

West Virginia Mussel Survey Protocols

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Middle Island Creek mussels including federally endangered Snuffbox. Photo by Janet L. Clayton

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1.0 Introduction

All mussels are protected in the State of West Virginia pursuant to West Virginia §20-2-4 and CSR 58-60-5.11. In addition, ten federally endangered freshwater mussel species (ES) are known to occur in the State. These species are protected by the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Impacts to State and Federal protected mussels and their habitats should be avoided and minimized to the maximum extent practicable. All streams that contain mussels or potential mussel habitat must be surveyed prior to any proposed streambed disturbance. Areas with mussels or mussel habitat should be avoided whenever possible. The current mussel stream list and associated shapefile can be found at the West Virginia Division of Natural Resources' (WVDNR) website <http://www.wvdnr.gov/Mussels/Main.shtm>.

The protocols herein are designed to document the potential presence or absence of federally listed mussel species as well as provide for the long-term sustainability of native mussel communities within West Virginia. These protocols were developed to provide consistent and standardized guidance to project applicants about acceptable survey methods and levels of effort for different types of projects that are commonly encountered. The current accepted protocol and supporting materials can be found at the WVDNR website mussel page. This Protocol is not designed to dictate research projects, but only those surveys used to make management decisions regarding instream impacts.

2.0 Stream Groups in WV

For ease of determining the appropriate survey type where state and federally protected mussels may occur, West Virginia mussel streams have been placed into four groups. A stream list by County is provided as Appendix A on the WVDNR's website mussel page. An NHD shapefile of mussel streams will also be posted to the website and will assist in determining stream reaches requiring surveys. Using the NHD mussel stream shapefile, locate the point of anticipated stream impact. If it falls on a highlighted stream then a mussel survey is required. This shapefile replaces the previous protocol criteria of "watershed area above the direct impact point is 2590ha (10mi²) or larger". The metadata associated with the file will also indicate to which group the stream reach belongs. This stream layer is applicable to direct effect areas only. If the impact area is upstream of a highlighted Group 2 stream reach then the applicant is still required to address indirect effects.

Group 1: High Quality Streams (as listed by the WVDNR and having potential habitat for mussels) and State listed mussel streams, ES not expected.

Group 2: Small to mid-sized streams with ES expected.

Group 2.5: These are typically small streams that join either a Group 2 or Group 4 Stream which may potentially contain ES and thus the lower ½ mile of the stream is considered a Group 2.

Group 3: Large Rivers where ES are not expected. These include the Ohio River upstream (US) of Hannibal Lock and Dam and the Monongahela River.

Group 4: Large Rivers where ES are expected. These include the Ohio River downstream (DS) of Hannibal Lock and Dam, Little Kanawha River (slack-water section adjoining the Ohio River) and the Kanawha River.

3.0 Justifications and Alternatives Analysis

Various laws, regulations, and policies require that impacts to aquatic resources, including freshwater mussels, endangered species and their habitats, be avoided and minimized to the maximum extent practicable. For example, Clean Water Act 404 (b) (1) Guidelines state that “no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem.” The Guidelines further specify that the evaluation of practicable alternatives should include alternative construction methods that do not involve dredge or fill material into waters of the U.S. and alternative locations including “areas not presently owned by the project proponent but which could reasonably be obtained, utilized, expanded or managed in order to fulfill the basic purpose of the proposed activity” (§ 230.10 (a) (2)). Nationwide permit pre-construction notifications for the U.S. Army Corps of Engineers in West Virginia must include a “description of the ways in which the proposed project has been designed to avoid and minimize adverse impacts”. The General Conditions that apply to all nationwide permits also specify that “no activity may occur in areas of concentrated shellfish populations,” unless the activity is related to various shellfish harvesting or restoration activities. The Endangered Species Act, through the Section 7 consultation process, requires that Federal agencies consult with the U.S. Fish and Wildlife Service (USFWS) to identify and implement measures to avoid or minimize adverse effects to federally listed species, prior to issuing any permits that may result in the incidental take of federally listed species.

Project proponents can frequently save time and money, and avoid delays in their project permitting, by developing project alternatives early in their planning process. In addition, during previous project consultations involving impacts to mussel populations, the USFWS and WVDNR have found that practicable alternatives to avoid and minimize impacts can be developed for almost all projects.

To ensure that projects are implemented consistent with regulations and to minimize project delays, all survey proposals submitted to the USFWS and WVDNR should include documentation that avoidance is not possible and should also include an alternatives analysis. Survey permits may not be approved if the applicant does not provide adequate justification that instream impacts cannot be avoided. **Discussion of alternatives and how impacts will be avoided and minimized shall be included in the scope of work.**

3.1 Alternative Construction Methods:

Projects should first be designed to avoid and minimize impacts to waters of the U.S. including impacts to streams containing mussel populations. For example, where possible, road crossings should be designed to completely span mussel streams. Routes for pipelines should be designed to avoid crossing mussel streams and minimize the number of stream crossings.

Activities such as pipeline/waterline crossings shall address alternative methods such as directional boring. Horizontal drilling practices shall be the first priority over open trenching to possibly minimize impacts to mussels and avoid habitat degradation and fragmentation. A response plan for an inadvertent release shall be provided along with an analysis on the potential for such an event to occur. If horizontal drilling practices are not being proposed, documentation as to why this alternative is not practicable shall be provided. This documentation shall include detailed information on project constraints, and engineering and/or geologic evaluations sufficient to justify why this construction method cannot be implemented or would have a high likelihood of failure.

3.2 Alternative Locations:

Moving project locations slightly upstream or downstream, or making minor modifications to the project design, is often sufficient to avoid and minimize impacts to mussel populations including endangered species and may allow projects to proceed with minimal delays. Any project that has potential alternative locations for activities (example: bridge alignments, pipeline crossings) shall include surveys for alternative locations. We recommend a phased approach to prioritize sites with follow-up surveys within the least impacting project site selected. All proposals shall include survey areas large enough to include all alternative locations.

4.0 Surveyor Qualifications

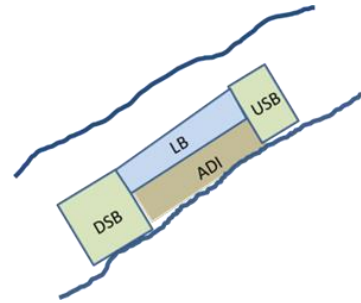
Only approved surveyors will be permitted to conduct/contract mussel surveys in WV. Approval is a two part process. Once approved the surveyor must meet specific standards to maintain certification.

- Identification testing is required through the WVDNR.
 - Approved for endangered species streams (Groups 2 and 4): overall score of 85% and score 100% on the endangered species.
 - Non-endangered mussel streams (Groups 1 and 3): overall score of 85%.
 - The test is closed book and closed shell (simulating live condition).
- Must possess adequate experience and submit references.
 - Endangered species streams (Groups 2 and 4): at least 3 years of field experience conducting surveys similar to the WV Mussel Survey Protocols and submit two acceptable letters of reference.
 - Non-endangered species streams (Groups 1 and 3): at least 2 years of field experience conducting surveys similar to the WV Mussel Survey Protocols and submit two acceptable letters of reference.
- To maintain certification the surveyor must:
 - Provide documentation that the surveyor is maintaining familiarity with WV's federally listed species through training or fieldwork. Minimum requirements based on a running two year average: Must handle 5 individuals (5 each of males and females if applicable) of each species per year in the field; or 0.5 hours per species in a museum or reference collection. Specimens can be from outside WV.
 - Provide training hours and location of reference collection with approximate number of each federally listed species, by sex, handled each year.
 - If reference collection is not a recognized museum such as Ohio State University, Carnegie, etc. then the collection must have prior approval from the State Mussel Program leader.
 - Provide approximate number of each federally listed species, by sex, handled each year in the field.
 - Provide a yearly tally of number of surveys conducted by Stream Group. These may include surveys in other states and placed into equivalent Stream Group.
 - Reporting is due February 15 for the previous year's efforts.

5.0 Establishing Areal Extent of the Project – Project Specific Guidance

Five distinct survey areas can be defined for each project. These include the area of direct impact (ADI), upstream buffer (USB), lateral buffer (LB), downstream buffer (DSB), and spudding area if not included in the other areas. Table 3 (Section 10) summarizes the specific layout of buffer zones and survey areas organized by stream Group and potential project type.

Where a project does not span the width of the stream, the survey widths of the USB and the DSB shall be equal to the width of the ADI and includes any associated LB applied to the ADI (Example at right).



Special considerations are discussed in more detail below.

5.1 Commercial Sand and Gravel Dredging

1. Applications for permits will be considered only within the New Cumberland Pool of the Ohio River.
2. If less than 5 years has elapsed since the last dredging of the specific site, then no additional surveys shall be required. If more than 5 years has elapsed or the previously dredged area is being expanded, then mussel surveys are required.
3. Dredging is prohibited within 100m of the shoreline.
4. Dredging is prohibited within 457m (1500ft) upstream, 152m (500ft) lateral and downstream of a mussel population. (Per existing permit.)
5. Dredging is prohibited within 500m upstream and 150m downstream of an island and all areas in between.
6. Dredging is prohibited within 152m (500ft) upstream and 91m (300ft) downstream of embayments and stream mouths. (Per existing permit.)
7. Dredging is prohibited within 305m (1000ft) of water treatment facility intakes. (Per existing permit.)

5.2 Maintenance Dredging

1. Instream disposal of dredge material is not covered within project specific guidance and will require additional coordination with the WVDNR and USFWS.
2. If less than 5 years has elapsed since the last dredging of the specific site, then no additional surveys shall be required. If more than 5 years has elapsed or the previously dredged area is being expanded or moved, then mussel surveys shall be required.
3. See Spudding, Section 7.1.12. (Example 1)

5.3 Barge Loading Facilities (Non-Dredging Activities)

1. If the activity is at an existing facility and includes installation of mooring cells, tri-ties, etc. within the current foot-print of the facility then only the ADI and surrounding buffers must be surveyed using cells. For Group 4 streams, qualitative timed searches for species richness curve are to be conducted around the cells. (Examples 2-4)
2. For Group 4 streams, if the proposed activity is a new facility or expansion of an active facility downstream, the survey extent shall include at a minimum 500m DSB and 150m USB and 150m LB of the ADI. The survey shall include sufficient area such that placement of structures and barge activities can be placed within the area least likely to impact mussel communities or potential habitat. If the proposed activity includes an active facility and the expansion is upstream then the survey extent shall include a 150m buffer surrounding the ADI. Transects should be placed to bisect mooring locations if known.
3. See Spudding, Section 7.1.12. (Example 1)

5.4 Large Scoping Projects (such as hydropower studies or new barge loading facilities, determining alignment for bridges, or determining location for any instream construction such as intakes and discharges)

1. Transect spacing shall not exceed 100m in Group 3 and 4 streams. In Group 1 and 2 streams transect spacing shall not exceed 25m on average. The transects should be placed in the best available habitat but maintain an average 25m spacing. Such a transect layouts are not designed to find ES but to document mussel concentrations to aid in project design. Once the project design is drafted then a Phase 1 and potentially a Phase 2 survey would be required. This type of survey assists in the first step which is to avoid impacts.
2. Transects should be placed throughout any potential alternative areas plus buffer zones.

5.5 Bridge Projects

1. **Note: hydraulic changes occur with causeway construction and shall be considered as part of the ADI. If a causeway is deemed necessary, temporary bridges incorporated into the causeway design is the preferred method.**
2. The ADI shall include any area that may be impacted by bridge construction, demolition, causeway, staging areas, etc. Any area that may be physically and hydraulically impacted shall be included in the survey extent.
3. For new bridges, or complete removal and replacement of existing bridges, initial surveys shall include all areas that can be used for alternative construction sites.
4. If no other impacts, the ADI shall include a 5m buffer surrounding a pier.

5.6 Waterline/Pipeline and other Corridor Disturbances

1. Discharge Outfalls, including those with diffusers, shall include the mixing zone (MZ) and appropriate buffer as described.
2. If the pipe is not trenched (example – suspended on pillars), a 5m buffer is acceptable on the DS extent. Depending on discharge composition of the outfall, relocation of mussels from the MZ may be required.

5.7 Shoreline Structures (example riprap)

1. If the ADI near shore is anticipated to be more impacted than further out, then the area should be broken into two cells. For example, you have an undulating shoreline which will be riprapped. The keyway will definitely impact the first 3m but may or may not impact out to 10m. It is better to conduct a 3m wide cell and then another 7m wide cell. If it is all covered in one cell, and mussels are found only in the outer portion of the cell, it could affect management decisions and require salvage when none is needed.
2. See Spudding, Section 7.1.12.

5.8 Water Intake

1. Water Intake structures covered here are associated with the stream edge. Those that extend into the stream would be covered under waterline/pipeline above. Water withdrawals from Group 2 streams should include additional coordination with the USFWS including an approved monitoring plan and evaluation of areas that could be affected by the water withdrawal.
2. See Spudding, Section 7.1.12.

5.9 Non-Commercial Docks in Group 3 and 4 streams do not require a mussel survey as long as they meet all the following criteria:

1. Do not extend riverward more than 10m from low water mark (water's edge),
2. Do not contain any fill material other than pilings or posts, and any shoreline protection material such as riprap is only placed above the low water mark,
3. Contain 4 or fewer pilings or posts that impact an area less than a combined total of 1m²,
4. Are less than 10m (32.8ft) in length,
5. If within 500m (1640ft) of an island must receive clearance from USFWS.

6.0 Survey Application Requirements and Timelines

Even though standardized protocols are established for most types of projects, survey plans must be provided to appropriate State and Federal officials when applying for a scientific collecting permit. This is to ensure that the appropriate level of effort is being applied for the given stream type and construction activity and to allow time for agency staff to review existing data from the proposed survey area and work with the applicant to design the appropriate survey extent as described below. Appropriate State and Federal officials shall be notified at least 30 days prior to the time the actual survey will occur. In addition, State and Federal agencies shall be given at least 30 days to review survey results prior to the anticipated start of any construction activity. Contact information is provided in Table 1, Section 10.0.

Requests for surveys shall include a full description of the project. In Group 2 and 4 streams this is important so that effects from all aspects of the project can be evaluated, and to determine whether other federally listed resources may be affected. It is important to note that "project" includes all project features, not just the portion of the project prompting the need for a mussel survey or the submittal of a permit application (e.g., to West Virginia Department of Environmental Protection or the U. S. Army Corps of Engineers). For example, an oil or gas pipeline stream crossing project would include not only the stream crossing, but also the well pad, the roads, staging areas, impoundments and holding pits, and oil and gas lines associated with the well or well field. This data will help to better conserve mussel resources, ensure that effects from interrelated and interdependent projects are considered, evaluate cumulative impacts, and better implement recovery efforts for these species.

Activities to be conducted on any federally endangered species (ES) stream or potential ES stream (Groups 2 and 4) must have written concurrence from the USFWS prior to conducting any project activities including surveys, relocations and/or construction activities. Non-ES streams (Groups 1 and 3) require coordination with the WVDNR only.

6.1 Survey Scope Checklist:

- Full description of the project including justification, alternative(s), minimization efforts, etc.
- Protocol form.
- Figure showing survey design overlaid on project diagram.
 - Show all areas as appropriate (ADI, salvage buffer, USB, LB, DSB, MZ and spud areas). These areas are described in further detail in Section 7.1.1
- Map showing project location sufficient to delineate all pertinent impact and buffer areas on recognizable landscape features (approximately 1:25,000).
- Survey methodology.
- Who will be conducting the survey? If not the approved surveyor, qualifications of collectors must be provided along with a QA/QC plan.

7.0 Conducting the Survey

7.1 Definitions

7.1.1 Survey Areas include area of direct impact (ADI), upstream buffer (USB), upstream salvage buffer (USSB), downstream buffer (DSB), downstream salvage buffer (DSSB), lateral buffer (LB), and lateral salvage buffer (LSSB). The salvage zone includes the ADI, USSB, LSB, and DSSB. The spud area includes any area in which the work barge may be spudded during the project (Section 7.1.12). Mixing zone (MZ) must be addressed for all discharge type projects.

7.1.2 Timed Search (qualitative) surveys consist of visually searching throughout a larger defined area (such as DSB, DSSB, ADI, LB, LSB, USB, USSB or mussel concentration) for a given period of time.

Timed searches can be applied to each Group as follows:

- **Group 1:** No need to divide into cells, although maybe considered with respect to potential mussel salvage. Cover the whole ADI or buffer area in a time period defined by the size of the area to be surveyed (timed searches within each survey area) at a rate of 0.2 min/m^2 in areas of heterogeneous substrate, then an additional 0.3 min/m^2 if mussels are found. The areas may be divided into smaller units (cells – no size limit) if the area can be stratified by habitat. For example the DSB has a large area that appears to be of poor habitat and mussels are not expected. Delineate the area and survey at rate of 0.2 min/m^2 . The other sub area has higher potential for mussels and indeed a few were found. This area would then be required to be surveyed for an additional 0.3 min/m^2 . (Example 5)
- **Group 2:** Timed searches are not required if using cells. If stream width is greater than 20m and transects are used, then timed searches are to be used to complete the species richness curve.
- **Group 3:** Used to delineate mussel concentrations as needed,
- **Group 4:** Conduct timed searches between transects with suitable habitat (if no mussels are found along the transect), and in mussel concentrations to increase the probability of finding an ES and to develop a species richness curve (Section 7.1.7).

7.1.3 Cells are more appropriate for surveying small to mid-sized Group 2 streams and are required on Group 2 streams 20m wide or less. Cells are encouraged for all surveys except in Group 3 and 4 streams that have extensive ADI and buffer areas. In these large areas the mussel concentrations are best delineated using transects. A cell survey is conducted by dividing each survey area into a series of cells in which each cell is surveyed and data recorded separately. Maximum acceptable cell size is 100m^2 . Minimum search effort shall be 0.2 min/m^2 . If any mussels are found, then an additional 0.3 min/m^2 is required which provides for a minimum total search effort of 0.5 min/m^2 . Cells are required for salvage unless using moving transects (Section 7.1.10).

Cells further defined by group:

- **Group 1:** Not required though may be used if needed to better apply search effort in areas with mussels and suitable habitat, no maximum size defined.
- **Group 2:** All streams <20m wide, preferred in all Group 2 streams, particularly if impact area and buffers are small. If surveying with transects, once a trigger is established, all triggered areas plus areas of similar habitat between triggered areas plus a 10m buffer surrounding are to be surveyed using cells.
- **Group 3:** Small impact areas (i.e. boat ramp, barge cell, water intake, bridge pier)
- **Group 4:** Small impact areas (i.e. boat ramp, barge cell, water intake)

7.1.4 Transect Surveys are conducted by placing lines perpendicular to flow and subdivided into segments as noted below for each stream group. A transect survey must contain at least 500m of transect search area and consist of a minimum of five transects, three of which must be placed within the ADI. Along each transect, surveyors shall visually search (Section 7.1.9) an area 1m wide for mussels and record all data separately for each segment. The entire segment must be covered and the minimum search effort for transects shall be 1min/m² in heterogeneous substrates.

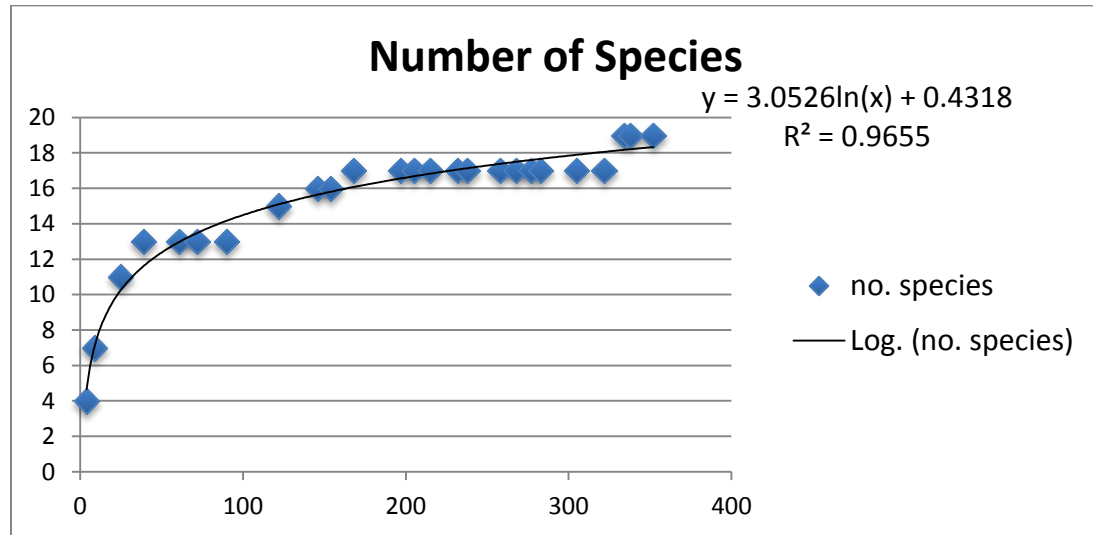
- **Group 1:** Transects (5m segments) may be used on large (>50m wide) Group 1 streams to delineate areas which require additional survey effort. Maximum 10m transect spacing.
- **Group 2:** Transects (5m segments) may be used for Group 2 streams (greater than 20m wide) if it appears the reach may be stratified by habitat and some strata appear to have limited mussel resources. Transects would be used to delineate the habitats and mussel resources that require further survey effort by cells. If surveying with transects, once a trigger is established, all triggered areas plus areas of similar habitat between triggered areas plus a 10m buffer surrounding are to be surveyed using cells.
- **Group 3 and 4:** Transects (10m segments) may be used for large impact areas such as proposed maintenance dredging. If using transects, a Phase 1 survey within a Group 4 stream must include qualitative timed search surveys for development of a species richness curve. Maximum transect spacing is 10m within the ADI and salvage buffers, 25m within all other areas.

7.1.5 Salvage Zone is defined as the area within the ADI containing mussels connected by similar habitat plus associated buffer areas described in Table 3 from which mussels must be relocated prior to conducting instream activities.

7.1.6 Quantitative Samples are required within the salvage zone as part of a Phase 2 survey on Group 2 streams only if a mussel concentration area is located within the salvage zone. These samples shall consist of 0.25m² quadrats using random start methodology as described by Smith *et al.* 2001. Substrate shall be excavated to a depth of 15cm (6in) or hardpan. The material shall be collected and taken to the surface and sorted removing all live and dead shell material. The minimum number of samples required is based on the rate of 3 quads per 100m² or 3 quads per 10 by 10m cell area within the delineated area of the mussel concentration area within the salvage zone only. A minimum of 50 quadrat samples shall be collected regardless of sample area.

7.1.7 Species Richness Curve shall be developed for Group 2 and 4 streams to demonstrate that most species have been recorded. Data from samples within mussel concentration areas should be used to develop the curve. Data collected from Group 2 cells do not need supplemented with timed searches. Data from Group 4 transects will need to be supplemented with timed searches conducted within the mussel concentration area (10min increments) until no new species are found in six consecutive samples. For example, if in bag six a new species is recorded then another six samples are required assuming no new species were found in them. The Species Richness Curve is generated by plotting cumulative number of individuals (X axis) vs. cumulative number of species (Y axis). Sufficient data should be collected to reach the plateau on this chart. For curve development, each transect segment is a sample, each quadrat excavation is a sample, and each qualitative search effort of 10min is a sample. A chart depicting the

curve and associated logarithmic regression line shall be provided in the report. The number of individuals required to be collected for recovery of an additional species shall be calculated using the regression model. In the example below, a total 352 individuals were collected of 19 species. Using the regression formula, it would require 611 individuals to find one additional species.



- 7.1.8 Mussel Concentrations and Potential ES areas:** Mussel Concentration Area is defined for purposes of determining potential for ES. The Mussel Concentration Area is defined as an area encompassing all triggered areas connected by similar habitat plus a 10m buffer surrounding it. Not detecting an ES during a Phase 1 survey does not confirm that it is not present. The presence of a diverse mussel concentration indicates ES potential. The mussel concentration area may encompass multiple areas only if they are separated by more than 20m of dissimilar or unsuitable habitat, otherwise the entire area should be surveyed. Trigger criteria are as follows:
- **Group 2:** 2 species not in Table 2 (Section 10) and/or density of 0.5/m² (all species combined)
 - **Group 4:** 3 species not in Table 2 along any 1 transect or combination of transects equal to 100m or within 100m² of cells, or within a timed search survey between transects and/or density of 0.5/m² (all species combined) within any area of the survey.

If a mussel concentration is found, then ES may be present. These areas should be avoided to the maximum extent practicable. If the area cannot be avoided then a Phase 2 survey must be undertaken as described below. The species listed in Table 2 are not used in describing a mussel concentration with ES potential due to their general habitat preferences and being commonly found in lakes and slackwater and not typically associated with the current list of ES found within West Virginia.

- 7.1.9 Visual or Surface Searches:** A visual search includes moving cobble and woody debris; hand sweeping away silt, sand and/or small detritus; and disturbing/probing the upper 5cm (2in) of substrate in order to better view the mussels which may be there. A minimum effort of 1.0 min/m² shall be expended in areas of heterogeneous substrate and 0.5 min/m² of homogenous substrate for transect surveys, 0.2 min/m² for cells

without mussels and 0.5 min/m² for cells with mussels. The effort for timed searches in Group 1 streams is the same as that for cells. Waterscopes are typically not a good method for conducting the above searches as the substrate is to be disturbed and probed for mussels not visible at the substrate surface.

7.1.10 Habitat: appropriate information describing depth and habitat, based on the modified Wentworth scale, shall be recorded by cell or transect segment. Additional descriptions, such as depositional areas, detritus, scoured areas, etc., may be used for further clarification. Minimum search effort is based on the type of habitat present. A mixture of substrates such as sand and cobble are defined as heterogeneous. If there are rocks present that require flipping and moving to look under and around them, this is heterogeneous substrate. Homogenous substrates are those that can be easily surveyed by running fingers through the substrate such as silt and loose sand or bedrock.

7.1.11 Moving Transect is a method used for Group 1 surveys or mussel salvage whereby a defined section is cleared, and then the line is moved to define a new area for clearing. For example, a 1m area upstream of an established transect line is searched and mussels salvaged. A minimum effort of 0.5 min/m² is required per pass if mussels are observed. Successive passes are to be made through the area per salvage criteria (Section 8.0). Once the area is cleared, the transect is moved upstream in 1m increments, and the new areas are cleared sequentially. The process is repeated until the entire salvage area is cleared of mussels. Number of mussels and effort per pass is to be recorded.

7.1.12 Mussel Processing: In each segment or cell, mussels observed (live and dead) are to be bagged and brought to the surface for further processing and positive identification. Mussel nomenclature shall follow that of Williams *et al.* 2017 or any newer common and scientific names document posted to the FMCS website (molluskconservation.org). Mussels shall be kept in water at all times, except for the brief period that they need to be out of the water to be measured or photographed, but no longer than five minutes at a time. Mussels observed along the transect or within a cell will be recorded as occurring in a particular segment or cell.

All ES are to be hand-placed into the substrate. For Group 3 and 4 streams, non-ES mussels may be dropped from a boat into the delineated area from May 1 to September 1. In areas of high velocity such as the upper Kanawha River, Group 1 and 2 streams, or any stream from September 1 to May 1, mussels are to be hand-placed into the substrate.

7.1.13 Spudding: Work barges are typically held in place by spuds which are pipes or poles that can be driven into the river bottom to provide stability. Spuds vary in size. Project designs should include the associated impact expected by spudding if it is to occur outside of the ADI. Project impact minimization procedures can include reducing the number of times the work barges need to be moved during the operation. The project description should



include size and number of spuds that will be used and the expected number of movements. The project diagram should depict the spud area if outside the ADI and data should be provided for this area separately. (Example 1)

7.2 Survey Conditions, Constraints, and Data Required

7.2.1 Data Longevity:

Survey data collected at a specific site will be considered valid for five years from the date the survey was conducted. If mussel relocations are conducted, they should be done within the same field season as the expected instream activities. If the proposed instream activities are to be conducted before July 15, then relocations may be conducted within the previous field season. After July 15, additional relocation efforts may be required just prior to construction activities depending on the results of earlier survey/relocation efforts. Areas that have been dredged within the previous five year period do not need to be resurveyed unless the area is to be expanded or moved. The previous data of June 15 was changed to July 15 due to the overlap of the fish spawning season which closes July 1. This now allows the project 15 days post fish spawning season to commence construction activities.

7.2.2 Mussel Survey Period:

The survey period shall be from May 1 to October 1. Requests to conduct surveys outside this time period will generally not be approved. Surveys to be completed in the current calendar year should have the scope of work to the appropriate State and Federal official by September 1. Any survey work approved outside this period will be done only under extenuating circumstances, with separate approval obtained from the appropriate State and Federal agencies prior to conducting the work, and may require a revised protocol.

7.2.3 Visibility Requirements:

Qualitative surface surveys must have a minimum visibility of one-half meter (50cm, or approx. 20in), with or without lights at **depth of survey**. If suitable visibility is not present at the intended time of the survey, then the survey must be re-scheduled, or a different protocol must be employed in consultation with the appropriate State and Federal agencies. (Example, more extensive quantitative surveys with excavations may be required). Visibility (in centimeters) is a required field on the Stream and Weather Conditions datasheet.

7.2.4 Workable Flow Requirements:

Surveys should be conducted under low to moderate flows. If the area cannot be effectively surveyed under existing flow conditions the survey must be re-scheduled. Any variance must be approved by the appropriate State and Federal agencies.

7.2.5 Minimum Data to be Recorded:

Standard WVDNR datasheets can be found on the WVDNR website mussel page. **All datasheets are to be completed in their entirety and shall be incorporated as appendices in the final project report.** Data shall be compiled and summarized separately at a minimum for all areas (Section 7.1.1), if applicable. A separate datasheet is required for qualitative search(es) within the potential relocation area(s). At a minimum, coordinates, in decimal degrees, shall be provided for the US and DS extent of the USB, ADI, DSB, and any relocation sites. A photographic voucher of all native species must be provided. Any questionable individuals should also be photo vouchered

and should be videoed providing a better reference for verification. The final report shall include a map of the surveyed area along with the proposed project activities, and a copy of the valid collecting permit. **Note: stating “see attached report” on the data sheet is not acceptable. If you are asked to collect a particular type of data, it shall be in the report or attached as appendices.**

7.3 Extent of Areas to be Surveyed

- 7.3.1 **Minimum coverage** shall include the area of direct impact (ADI) and appropriate buffers, including any alternative locations. See also Spudding, Section 7.7.13. Table 3 summarizes buffer requirements by stream group and activity type. If the project may affect the local hydraulics of the stream, such as hydropower projects or installation of in-stream structures, then the survey effort shall encompass the area that may be affected. Hydraulic modeling may be required to determine the extent of hydraulic changes. If modeling is not conducted prior to surveying, the survey shall extend at least 1.6km (1mi) downstream. Additional surveys may be required if subsequent modeling determines hydraulic changes will extend further downstream.
- 7.3.2 The **mixing zone** of an outfall shall be included within the survey area as shall the appropriate buffers around the mixing zone as described in Table 3. According to the WV Department of Environmental Protection (WVDEP) (http://www.dep.wv.gov/WWE/permit/individual/Documents/370_Mzguide.pdf), an outfall should not discharge within 5 river widths of sensitive areas, endangered species, public water supply intakes, bathing areas, tributary mouths, or other point source discharges. If they do, the initial downstream boundary estimations for the mixing zone should be at a distance preventing overlap. If not, the initial downstream boundary estimations should be a distance of 5 river widths. Mixing zone, as defined, cannot harm endangered species. Some mussels, including endangered species are more sensitive than species used to develop WV water quality criteria, and in these cases the mixing zones should be developed based on review of the available literature. The buffer zone should extend at least an additional 100m downstream of the mixing zone. Hydraulic and mixing zone model data shall be included with the proposed scope of work to define the survey area.

7.4 Stream Type Specific Guidance

- 7.4.1 **Group 1 streams** are those small to mid-sized streams not suspected of containing ES and timed search surveys are acceptable. These streams only require coordination with the WVDNR. If avoidance of instream impact is not possible, a mussel survey and subsequent relocation is required. At a minimum, data are to be provided for each survey area **separately**. Each of the areas shall be searched for a minimum effort of 0.2 min/m². A minimum search effort of 0.5 min/m² shall be conducted in areas with mussels. If mussels are observed, the salvage zones shall be delineated as described in Table 3. Salvage shall be conducted as per Section 8.0. **Group 1 streams require coordination with the WVDNR only unless an ES is found, at which time, all work shall cease and the WVDNR and USFWS must be contacted immediately. All mussels are to be returned to the area from which they were collected.**
- 7.4.2 **Group 2 streams** are those small to mid-sized streams with ES expected and require coordination with the WVDNR and the USFWS.

The objective of a Phase 1 is to determine if the project area supports a mussel concentration and/or has the potential to harbor ES (defined by the trigger criteria below), so that impacts to mussel concentrations can be avoided and minimized. If triggers are met within the ADI and salvage buffers and avoidance is not an option, quantitative sampling (Phase 2) is required within the salvage zone to increase the probability of finding small, buried ES.

Phase 1 surveys are used to determine the mussel distribution within the project area and delineate mussel concentrations and/or areas that have potential to harbor ES. Data is to be compiled separately for all areas (Section 7.1.1). **Streams 20m wide or less** must be surveyed using cells not to exceed 100m² in size. Each cell with heterogeneous habitat will be searched for 0.2 min/m² or 20 min/100m² cell. All cells in which any mussels are found are to be searched for an additional 0.3 min/m² (30 min/100 m² cell) minimum. Data (mussels, effort, and habitat) are to be recorded by cell position. For **streams greater than 20m wide**, the preferred survey method is by cells; however, transects may be used to delineate mussel concentrations or areas that potentially support ES. Transects, as defined, shall be surveyed 1m in width, spaced no more than 10m apart, and placed perpendicular to stream flow. Data (mussels, effort and habitat) are to be recorded by 5m segment along the transect. Delineate the area that includes all transect segments that meet the trigger criteria below and all similar habitat between these segments plus 10m surrounding the delineated area. Divide the area into cells no more than 100m². Search each cell for a minimum of 0.5min/m². Transects may also be more appropriate for surveys where the objective is to determine the area of least impact (best alternative) over a long stretch of stream. Transects shall be placed in best habitat spaced at an average of 25m. Once the priority location is selected, cells are then required within the mussel concentration areas.

Phase 2 surveys are required if the area cannot be avoided by both direct and indirect impacts during construction and operation of the project and if either of the below triggers are met within any portion of the salvage zone. If ES are found, additional minimization and conservation measures must be developed and/or formal consultation with USFWS will be required.

Before a Phase 2 survey can be conducted:

- The area of unavoidable impact must be defined,
- Documentation of why avoidance is not possible must be provided and approved.

Phase 2 triggers:

- Mussel density of 0.5/m² (all species included) within the salvage zone determined during Phase 1, and/or
- Presence of at least two species not listed in Table 2 found within the salvage zone.

The objective of a Phase 2 is to collect sufficient data to further determine if ES are likely to be present within the salvage zone and provide additional density information if an ES is observed. The Phase 2 survey for a Group 2 stream consists of a quantitative survey using excavations as described by Smith *et al.* (2001). This survey shall be conducted using the systematic random start methodology throughout the area meeting the trigger criteria within the salvage zone only. This area is defined as an area encompassing all triggered areas connected by similar habitat plus a 10m buffer surrounding it. The boundary of the Phase 2 area should not exceed the salvage area. The number of quantitative samples to be collected shall be calculated at the rate of 3 quads per 100m²

of the area. If surveying using cells, this equates to 3 quads per 10 by 10m cell. At a minimum, 50 quadrats are required within the mussel concentration area of the salvage zone.

7.4.3 Group 3 streams are large rivers where ES are not expected. These include the Ohio River US of Hannibal Lock and Dam and the Monongahela River.

The objective of the survey is to determine if mussels are present, delineate the area of mussel concentration, and facilitate mussel salvage and relocation if advised by the State resource agency. The survey design shall consist of transects, 1m in width, placed perpendicular to stream flow or cells not to exceed 100m² in size. Maximum transect spacing depends on project type (Table 3) but shall not exceed 25m unless a scoping project. If transect spacing is greater than 10m and no mussels are observed in two adjacent transects, with at least one of the transects containing apparent suitable mussel habitat, then a timed search for a minimum of 10 minutes shall occur between the two transects in the area of suitable mussel habitat. If any live and/or fresh dead mussels are found between the two transects during the search, then an additional transect shall be placed there and a search conducted as previously described. Cells may also be used and shall not exceed 100m² in size. Data shall be compiled for each survey area separately and recorded by transect segment or by cell position. Cells are encouraged in those areas without an extensive ADI and buffer area. Cells allow better transition for moving into the salvage phase. In larger areas, such as maintenance dredging, long linear projects, and scoping projects, the targeted mussel areas are best delineated using transects. Delineate the distribution of mussels and/or suitable habitat using data obtained during sampling of cells or transects.

7.4.5 Group 4 streams are large rivers where ES are expected. These include the Ohio River DS of Hannibal Lock and Dam, Little Kanawha River (slack-water section adjoining the Ohio River) and the Kanawha River.

Phase 1 objective is to determine if a mussel concentration is present and to delineate the area which could potentially contain ES, so that impacts to mussel concentrations can be avoided and minimized. The survey design shall consist of transects, 1m in width, placed perpendicular to stream flow or cells not to exceed 100m² in size. Maximum transect spacing depends on project type (Table 3) but shall not exceed 25m unless a scoping project. If transect spacing is greater than 10m and no mussels are observed in two adjacent transects, with at least one of the transects containing apparent suitable mussel habitat, then a timed search for a minimum of 10 minutes shall occur between the two transects in the area of suitable mussel habitat. If any live and/or fresh dead mussels are found between the two transects during the search, then an additional transect shall be placed there and a search conducted as previously described. Data shall be compiled for each survey area separately and recorded by transect segment or by cell position. Additional timed search surveys shall be conducted within areas of mussel concentrations for species richness curve development (Section 7.1.7).

If the triggers are met within any portion of the delineated area, that area should be avoided (direct and indirect impacts) during construction and operation of the project. If the area cannot be avoided a Phase 2 survey may be required. If ES are found, additional minimization and conservation measures must be developed and/or formal consultation with FWS will be required.

Survey results that trigger avoidance or a Phase 2 survey include:

- Mussel density of $0.5/\text{m}^2$ (all species included) in any area of the survey and/or
- Presence of at least three species not listed in Table 2 along any one transect (at least 100m in length) or a combination of adjacent transects (at least 100m combined length), within 100m^2 of cell area, or within a qualitative survey conducted between transects.

Phase 2 survey objective is to collect sufficient data to increase the probability of detecting an ES. If transect spacing is greater than 10m, a Phase 2 survey shall consist of additional transects placed between the original surveyed transects within the mussel concentration area. The mussel concentration area is defined as an area encompassing all triggered areas connected by similar habitat plus a 10m buffer surrounding it. In other words, an additional transect shall be placed downstream of the most downstream transect that met the above criteria and upstream of the most upstream transect that met the above criteria. If the distance to the next transect upstream and downstream is greater than 10m, the additional transects shall be placed 10m upstream and downstream. The boundary of the Phase 2 area shall not exceed the Phase 1 area. Transect spacing of 10m or use of cells does not require a Phase 2 survey.

8.0 Conducting a Salvage and Relocation

All native mussels are protected within the state of WV and if avoidance options are exhausted, mussels must be relocated from the area of direct impact and appropriate buffer areas (salvage zone) as described in Table 3. **No mussels are to be moved without prior authorization from appropriate State and Federal authorities.** On streams with potential ES (Groups 2 and 4), coordination with the USFWS must occur prior to any relocation efforts. Relocation of any federally listed mussels will require formal consultation. This consultation process requires that the Federal action agency develop a Biological Assessment (BA) that quantifies the potential impacts to the species and that an incidental take authorization be issued by the USFWS prior to conducting any activities that could adversely affect these species. This process may take up to 135 days from the time that a completed BA is submitted to the USFWS. Impacts to federally listed mussel species and their habitats must be avoided and minimized to the extent practicable. Additional conservation measures above and beyond relocations may be required if the proposed project may adversely affect federally listed species. If the project is covered by an HCP, a mussel salvage still must be conducted prior to commencement of instream construction activities as all mussels are protected in the State of WV.

1. For Group 1 and 3 streams, approval to relocate may be granted by WVDNR solely. Depending on the type and extent of the project and potential for significant mussel resources to occur, some projects may receive approval to salvage mussels at the time of the initial survey. In some cases, mussels may be required to be held on site while additional coordination with the State is required to determine if salvage is the best option.
2. For Group 2 and Group 4 streams, relocations shall not be conducted until a review of findings by the WVDNR and USFWS has been conducted and approved, and written concurrence provided by the USFWS.
3. The salvage effort shall be systematically conducted by a "moving transect" or establishing cells not to exceed 100m^2 . The minimum effort is $1\text{min}/\text{m}^2$ ($0.5\text{min}/\text{m}^2$ first pass, $0.5\text{ minutes}/\text{m}^2$ second pass).

4. Multiple passes shall be made through each cell or moving transect until two or fewer mussels per 100m² or less than 5 percent of the original number collected (not to exceed 4 mussels) are recovered on the final pass.
5. Salvage efforts shall meet the same standards as surveys (i.e. visibility requirements (≥ 50 cm), workable streamflow conditions, and mussel survey period).
6. WVDNR or USFWS personnel will randomly conduct quality assurance checks on relocations.
7. Relocation sites shall be upstream (preferred) to an area of equal or better habitat, or to an approved relocation site in a discrete area recommended by the WVDNR. For Group 1 streams, a 15min qualitative survey of the relocation site shall be conducted at a minimum. All observations of resident mussels are to be reported including site coordinates in decimal degrees. For all other stream groups, one hour of qualitative searches (six 10min searches) to delineate an area with similar species and equal or better density than the collection area shall be conducted. The relocation area is to be equal or larger in size to the collection area. The relocation area data is to be reported on a separate DNR datasheet and protocol form.
8. Generally, monitoring of common species are not required. Monitoring of relocated ES are required and addressed through the Section 7 consultation process with the USFWS.
9. For Group 3 and 4 streams, non-ES mussels may be dropped from a boat into the delineated area May 1 to September 1. In areas of high velocity such as the upper Kanawha River, Group 1 and 2 streams, or any stream from September 1 to May 1, mussels shall be hand-placed into the substrate. ALL ES are to be hand-placed into the substrate from the area in which they were collected unless otherwise authorized.
- 10. If any ES are found during relocation efforts for projects in any Stream Group where no ES were found during previous survey efforts, and no incidental take authorization from the USFWS has been received, then relocation efforts must stop and the USFWS and WVDNR should be immediately contacted.**
11. Relocations must be conducted within the same year as the start of instream construction. If instream activities have not commenced prior to July 15 of the next year, additional relocation efforts may be required just prior to construction activities depending on the results of earlier relocation efforts.

9.0 Reporting Requirements and Deadlines

All data as per the scientific collecting permit are due by November 15. If the project report is not available at that time, the surveyor must notify the permitting agency of the delay and establish a submittal deadline. If the survey was not conducted, the permittee must notify the permitting agency by November 15, though earlier is preferred.

Report Checklist: Below is a checklist of deliverables to be included in a mussel survey report. If supplying reports addressing multiple sites, please place all materials for each site together so each can be easily reviewed in its entirety. Incomplete data will delay project reviews and project concurrence will not be provided until complete data is provided. See Examples 6 to 8 for assistance in planning your data tables. This is not the required format but data must be included. All text and tables should have font size such that they are legible (without a magnifying lense) when documents are printed.

- Visibility at time of survey in centimeters.

- Summary Data Table(s) by area (Section 7.1.1), total salvaged (ADI plus salvage buffers) by species by method. This should also include the qualitative searches used in the species richness curve, provided by 10min collection with total.
- If salvage not completed, provide estimated number by species for ADI and salvage buffers required to be salvaged if project moves forward.
- Mussel Data by cell or transect segment (full data table or spreadsheet required).
 - Mussel Data by pass for each salvaged segment or cell shall be provided).
- Survey effort by cell or transect segment (full data table or spreadsheet required).
 - Effort by pass for each salvaged segment or cell shall be provided.
- Habitat Data by cell or transect segment.
- Group 2 and 4 – Species Richness Curve with calculations and calculate number of mussels needed to collect an additional species.
- Protocol Forms (updated with actual survey information) for project and relocation areas.
- Figure showing cell/transect locations with planned impact area(s).
- Results of qualitative survey at relocation site with coordinates.
- Photo Vouchers and photos of odd, questionably identified species.
- DNR Data Sheets.
 - Protocol Form(s) (Survey and Relocation Area)
 - Current Stream Weather Conditions (Required fields: Temperature in Celsius and Visibility in centimeters).
 - Mussel Survey Data Sheet by species (summary by area by method with total for site)
 - Mussel Survey Data Sheet by species (summary for relocation area)
- Copy of state scientific collecting permit
- Copy of USFWS concurrence form(s) (USFWS concurrence required for Phase 1, Phase 2, and Salvage)

Remember, if you are asked to collect the data, provide it. The management decision makers should be able to re-create all analyses conducted from the data provided.

10.0 Tables

Table 1. Contact information for State and Federal Agencies.

West Virginia Division of Natural Resources Scientific Collecting Permit Barbara Sargent PO Box 67 Elkins, WV 26241 304-637-0245 Barbara.D.Sargent@wv.gov	U.S. Fish and Wildlife Service Ecological Services Endangered Species Biologist 694 Beverly Pike Elkins, WV 26241 304-636-6586 x19 Barbara_douglas@fws.gov (Official requests are to be sent by hard copy mail)
West Virginia Division of Natural Resources State Malacologist Janet Clayton PO Box 67 Elkins, WV 26241 304-637-0245 Janet.L.Clayton@wv.gov	http://www.wvdnr.gov/Mussels/Main.shtm All required forms, current stream list, current protocol, approved surveyors list, etc. can be found on the WVDNR website mussel page.

Table 2. Species that can be excluded in defining a diverse mussel concentration by stream group.		
Species	Group 1&2	Group 3&4
<i>Lampsilis siliquoidea</i>	X	X
<i>Lasmigona complanata</i>		X
<i>Leptodea fragilis</i>		X
<i>Obliquaria reflexa</i>		X
<i>Potamilus ohiensis</i>		X
<i>Potamilus alatus</i>		X
<i>Pyganodon grandis</i>	X	X
<i>Strophitus undulatus</i>	X	X
<i>Utterbackia imbecillis</i>	X	X
<i>Utterbackiana suborbiculata</i>		X

Table 3. Summary of buffer requirements and maximum transect spacing for various types of stream disturbances. Units are in meters. Survey extent shall include all buffers and the area of direct impact (ADI). After demonstrating need and receiving approval, mussels may be relocated from area described (salvage zone).

	US Buffer	DS Buffer	L Buffer	Salvage Zone (SZ) (ADI + Buffer Below)		Maximum Transect Spacing
				US & L	DS	
Group 4	Phase 2 Surveys may be required if trigger met during Phase 1					
Dredging (Maintenance)	150	500	150	10	10	25/10SZ
Loading Facility (non-dredging activities: within active facility)	25	25	25	5	10	cells or 10
Barge Loading (new or expanding US or DS, see Section 5.3 for required buffers)						
Scoping Projects		Project Specific (PS)				100
Bridge Projects	50	100	BB	5	10	10
Waterline/Pipeline Corridor Disturbances	50	100	BB	5	10	10
Water Intakes (at shoreline)	10	10	10	5	10	cells
Shoreline Protection	10	10	10	5	10	cells
Projecting Dike Structures	10	20	10	5	10	cells
Outfalls	10	MZ + 100	10	PS		PS
Group 3	Relocation at time of survey if authorized					
Dredging (Commercial Sand & Gravel)	152	457	152	10		25
Dredging (Maintenance)	50	150	50	10		25/10SZ
Loading Facility (non-dredging activities)	25	25	25	5	10	cells 25/10SZ
Scoping Projects		Project Specific				100
Bridge Projects	10	25	BB ^b	5	10	cells
Waterline/Pipeline Corridor Disturbances	10	25	BB	5	10	cells
Water Intakes (at shoreline)	10	10	10	5	10	cells
Shoreline Protection	10	10	10	5	10	cells
Projecting Dike Structures	10	20	10	5	10	cells
Outfalls	10	MZ + 20	10	PS		cells
Group 2	Phase 2 surveys required if trigger met during Phase 1					
Scoping Projects		Project Specific				Average 25
Bridge Projects	50	100	BB	5	10	10
Waterline/Pipeline Corridor Disturbances	50	100	BB	5	10	10
Water Intakes (at shoreline)	10	10	10	5	10	cells
Shoreline Protection	10	10	10	5	10	cells
Outfalls	10	MZ + 20	10	PS		10
Group 1	Relocation at time of survey if approved					
All Projects	10	25	10 or BB	5	10	TS

^b pier only, 10m LB
 TS Qualitative Timed Search
 PS Project Specific

BB Bank to Bank
 MZ Mixing Zone
 US Upstream
 L Lateral

DS Downstream
 cells: not applicable, cells required

11.0 References:

Smith, D. R., R. F. Vilella, and D. P. Lemarie'. 2001. Survey protocol for assessment of endangered freshwater mussels in the Allegheny River. *Journal North American Benthological Society* 20(1):118-132.

Williams, J.D., A.E. Bogan, R.S Butler, K.S. Cummings, J.T. Garner, J. L. Harris, N.A. Johnson and G.T. Watters. 2017. A revised list of the freshwater mussel (Mollusca: Bivalvia: Unionida) of the United States and Canada. *Freshwater Mollusk Biology and Conservation* 20:33-58.

12.0 Acknowledgements

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13.0 Examples

Example 1. Group 3 maintenance dredging of a 20 by 200m area is proposed (orange rectangle=ADI). Within the ADI and the salvage buffer (the ADI and a 10m salvage buffer around it, yellow outlined area) 1m wide transects are required at 10m spacing (purple lines). The mussels, effort and habitat data shall be provided by the ADI segments and the salvage buffer segments. Outside of the salvage zone, transects are spaced at 25m intervals. The USB of 50m includes two 70m transects (green). The remaining lateral buffer (minus the 10m salvage buffer) consists of 10 transects, 40m in length (blue) and the DSB (magenta) consists of six 70m transects at 25m intervals. If spudding is to occur outside the ADI then those areas should be indicated and data provided for each spud area (black rectangles).



Example 2. If a new mooring cell or tri-tie (orange circle) is being placed within an active facility, the area may be best surveyed using cells to cover the 25 by 25m buffer surrounding the mooring cell. The mussels, effort and habitat shall be recorded by cell for each of the areas being sure to delineate between the salvage zone and the additional buffer surrounding it. Green is USB, yellow is salvage buffer, blue is LB, and magenta is DSB. If the stream is Group 4, at least six 10min qualitative searches must be conducted around the cells (squiggly lines).



Example 3. If multiple moorings are to be installed within an active facility one can see that this scenario quickly becomes an underwater nightmare if using cells, thus transects may be more appropriate for Group 4 streams in which the mooring cells are in close proximity to each other and salvage is not being undertaken simultaneously.



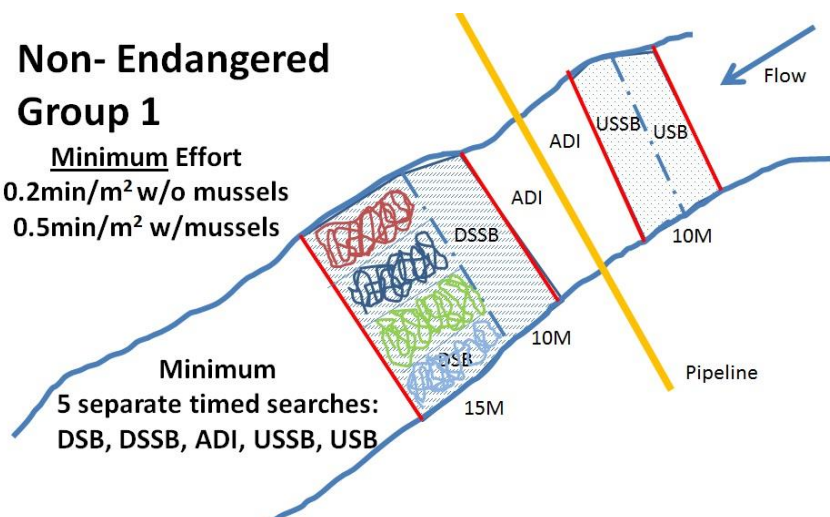
Example 4. Therefore if 3 or more moorings are to be installed, within close proximity to each other, the area may be best surveyed using transects. Be sure to place a transect through each proposed mooring location. Remember that at least 500m of transects must be surveyed and transect spacing is 10m. In this scenario, 12, 45m transects are being surveyed.



Example 5. Group 1 survey must record data separately for at least the 5 major areas. It may benefit the surveyor to stratify the areas based on habitat and the likelihood of finding mussels in each area as shown here in the DSB. Mussels, effort and habitat by sub-area are then recorded.

Non- Endangered Group 1

Minimum Effort
0.2min/m² w/o mussels
0.5min/m² w/mussels



Minimum
5 separate timed searches:
DSB, DSSB, ADI, USSB, USB

Example 6 shows an acceptable data table for Phase 1 results. Note the buffer survey areas were broken into areas to be salvaged and those not. These abbreviations have been standardized in Section 7.1.1.

Cell #	Survey Area	Approximate Cell Size (m ²)	Total Search Effort (min)	Average Depth	Dominant / SubDominant Substrate Types (%)
1	USB	50	15	2'	Sand / LWD
2	USB	50	15	7'	Sand (60) / Silt (40)
3	USB	50	15	10'	Cobble (70) / Silt (30)
4	USB SZ	50	15	2'	Sand / LWD
5	USB SZ	50	30	7'	Sand (60) / Silt (40)
6	USB SZ	25	20	9'	Cobble (70) / Silt (30)
7	USB	25	10	12'	Cobble (70) / Silt (30)
8	ADI	100	60	2'	Sand / LWD
9	ADI	100	60	6'	Sand / LWD
10	LB SZ	50	30	9'	Cobble (60) / Gravel (40)
11	LB	50	20	13'	Cobble (60) / Gravel (40)
12	DSB SZ	100	30	2'	Sand / LWD
13	DSB SZ	100	60	8'	Sand (40) / Cobble (40) / Silt (20)
14	DSB SZ	50	30	12'	Cobble (40) / Gravel (30) / Sand (30)
15	DSB	50	25	14'	Cobble (60) / Sand (20) / Gravel (20)

Example 7 provides further detail on mussels collected during salvage efforts. Data is supplied by cell by pass. The only thing missing is the effort used during each pass.

Cell #	Pass #	Species	# Collected	Abundance by Pass
1	1	<i>L. cardium</i>	2	.
1	1	<i>L. siliquioidea</i>	2	.
1	1	<i>L. complanata</i>	1	.
1	1	<i>L. costata</i>	3	.
1	1	<i>L. fragilis</i>	2	.
1	1	<i>P. alatus</i>	5	.
1	1	<i>P. grandis</i>	3	.
1	1	<i>S. undulatus</i>	2	.
1	1	<i>T. verrucosa</i>	1	21
1	2	<i>L. siliquioidea</i>	1	.
1	2	<i>L. fragilis</i>	1	.
1	2	<i>P. alatus</i>	2	.
1	2	<i>P. grandis</i>	1	5
1	3	<i>T. verrucosa</i>	1	1
2	1	<i>L. cardium</i>	5	.
2	1	<i>L. costata</i>	4	.

Example 8 provides a summary table of species collected by area. The only thing missing on this one is a total by species column. Supply table for each method used and then a summary for all methods.

Species	ADI	LB	LB SZ	DSB	DSB SZ	USB	USB SZ
<i>L. siliquioidea</i>	2	0	1	0	1	0	0
<i>P. alatus</i>	0	0	1	2	3	0	2
TOTAL	2	0	2	2	4	0	2