the VA Rte 616 culvert crossing

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.797246, -77.45743

Survey End: 38.800991, -77.456241

Survey Date: 9/21/2019

Survey Effort: 1.5 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
Elliptio complanata (shell, common)
Pyganodon grandis (shell, rare)
Live *Corbicula fluminea* (extremely abundant)
Live *Cipangopaludina chinensis malleata* (common)

Survey Record #4

Site #: DAGUNA09212019.2

Stream: Bull Run, Reach 4

County: Prince William and Fairfax Counties

Description: 1,200 m of Bull Run from 100 m upstream of the VA Rte 616 bridge to 100 m upstream of the Flat Branch confluence

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.797657, -77.458904

Survey End: 38.795719, -77.470674

Survey Date: 9/21/2019

Survey Effort: 6 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
26 Live *Elliptio complanata*
2 Live *E. fisheriana*
1 Live *Strophitus undulatus*
Live *Corbicula fluminea* (common)

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Survey Record #5

Site #: DAGUNA09212019.3

Stream: Cub Run, Reach 5

County: Fairfax Counties

Description: 100 m of Cub Run from its mouth upstream

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.796612, -77.465973

Survey End: 38.797578, -77.465508

Survey Date: 9/21/2019

Survey Effort: 0.5 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
Elliptio complanata (shell, rare)
Live *Corbicula fluminea* (rare)

7509 Pin Oak Circle Bristol, VA 24202
Contact: 276-608-6508 or 540-230-1042
DagunaConsulting@gmail.com

Survey Record #6

Site #: DAGUNA09212019.4

Stream: Flat Branch, Reach 6

County: Prince William

Description: Surveyed 850 m stream from its mouth upstream

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.795876, -77.469409

Survey End: 38.790749, -77.476675

Survey Date: 9/21/2019

Survey Effort: 1 person-hour

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
Corbicula fluminea (rare)

7509 Pin Oak Circle Bristol, VA 24202
Contact: 276-608-6508 or 540-230-1042
DagunaConsulting@gmail.com

Survey Record #7

Site #: DAGUNA09202019.1

Stream: Flat Branch, Reach 7

County: Prince William

Description: Surveyed 1,450 m stream from the end of Reach 6

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.790749, -77.476675

Survey End: 38.78198, -77.48695

Survey Date: 9/20/2019, 9/21/2019, 9/24/2019

Survey Effort: 3.5 person-hours

Personnel: B. J. K. Ostby, B. B. Beaty

Mollusks Observed:
Corbicula fluminea (uncommon)

7509 Pin Oak Circle Bristol, VA 24202
Contact: 276-608-6508 or 540-230-1042
DagunaConsulting@gmail.com

Survey Record #8

Site #: DAGUNA09192019.1

Stream: Flat Branch, Reach 8

County: Prince William

Description: Surveyed of 1,600 m of stream from Lomond Drive crossing to 100 m upstream of the Rte 234 (Sudley Road) crossing

Drainage: Occoquan (02070010)

USGS Quadrangle Map: Manassas

Projection: WGS 84

Survey Start: 38.78198, -77.48695

Survey End: 38.769083, -77.494916

Survey Date: 9/19/2019

Survey Effort: 2.5 person-hours

Personnel: B. J. K. Ostby

Mollusks Observed:
Corbicula fluminea (uncommon)

APPENDIX B
HARPERELLA SURVEY REPORT
ROUSE ENVIRONMENTAL SERVICES

Rouse Environmental Services

Environmental Consultation & Permitting

November 13, 2019

Stantec Consulting Services, Inc.
5209 Center Street
Williamsburg, Virginia 23188-2680

Attn: Mr. Sean Wender

Subject: Project R19019, Survey for *Ptilimnium nodosum* (Harperella), Route 28 Corridor Environmental Assessment, Prince William County, Virginia.

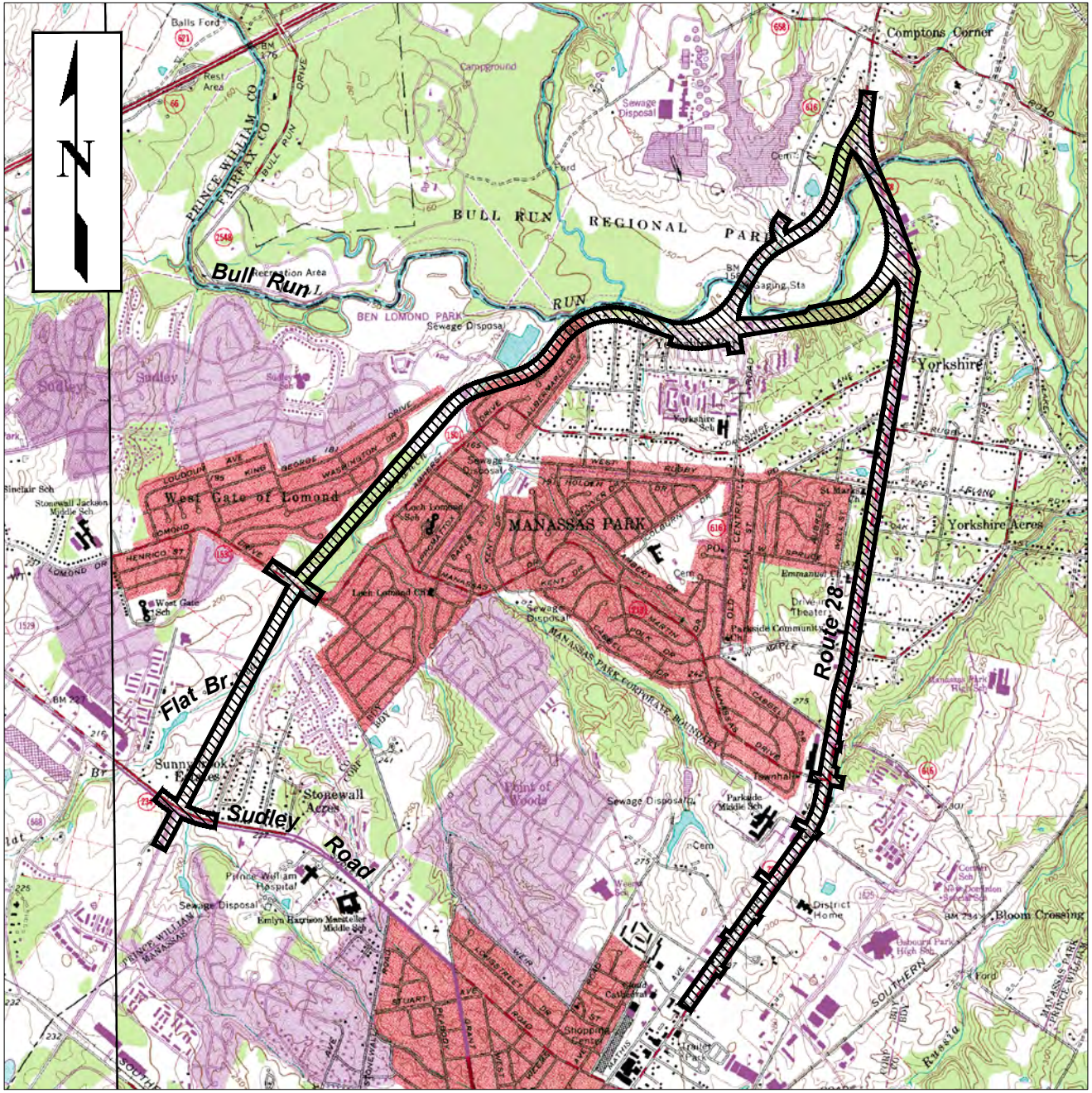
Gentlemen:

Provided here are our findings from our surveys for potential populations of *Ptilimnium nodosum* (Harperella) in connection with the above referenced project. This report represents the completion of our services rendered per our sub-consultant agreement effective September 9, 2019.

1. BACKGROUND

The Prince William County Department of Transportation (PWC DOT), in coordination with the Virginia Department of Transportation (VDOT) and the Federal Highway Administration (FHWA), is preparing an Environmental Assessment (EA) to evaluate the potential social, economic, and environmental effects associated with proposed improvements in the Route 28 corridor between Sudley Road in Prince William County and Compton Road in Fairfax County.

The EA will evaluate three alternatives developed in the December 2017 Route 28 Corridor Feasibility Study, a long-term corridor feasibility study funded by the Northern Virginia Transportation Authority (NVTA) to develop a plan to address the issues along the Route 28 corridor. The approximate extent of the combined three alternatives currently being considered (Alternatives 2a, 2b and 4) is shown on our *Project Location Map* included as Figure 1 to this report.



ROUTE 28 CORRIDOR ENVIRONMENTAL ASSESSMENT, PRINCE WILLIAM CO., VIRGINIA

LEGEND

PROJECT LIMITS (Alternatives 2a, 2b & 4 combined)

FIGURE 1

PROJECT LOCATION MAP

SCALE: 1" ≈ 3000'

SOURCE: USGS 7.5' TOPOGRAPHIC MAPS - GAINESVILLE & MANASSAS QUADRANGLES (Photorevised 1983)

November 2019 **R19019**

Rouse Environmental Services

We were originally contacted by Stantec regarding the need for a survey of potential populations of *Ptilimnium nodosum* (Harperella) in connection with the EA. *P. nodosum* is a globally rare herb of the Parsley family generally found growing within rocky or gravely shoals at the margins of swift flowing streams. Due to its rarity and loss of potential habitat from development, *P. nodosum* has been formally listed as *Endangered* by the US Fish & Wildlife Service (USFWS). The plant has also received formal recognition as *Endangered* by the Virginia Department of Agriculture & Consumer Services under the Commonwealth of Virginia's Endangered Plant & Insect Act.

Ptilimnium nodosum is currently known in Virginia from nearby Aquia Creek, south of the project area in adjoining Stafford County, Virginia. We understand that Stantec previously conducted a habitat assessment for *P. nodosum* in connection with the three alternative alignments being considered and had identified seven distinct areas of potential habitat for the plant, totaling less than 2 acres in extent. The areas of potential habitat were outlined to us on their *Threatened and Endangered Species Habitat Map* sent to us as a PDF attachment in an email dated July 25, 2019, and also as a shapefile (*rte_habitat.shp*) sent as an email attachment on September 9, 2019. The objective of our study was to conduct surveys for potential populations of *P. nodosum* within each of these areas of potential habitat as previously identified by Stantec and provide an evaluation of the likelihood of the plant's occurrence at these locations.

2. DATA REVIEW AND FIELD STUDY

Generally, a desktop review is conducted to further refine areas of potential habitat for *Ptilimnium nodosum* within the designated project limits. As this preliminary work had already been conducted by Stantec, we relied on the results of their efforts during our follow-up surveys. Survey areas identified on the shapefile provided by Stantec were incorporated onto base maps taken into the field. The survey limits were also uploaded to a handheld GPS receiver for better location and orientation while in the field. The locations of the seven survey areas, in relation to the overall study limits for the EA, are shown on our *Survey Areas Map* included as Figure 2.

Surveys were conducted on September 18, 2019, a time of year when *Ptilimnium nodosum* has been deemed by the USFWS as searchable in Virginia. The field work was led by myself, Garrie Rouse, a botanist recognized by the USFWS as qualified to conduct surveys for the target plant. We documented plant species as they were encountered during the course of our surveys. A listing of these taxa is provided as an attachment to this report.

Normally, representative photographs of habitat encountered within each of the survey areas would be included in our reporting. Our camera, however, was damaged by water during the course of our field surveys and we were unsuccessful in retrieving photographs from it.

N

SA6

SA5

SA4

SA7

Bull Run

Flat Branch

SA3

SA2

SA1

Old Centerville Road

Sudley Road

Route 28

LEGEND

LIMITS OF ROUTE 28 CORRIDOR STUDY.

SA7

AREAS OF PREVIOUSLY IDENTIFIED POTENTIAL HABITAT SURVEYED FOR *Ptilimnium nodosum* ON 9/18/19

Notes: 1) Aerial imagery taken from NAIP digital orthophotgraphs flown in 2011. 2) Areas of previously identified potential habitat provided by Stantec on Shapefiles dated 9/12/19.

Rouse Environmental Services

Survey Areas Map

Route 28 Corridor
Environmental Assessment,
Prince William County, Virginia

Figure 2

SCALE: 1"= 500'

DRAWN BY: G. Rouse DATE: 11/11/19

3. SUMMARY OF FINDINGS

Within the northern part of its range, *Ptilimnium nodosum* is generally found growing on rocky or gravelly shoals, or in crevices of bedrock exposures where sediments have collected, at the margins of clear, swift-flowing, larger streams and small rivers. The plant apparently prefers seasonally fluctuating water levels sufficient to produce scour and maintain openings within a stream's fallway but, at the same time, may have a very narrow range of water depths that it can actually tolerate.

All seven areas of potential habitat for *Ptilimnium nodosum*, as previously identified by Stantec, were carefully and systematically surveyed for the possible presence of the plant. Three of these areas occurred along Flat Branch, a tributary draining from the south to Bull Run, two areas occurred along an unnamed tributary draining from the north to Bull Run, and the remaining two survey areas were from Bull Run itself, which cuts through the northern end of overall study area for the EA in a general, west to east direction (see Figure 2). A brief description of our findings from each survey area follows.

Survey Area 1 (SA1): SA1 represents a segment of Flat Branch just south of where Sudley Road crosses the creek. Some good structure within the stream bed was found here producing moderate to good potential habitat for *Ptilimnium nodosum.* The relatively narrow width of the stream bed and partial shading over some areas of the stream segment, however, rendered some portions of the site less than ideal for the plant. Despite our systematic survey of what good habitat was available, no individuals of *P. nodosum* were found during the course of our field investigations.

Survey Area 2 (SA2): SA2 represents a continuation of potential habitat along Flat Branch just north of where Sudley Road crosses the creek. Habitat here was much the same as it was for SA1. Despite our systematic surveys of what good habitat was available, no individuals of *Ptilimnium nodosum* were found during the course of our field investigations here.

Survey Area 3 (SA3): SA3 represents a very small segment of Flat Branch in the vicinity of a sewer line easement, approximately 1500 feet north of where Sudley Road crosses the creek. The stream channel at this location is deeply entrenched (1-3 feet) within fine sediments. Likewise, the fallway was entirely flooded with standing water, despite our survey being conducted at a normally dry time of the year and following a minor drought. These conditions would normally provide little to no suitable habitat for *Ptilimnium nodosum.* No individuals of *P. nodosum* were found during the course of our field investigations at this site.

Survey Area 4 (SA4): SA4 represents a segment of Bull Run, approximately 1200 feet west of Old Centreville Road. Sufficient drainage area exists above this point to produce the openings in canopy and structure within the stream bed suitable for harboring potential populations *Ptilimnium nodosum*. Despite our systematic survey of areas of potential

habitat present at the site, no individuals of *P. nodosum* were found during the course of our field investigations there.

Survey Area 5 (SA5): SA5 represents a segment of an unnamed stream north of Bull Run and running parallel to the east side of Ordway Road before its outfall to Bull Run itself. There was some, limited habitat near the upper (northern) and lower (southern) end of this stream segment. But, for the most part, the stream banks were too deeply cut and the streambed too flooded with deep water for much of its length to be conducive for the growth and persistence of *Ptilimnium nodosum.* This stream apparently receives the outflow from a finishing pond of the Upper Occoquan Service Authority Regional Water Reclamation Plant, and it is our estimation that the flows experienced along this segment are augmented well above what would normally be supported by the drainage area behind it. Despite our systematic survey of what limited habitat was available, no individuals of *P. nodosum* were found during the course of our field investigations.

Survey Area 6 (SA6): SA6 represents a very small segment of the same unnamed stream found at SA5, but on the west side of Ordway Road. Conditions here were much the same as it was for SA5. Despite our systematic surveys of what limited habitat was available, no individuals of *Ptilimnium nodosum* were found during the course of our field investigations here.

Survey Area 7 (SA7): SA7 is another segment of Bull Run, approximately 1500 feet east of Old Centreville Road. As with SA4, sufficient drainage area exists above this point to produce the openings in canopy suitable for harboring potential populations *Ptilimnium nodosum*. Some suitable structure within the bed of Bull Run was observed on the northern side. The southern side of Bull Run, however, was too deeply cut, with no exposure of bars or shoals conducive for the growth the plant. Despite our systematic survey of what potential habitat was available, no individuals of *P. nodosum* were found during the course of our field investigations of this site.

Given that our surveys were conducted during a time of year when the plant is deemed be searchable, that all potential habitat was canvassed during the course of our field investigations, and that we were unsuccessful in locating individuals of the target species, we consider there to be a low potential for the occurrence of *Ptilimnium nodosum* within the seven areas of potential habitat as previously identified by Stantec in connection with the EA of the Route 28 Corridor project.

4. LIMITATIONS

Our study was limited to the survey of *Ptilimnium nodosum* within the seven previously identified areas of potential habitat within the overall project, as delimited by Stantec, and did not include searches for potential populations of other rare, *Threatened* or *Endangered*

species, nor searches for *P. nodosum* outside of these limits. In addition, our study did not include the identification or delineation of wetlands, processing of permits, meetings with local, state or federal officials, land surveying services and environmental concerns or services that were not specifically described herein.

Ecological conditions and species distributions represent dynamic processes. The USFWS has specified the period of time that a survey is valid for each of the listed plant species in Virginia. Surveys for *P. nodosum* are good for a period of one year from the date of the survey. The findings presented in this report, therefore, are acceptable to the USFWS until September 18, 2020.

We appreciate the opportunity to have been of service to you on this project. Please do not hesitate to contact us should you have any questions regarding our findings.

Sincerely,

Garrie D. Rouse
Consulting Scientist

Attachment: Checklist of Plant Species Encountered during *Ptilimnium nodosum* Surveys (September 18, 2019)

Attachment

PARTIAL CHECKLIST OF PLANT SPECIES ENCOUNTERED DURING *PTILIMNIUM NODOSUM* SURVEYS, ROUTE 28 CORRIDOR ENVIRONMENTAL ASSESSMENT, PRINCE WILLIAM COUNTY, VIRGINIA (September 18, 2019)

Rouse Environmental Services

PARTIAL CHECKLIST OF PLANT SPECIES ENCOUNTERED DURING *PTILIMNIUM NODOSUM* SURVEYS, ROUTE 28 CORRIDOR ENVIRONMENTAL ASSESSMENT, PRINCE WILLIAM COUNTY, VIRGINIA (September 18, 2019)

Scientific Name:	**Common Name:**
Acer negundo L.	boxelder
Acer saccharinum L.	silver maple
Ageratina altissima (L.) King & H.E. Robins.	white snakeroot
Ambrosia artemisiifolia L.	annual ragweed
Andropogon gerardii Vitman	big bluestem
Artemisia vulgaris L.	common wormwood
Arthraxon hispidus (Thunb.) Makino	small carpgrass
Asclepias syriaca L.	common milkweed
Asimina triloba (L.) Dunal	pawpaw
Bidens aristosa (Michx.) Britt.	bearded beggarticks
Bidens bipinnata L.	Spanish needles
Bidens frondosa L.	devil's beggartick
Boehmeria cylindrica (L.) Sw.	smallspike false nettle
Bromus inermis Leyss.	smooth brome
Campsis radicans (L.) Seem. ex Bureau	trumpet creeper
Catalpa speciosa (Warder) Warder	northern catalpa
Centaurea biebersteinii DC.	spotted knapweed
Chasmanthium latifolium (Michx.) Yates	Indian woodoats
Cichorium intybus L.	chicory
Cirsium discolor (Muhl. ex Willd.) Spreng.	field thistle
Commelina communis L.	Asiatic dayflower
Dactylis glomerata L.	orchardgrass
Daucus carota L.	Queen Anne's lace
Dichanthelium clandestinum (L.) Gould	deertongue
Diospyros virginiana L.	common persimmon
Dipsacus laciniatus L.	cutleaf teasel
Dryopteris marginalis (L.) Gray	marginal woodfern
Echinochloa muricata (Beauv.) Fern.	rough barnyardgrass
Eclipta prostrata (L.) L.	false daisy
Eleusine indica (L.) Gaertn.	Indian goosegrass
Elymus virginicus L.	Virginia wildrye
Erechtites hieraciifolia (L.) Raf. ex DC.	American burnweed
Eupatorium serotinum Michx.	lateflowering thoroughwort
Eurybia divaricata (L.) Nesom	white wood aster
Fraxinus americana L.	white ash
Glechoma hederacea L.	ground ivy
Ipomoea lacunosa L.	whitestar
Juniperus virginiana L.	eastern redcedar
Justicia americana (L.) Vahl	American water-willow
Kyllinga pumila Michx.	low spikesedge
Leersia oryzoides (L.) Sw.	rice cutgrass
Leersia virginica Willd.	whitegrass
Lespedeza cuneata (Dum.-Cours.) G. Don	Chinese lespedeza

PARTIAL CHECKLIST OF PLANT SPECIES ENCOUNTERED DURING *PTILIMNIUM NODOSUM* SURVEYS, ROUTE 28 CORRIDOR ENVIRONMENTAL ASSESSMENT, PRINCE WILLIAM COUNTY, VIRGINIA (Continued)

Scientific Name:	**Common Name:**
Lindera benzoin (L.) Blume	northern spicebush
Lonicera japonica Thunb.	Japanese honeysuckle
Lonicera maackii (Rupr.) Herder	Amur honeysuckle
Ludwigia palustris (L.) Ell.	marsh seedbox
Microstegium vimineum (Trin.) A. Camus	Nepalese browntop
Morus alba L.	white mulberry
Murdannia keisak (Hassk.) Hand.-Maz.	wartremoving herb
Panicum dichotomiflorum Michx.	fall panicgrass
Pennisetum glaucum (L.) R. Br.	pearl millet
Perilla frutescens (L.) Britt.	beefsteakplant
Pilea pumila (L.) Gray	Canadian clearweed
Platanus occidentalis L.	American sycamore
Polygonum pensylvanicum L.	Pennsylvania smartweed
Polygonum perfoliatum L.	Asiatic tearthumb
Polygonum persicaria L.	spotted ladysthumb
Polygonum punctatum Ell.	dotted smartweed
Polygonum sagittatum L.	arrowleaf tearthumb
Polygonum virginianum L.	jumpseed
Polystichum acrostichoides (Michx.) Schott	Christmas fern
Quercus rubra L.	northern red oak
Quercus stellata Wangenh.	post oak
Robinia pseudoacacia L.	black locust
Rosa multiflora Thunb. ex Murr.	multiflora rose
Rubus argutus Link	sawtooth blackberry
Salix nigra Marsh.	black willow
Schizachyrium scoparium (Michx.) Nash	little bluestem
Schoenoplectus tabernaemontani Palla	softstem bulrush
Scirpus georgianus Harper	Georgia bulrush
Senna marilandica (L.) Link	Maryland senna
Setaria faberi Herrm.	Japanese bristlegrass
Solanum dulcamara L.	climbing nightshade
Solidago canadensis L.	Canada goldenrod
Sorghastrum nutans (L.) Nash	Indiangrass
Sorghum halepense (L.) Pers.	Johnsongrass
Symphyotrichum sp.	an aster
Toxicodendron radicans (L.) Kuntze	eastern poison ivy
Tridens flavus (L.) A.S. Hitchc.	purpletop tridens
Trifolium pratense L.	red clover
Verbesina alternifolia (L.) Britt. ex Kearney	wingstem
Viola sp.	a violet
Vitis sp.	a grape

APPENDIX C
USFWS BRIDGE ASSESSMENT FORMS

Bridge/Structure Assessment Form

This form will be completed and submitted to the District Environmental Manager by the Contractor prior to conducting any work below the deck surface either from the underside, from activities above that bore down to the underside, or that could impact expansion joints, from deck removal on bridges, or from structure demolish. Each bridge/structure to be worked on must have a current bridge inspection. Any bridge/structure suspected of providing habitat for any species of bat will be removed from work schedules until such time that the DOT has obtained clearance from the US Fish and Wildlife Service, if required. Additional studies may be undertaken by the DOT to determine what species may be utilizing structures prior to allowing any work to proceed.

Bridge #1	**Water Body** **Bull Run**	**Date/Time of Inspection** **9/18/2019 1100**

Route:	**County:**	**Federal Structure ID:**	**Bat Indicators** Check all that apply. Presence of one or more indicators is sufficient evidence that bats may be using the structure.				
28 Centreville Road	Fairfax	6269	Visual	Sound	Droppings	Staining	**Notes: (e.g., number & species of bats, if known. Include the results of thermal, emergent, or presence/absence summer survey)**
							Bridge assessed from suitable vantage points on ground that could be safely accessed.

Areas Inspected (Check all that apply)

Bridges		**Culverts/Other Structures**		**Summary Info (circle all that apply)**			
All vertical crevices sealed at the top and 0.5-1.25" wide & ≥4" deep		**Crevices, rough surfaces or imperfections in concrete**		**Human disturbance or traffic under bridge/in culvert or at the structure**	High	Low	None

All crevices >12" deep & not sealed		**Spaces between walls, ceiling joists**		**Possible corridors for netting**	None/poor	Marginal	Excellent
All guardrails				**Evidence of bats using bird nests, if present?**	Yes	No	
All expansion joints							
Spaces between concrete end walls and the bridge deck	X						
Vertical surfaces on concrete I-beams	X						

Assessment Conducted By: Sean Wender/Jason Mann Signature(s): 

District Environmental Use Only: Date Received by District Environmental Manager: _____

DOT Bat Assessment Form Instructions

1. Assessments must be completed a minimum of 1 year prior to conducting any work below the deck surface on all bridges that meet the physical characteristics described in the Programmatic Consultation, regardless of whether assessments have been conducted in the past. **Due to the transitory nature of bat use, a negative result in one year does not guarantee that bats will not use that structure in subsequent years.**
2. Any bridge/structure suspected of providing habitat for any species of bat will be removed from work schedules until such time that the DOT has obtained clearance from the USFWS, if required. Additional studies may be undertaken by the DOT to determine what species may be utilizing each structure identified as supporting bats prior to allowing any work to proceed.
3. Estimates of numbers of bats observed should be place in the Notes column.
4. Any questions should be directed to the District Environmental Manager.

Bridge/Structure Assessment Form

This form will be completed and submitted to the District Environmental Manager by the Contractor prior to conducting any work below the deck surface either from the underside, from activities above that bore down to the underside, or that could impact expansion joints, from deck removal on bridges, or from structure demolish. Each bridge/structure to be worked on must have a current bridge inspection. Any bridge/structure suspected of providing habitat for any species of bat will be removed from work schedules until such time that the DOT has obtained clearance from the US Fish and Wildlife Service, if required. Additional studies may be undertaken by the DOT to determine what species may be utilizing structures prior to allowing any work to proceed.

Bridge #2	**Water Body** **Bull Run**	**Date/Time of Inspection** **9/18/2109 1200**

Route:	**County:**	**Federal Structure ID:**	**Bat Indicators** Check all that apply. Presence of one or more indicators is sufficient evidence that bats may be using the structure.				
616 Old Centreville Road	Prince William	14303	Visual	Sound	Droppings	Staining	**Notes: (e.g., number & species of bats, if known. Include the results of thermal, emergent, or presence/absence summer survey)**
							Bridge assessed from suitable vantage points on ground that could be safely accessed.

Areas Inspected (Check all that apply)

Bridges		**Culverts/Other Structures**		**Summary Info (circle all that apply)**			
All vertical crevices sealed at the top and 0.5-1.25” wide & ≥4” deep		**Crevices, rough surfaces or imperfections in concrete**		**Human disturbance or traffic under bridge/in culvert or at the structure**	High	Low	None

All crevices >12" deep & not sealed		**Spaces between walls, ceiling joists**		**Possible corridors for netting**	None/poor	Marginal	Excellent
All guardrails				**Evidence of bats using bird nests, if present?**	Yes	No	
All expansion joints							
Spaces between concrete end walls and the bridge deck	X						
Vertical surfaces on concrete I-beams	X						

Assessment Conducted By: Sean Wender/Jason Mann Signature(s): 

District Environmental Use Only: Date Received by District Environmental Manager: _____

DOT Bat Assessment Form Instructions

1. Assessments must be completed a minimum of 1 year prior to conducting any work below the deck surface on all bridges that meet the physical characteristics described in the Programmatic Consultation, regardless of whether assessments have been conducted in the past. **Due to the transitory nature of bat use, a negative result in one year does not guarantee that bats will not use that structure in subsequent years.**
2. Any bridge/structure suspected of providing habitat for any species of bat will be removed from work schedules until such time that the DOT has obtained clearance from the USFWS, if required. Additional studies may be undertaken by the DOT to determine what species may be utilizing each structure identified as supporting bats prior to allowing any work to proceed.
3. Estimates of numbers of bats observed should be place in the Notes column.
4. Any questions should be directed to the District Environmental Manager.

Bridge/Structure Assessment Form

This form will be completed and submitted to the District Environmental Manager by the Contractor prior to conducting any work below the deck surface either from the underside, from activities above that bore down to the underside, or that could impact expansion joints, from deck removal on bridges, or from structure demolish. Each bridge/structure to be worked on must have a current bridge inspection. Any bridge/structure suspected of providing habitat for any species of bat will be removed from work schedules until such time that the DOT has obtained clearance from the US Fish and Wildlife Service, if required. Additional studies may be undertaken by the DOT to determine what species may be utilizing structures prior to allowing any work to proceed.

Bridge #3	**Water Body** **Flat Branch**	**Date/Time of Inspection** **9/18/2019 1300**

Route:	**County:**	**Federal Structure ID:**	**Bat Indicators** Check all that apply. Presence of one or more indicators is sufficient evidence that bats may be using the structure.				
1530	Prince William	25606	Visual	Sound	Droppings	Staining	**Notes: (e.g., number & species of bats, if known. Include the results of thermal, emergent, or presence/absence summer survey)**
							Bridge assessed from suitable vantage points on ground that could be safely accessed.

Areas Inspected (Check all that apply)

Bridges		**Culverts/Other Structures**		**Summary Info (circle all that apply)**			
All vertical crevices sealed at the top and 0.5-1.25” wide & ≥4” deep		**Crevices, rough surfaces or imperfections in concrete**		**Human disturbance or traffic under bridge/in culvert or at the structure**	High	Low	None

All crevices >12" deep & not sealed	X	**Spaces between walls, ceiling joists**		**Possible corridors for netting**	None/poor	Marginal	Excellent
All guardrails	X			**Evidence of bats using bird nests, if present?**	Yes	No	
All expansion joints							
Spaces between concrete end walls and the bridge deck	X						
Vertical surfaces on concrete I-beams	n/a						

Assessment Conducted By: Sean Wender/Jason Mann Signature(s): 

District Environmental Use Only: Date Received by District Environmental Manager: _____

DOT Bat Assessment Form Instructions

1. Assessments must be completed a minimum of 1 year prior to conducting any work below the deck surface on all bridges that meet the physical characteristics described in the Programmatic Consultation, regardless of whether assessments have been conducted in the past. **Due to the transitory nature of bat use, a negative result in one year does not guarantee that bats will not use that structure in subsequent years.**
2. Any bridge/structure suspected of providing habitat for any species of bat will be removed from work schedules until such time that the DOT has obtained clearance from the USFWS, if required. Additional studies may be undertaken by the DOT to determine what species may be utilizing each structure identified as supporting bats prior to allowing any work to proceed.
3. Estimates of numbers of bats observed should be place in the Notes column.
4. Any questions should be directed to the District Environmental Manager.

APPENDIX D
REPRESENTATIVE PHOTOGRAPHS

Photo 1: Bridge 1. View of expansion joint between lanes of Route 28 crossing Bull Run. Staining on piers appears to be due to runoff from road.

Photo 2: Bridge 1. View of pigeon nest on beam. Bird droppings present but no bat guano observed.

Photographs taken by: S. Wender and J. Mann
Stantec
September 18. 2019
Project 203401138

Photo 3: Bridge 1. View of water stains and accumulated sediment and gravel from road at the abutment. No bat guano was observed.

Photo 4: Bridge 1. View of concrete and debris accumulated on piers. Debris on beams from spider webs and bird droppings. No bat guano was observed.

Photographs taken by: S. Wender and J. Mann
Stantec
September 18. 2019
Project 203401138

Photo 5: Bridge 2. View of bridge and piers crossing Bull Run. No visible staining or guano.

Photo 6: Bridge 2. View of abutment and steel decking. No visible staining or guano.

Photographs taken by: S. Wender and J. Mann
Stantec
September 18. 2019
Project 203401138

Photo 7: Bridge 3. View of low bridge spanning Flat Branch. No guano or staining observed. Several bird nests and droppings were observed.

Photo 8: Bridge 3. View of abutment and steel beams and decking. No guano or staining observed. Scattered mouse droppings present.

Photographs taken by: S. Wender and J. Mann
Stantec
September 18. 2019
Project 203401138