Appendix M

AQUATIC MITIGATION

Bluestone Dam Safety Modification
Phase 5

Candidate Sites, Conceptual Mitigation Plans and HEP Analyses

February 2017

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Introduction

The following mitigation concepts were developed by the U.S. Army Corps of Engineers (USACE) Huntington District, in coordination with resource agencies including the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, National Park Service, West Virginia Department of Natural Resources, West Virginia Department of Environmental Protection, West Virginia State Historic Preservation Office, Virginia Department of Game and Inland Fisheries and Virginia Department of Environmental Quality. Some of the possible mitigation candidate sites were suggested by resource agencies, while others were identified by USACE. These mitigation concepts are individual measures which could be used as stand-alone projects or in combination to provide mitigation for impacts anticipated from the proposed Bluestone Dam Safety Modification Phase 5.

The candidate sites analyzed included Bluestone Lake Boulder Reefs, Barker's Bottom Island, Brandt Property, Carol Brown Farm, Crumps Bottom 1 and 2, Glen Lyn, Indian Creek, Lovern, and Wallace Property. As part of the planning process, site visits were conducted on most of the sites, with the exception of the Lovern and Carol Brown Farm. Conceptual plans for each of the sites were developed based on observations in the field and through desktop review of available site data.

Once conceptual plans were developed for each site, preliminary Habitat Evaluation Procedure (HEP) models were utilized to determine the estimated baseline habitat value of each site and estimated mitigation benefit of the possible restoration and/or preservation at each site. Due to the conceptual stage of design for the projects, these HEP models used data gathered during site visits and through desktop review of available data; no formal data plots were established and utilized at the terrestrial sites. Data points were, however, collected at the aquatic sites. Additional HEP models will be run using data points during the Pre-construction Engineering and Design (PED) phase for selected mitigation measures.

In cooperation with resource agencies, the initial suite of mitigation alternatives was screened in order to determine the most feasible plans to carry forward for further analysis, considering site availability, impacts to recreational resources, and proximity to the impacts being mitigated. This screening eliminated all alternatives with the exception of Bluestone Lake Boulder Reefs, Barker's Bottom Island, Carol Brown Farm and Lovern. The results of the HEP analyses for the four remaining mitigation alternatives are provided in Table 1. The Bluestone Lake Boulder Reefs and Barker's Bottom Island alternatives involve aquatic habitat restoration which utilized the smallmouth bass model to calculate direct Habitat Unit (HU) gains. The Carol Brown Farm and Lovern alternatives involve riparian habitat restoration and preservation, which utilized the mink model to calculate direct Habitat Unit gains, and the smallmouth bass model to calculate indirect Habitat Unit preservation in the portion of the New River adjacent to these riparian sites.

Table 1: HEP Analysis Results

Mitigation Alternatives	Direct Habitat Unit Gain	Indirect Habitat Unit Preservation
Bluestone Lake Boulder Reefs	2.69	n/a
Barker's Bottom Island	0.94	n/a
Carol Brown Farm	10.82	9.46
Lovern	34.03	38.09

The following conceptual plans include the four mitigation alternatives carried forward for further analysis. The conceptual plans provide an overview of baseline site conditions for each site, proposed ecological enhancements or preservation, success criteria, monitoring plans, adaptive management plans and results of the HEP analyses. Once a measure or combination of measures is chosen for implementation, the success criteria, monitoring plans and adaptive management plans described in this document will be further refined for the selected mitigation measures in coordination with the resource agencies to ensure that the selected plan fully mitigates for the habitat lost due to construction of the proposed Bluestone Dam Safety Modification Phase 5.

Candidate Site:

Bluestone Lake Boulder Reefs

1. Site Overview

Location

Three locations for proposed boulder reefs have been identified for further investigation. Site 1 is adjacent to the right descending bank of the New River within Bluestone Lake, approximately 1.2 miles upriver of Bluestone Dam (Figure 1). Site 2 is also located adjacent to the right descending bank of the New River within Bluestone Lake, approximately 1.5 miles upstream of the dam, and one mile downstream of the confluence of the Bluestone River. Site 3 is located adjacent to the right descending bank of the New River within Bluestone Lake, approximately 2.8 miles upstream of the dam, and one-quarter mile upstream of the confluence of the Bluestone River.

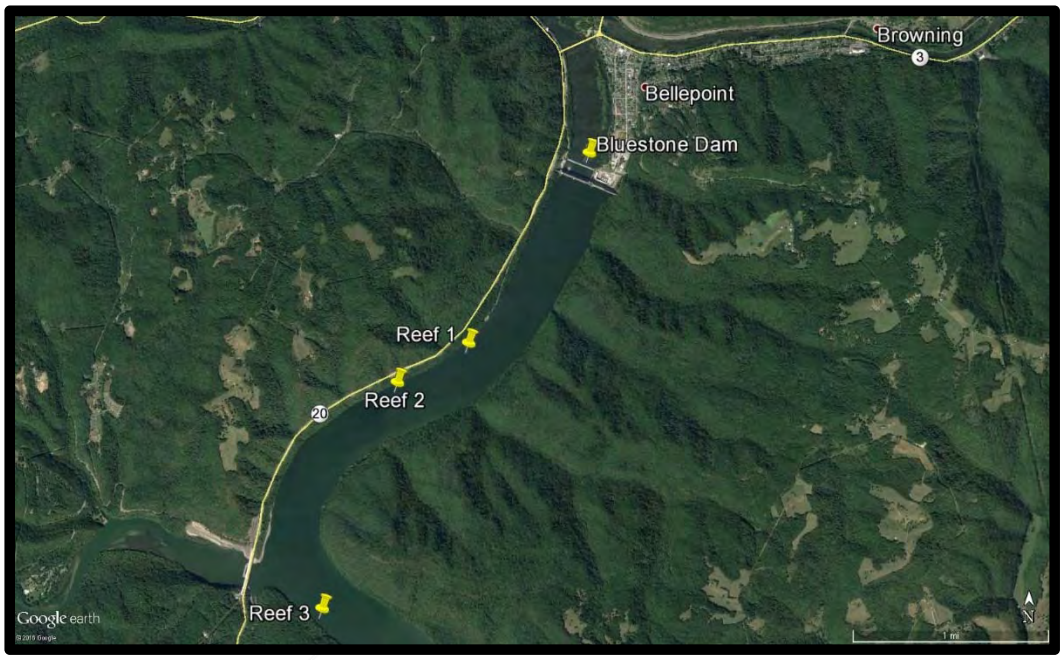

Figure 1: Location of possible boulder reef sites

Site Characteristics and Baseline Conditions

The three proposed sites are located within Bluestone Lake, which is the reservoir formed by the operation of the Bluestone Dam. At the lake's maximum flood control pool, the lake extends approximately 36 miles upstream from the dam. At summer pool elevation of 1,410 feet above mean sea level, the lake extends 10.7 miles behind the dam and covers 2,040 acres. At winter pool elevation of 1,406 feet, the lake extends 9.5 miles and covers 1,800 acres. The upstream area is part of a large drainage basin encompassing 4,565 square miles. Previous studies of existing habitat within the lake, particularly within the bounds of the summer pool, have shown that sedimentation within the lake has led to a loss of lake bottom structure, which has led to a decrease in cover for fish. Sediment surveys have shown that sediment has accumulated to elevation of 1,389 feet within the first five miles of lake upstream of the dam.

HEP Evaluation—Baseline Conditions

Habitat evaluations for these sites were conducted in January 2017. Site data was collected in the field. Habitat Evaluation Procedures (HEP) were used to determine the baseline habitat conditions, using the smallmouth bass model used for the Bluestone Dam Modification Impact HEP.

In their current condition, the sites would be expected to provide 14.4 Habitat Units (HUs). The habitat value was derived in part from the presence of gravel and boulder substrates, water depths greater than 1 meter and water temperature and turbidity within acceptable ranges. The HEP workbook for this site is provided in Appendix A.

Land Acquisition

The property is within the USACE fee boundary. No land acquisition is required.

2. Mitigation Work Plan

Mitigation Objectives

The goal of the proposed mitigation at these sites is to improve substrate and cover conditions to increase the Habitat Suitability Index according to the HEP smallmouth bass model. According to this model, the following criteria are pertinent to provide optimum habitat for smallmouth bass:

- Gravel, broken rock (1.6-2.0 cm), and boulder with adequate interstitial space as dominant substrate type within pool or shoal area
- 25-50% cover in the form of boulders, stumps, dead trees, and crevices or vegetation and rocks

The remaining variables within the lacustrine smallmouth bass model pertain to water depth, pH, total dissolved solids, dissolved oxygen, turbidity, and water temperature. These variables were not considered in development of the mitigation goals as these factors are either not impaired within Bluestone Lake, or cannot be manipulated or improved through the type of mitigation proposed.

Conceptual Ecological Enhancements

1. Commercially-acquired rock, ranging in size from one to five feet in average diameter, with 90% of the material being between 1.5 and 2.5 feet average diameter, would be placed in extended mound formations perpendicular to the bank at each of the three sites. The exact dimensions of the formation would be determined in final design, depending in part on the bathymetry of the site and could be instead configured parallel to the bank. For conceptual purposes, it is estimated that each site would contain three reefs, each running roughly perpendicular to the bank and parallel to each other. Each reef would be 300 feet long, 3 feet high and 30 feet wide. The centerline of the reefs at each site would be spaced approximately 100 feet apart.

2. This area of the lake is heavily used by recreational boaters, which limits the elevation to which in-lake features can be constructed; as noted in development of boulder reefs constructed as mitigation for earlier dam improvements, in-lake features cannot exceed an elevation of 1,402 feet to ensure safe passage of boats and year-round fish access during various pool elevation scenarios. Buoys or some other type of marker will be used to avoid collision with boats.

3. Along the bank in the vicinity of the reefs at each site, bankline trees would be cut and anchored to their trunk or other existing trees so that the felled tree rests at elevation 1410. One to two trees would be felled and anchored approximately every 50 feet along the bank line for 500 feet of bankline.

HEP Estimate of Restoration Gain

The potential HUs gained through restoration of the site would be produced by the increase in hard bottom substrate acreage through construction of the boulder reefs and cover by the felled trees. The increased smallmouth bass habitat is estimated to produce a net gain in habitat value of 2.69 HUs. The HEP workbook for this site is provided in Appendix A.

3. Success Criteria

The monitoring years in Table 2 refer to end of winter pool after Year 0, which is the year that the boulders and trees were placed. For example, Year 1 will be measured at the end of the first winter pool following the year that the features are installed. The goal of the success criteria is to ensure that the integrity of the installment, and the cover it provides, is maintained over the life of the project.

Table 2. Success Criteria

Monitoring Year	Success criteria
1, 5, 10	>75% of fallen trees remain in place Acreage of reef remains constant

4. Monitoring Plan

A baseline monitoring report would be completed by the USACE or a consultant hired by USACE after final construction is complete, followed by monitoring reports by USACE or a USACE-consultant five and ten years after the baseline report. The construction contractor will also be responsible for monitoring during one year after rock placement and tree felling, to ensure that at least 75% of the trees remain anchored and the acreage of rock cover constructed remains constant. This monitoring report schedule may be amended to account for delayed

achievement in success criteria. If success criteria are not met for a given year, additional monitoring reports will be required for at least two additional consecutive years to ensure success criteria are maintained.

Due to the small acreage of the mitigation site, the entire site will be surveyed, rather than plots, for monitoring purposes. Side scan sonar or other appropriate technology will be used to determine the dimension of the reefs during each monitoring period. Reports will be completed within 6 months of the monitoring activities, and will include the following items:

Baseline Monitoring Report:

- Description of mitigation activities completed and description of habitat and characteristics of the restored site.
    - Plan view of site showing location and dimension of reefs, overlaid on aerial photograph with coordinates of reef corners.
    - Plan view of felled trees with coordinates of each tree.
    - As-built survey of placed reefs.
- Photograph of each set of felled trees.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems, or other notes pertinent to the success of the mitigation.
- A description of any recommended adaptive management actions to address any conditions observed in the field.

Additional Monitoring Reports:

- Description and schedule of any adaptive management activities completed since last monitoring report.
- Description of river elevations (annual high, low, and average) and summary of weather patterns since last monitoring report, noting any unusual occurrences (e.g. ice storms).
- Results of in-water survey of reef dimensions.
- Photograph of each set of felled trees.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems, or other notes pertinent to the success of the mitigation.
- A description of any recommended adaptive management actions to address any conditions observed in the field.

5. Adaptive Management

As required under the Water Resources Development Act (WRDA) of 2007, Section 2036(a) and USACE implementation guidance, adaptive management would be included in mitigation planning for these sites. Adaptive management planning includes identification of key risks and uncertainties influencing the mitigation sites and how these factors relate to the achievement of

mitigation objectives, and development of possible contingency plan actions which could be implemented to address the influence of factors adversely affecting achievement of success criteria.

Until Year 1 success criteria have been demonstrated as achieved, the construction contractor will be responsible for implementing any adaptive management measures required. After Year 1 success criteria are achieved, USACE will resume responsibility for any adaptive management actions.

Primary risks and uncertainties which could influence project success include:

1. Flood events
2. Unusual weather
3. Settlement

If larger than expected flows are experienced into or out of Bluestone Lake, some displacement of the reef material could occur. If the acreage of rocky cover were to drop, commercially resourced material could be used to replaced bedrock boulders which are lost. If such flows, or other events such as ice storms or extreme high winds, were to displace any of the felled trees on the bankline which are not naturally replaced by other fallen trees, additional trees could be felled and attached to replace the trees lost.

Geotechnical analysis would be conducted prior to rock placement to determine the quantity and dimension of rock placement in order to achieve reefs of the required dimensions. However, if settlement occurs at a rate which significantly exceeds expectations such that the percent rocky acreage drops below the success criteria minimum, commercially resourced material could be used to rebuild the reef to the appropriate dimensions.

Candidate Site:

Barker's Bottom Island

1. Site Overview

Location

Barker's Bottom Island is located approximately 6 miles upstream of Bluestone Dam in Bluestone Lake (Figure 2).

Figure 2: Location of Barker's Bottom Island

Site Characteristics and Baseline Conditions

The island is approximately one acre, located approximately 400 feet from the left descending bank of the river. The island is vegetated with a mix of tree and shrub species which are adapted to frequent flooding, as the island elevation is approximately equivalent to the adjacent bankline. The frequent flooding of the island has led to erosion of the island's bankline, and sedimentation within the lake has led to a loss of lake bottom structure, which has led to a decrease in hardbottom habitat and cover for fish.

HEP Evaluation—Baseline Conditions

Habitat evaluations for these sites were conducted in January 2017. Site data was collected in the field. Habitat Evaluation Procedures (HEP) were used to determine the baseline habitat conditions, using the smallmouth bass model used for the Bluestone Dam Modification Impact HEP.

In its current condition, the site would be expected to provide 0 HUs over 10 years under the smallmouth bass model. This lack of habitat value is caused by the predominance of sand substrates at the site. The HEP workbook for this site is provided in Appendix A.

Land Acquisition

The property is within the USACE fee boundary. No land acquisition is required.

2. Mitigation Work Plan

Mitigation Objectives

The goal of the proposed mitigation at this site is to minimize sediment deposition, form persistent scour and provide sheltered shallow water habitat features. A secondary goal is to slow erosion of each end of the island.

Conceptual Ecological Enhancements

1. A series of discontinuous dikes would be built, 50 feet in length with 100 foot gaps between each, just off the right bank of the island, continuing southwest to the bankline (Figure 3). The cross-section of these dikes would be such that the crest would be approximately 1 foot above winter pool water elevation. Logs will be embedded as habitat components within the base of the dikes to enhance scour formation toward the channel and maintains sheltered shallow water habitat features which would be conducive to nesting, spawning, and retention of several early larval stage species. (Figure 4).

2. Continuous crescent dike features, which would be constructed at the head and toe of the island, will retain sediment to approximately 1 foot above winter pool crest elevation. This head and toe of island sediment accretion will form the substrate for the re-establishment of island riparian zones and the volunteering-in and long term establishment of inundation tolerant native woody vegetation.

Figure 3: Configuration of Barker's Bottom Island Dikes

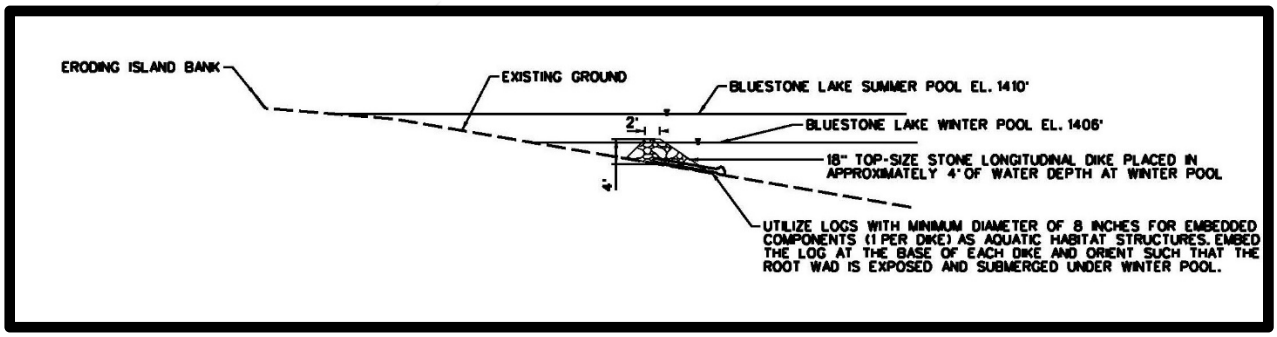

Figure 4: Typical Cross-section of Barker's Bottom Island Dikes

HEP Estimate of Restoration Gain

The potential HUs gained through restoration of the site would be produced by the increase in hard bottom substrate acreage through construction of the dikes. The increased smallmouth bass

habitat is estimated to produce a net gain in habitat value of 0.94 HUs. The HEP workbook for this site is provided in Appendix A.

3. Success Criteria

The monitoring years in Table 3 refer to end of winter pool after Year 0, which is the year that the dikes are constructed. For example, Year 1 will be measured at the end of the first winter pool following the year that the features are installed. The goal of the success criteria is to ensure that the integrity of the installment, and the habitat it provides, is maintained over the life of the project.

Table 3. Success Criteria

Monitoring Year	Success criteria
1, 5, 10	Acreage of dikes remains constant

4. Monitoring Plan

A baseline monitoring report would be completed by the USACE or a consultant hired by USACE after final construction is complete, followed by monitoring reports by USACE or a USACE-consultant five and ten years after the baseline report. This monitoring report schedule may be amended to account for delayed achievement in success criteria. If success criteria are not met for a given year, additional monitoring reports will be required for at least two additional consecutive years to ensure success criteria are maintained.

Due to the small acreage of the mitigation site, the entire site will be surveyed, rather than plots, for monitoring purposes. Reports will be completed within 6 months of the monitoring activities, and will include the following items:

<u>Baseline Monitoring Report</u>:

- Description of mitigation activities completed and description of habitat and characteristics of the restored site.
    - Plan view of site showing location and dimension of dikes, overlaid on aerial photograph with coordinates of ends.
    - As-built survey of placed dikes.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems or other notes pertinent to the success of the mitigation.
- A description of any recommended adaptive management actions to address any conditions observed in the field.

Additional Monitoring Reports:

- Description and schedule of any adaptive management activities completed since last monitoring report.
- Description of river elevations (annual high, low and average), summary of weather patterns since last monitoring report, noting any unusual occurrences (e.g. ice storms).
- Results of in-water survey of dike dimensions.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems or other notes pertinent to the success of the mitigation.
- A description of any recommended adaptive management actions to address any conditions observed in the field.

5. Adaptive Management

As required under WRDA 2007, Section 2036(a) and USACE implementation guidance, adaptive management would be included in mitigation planning for these sites. Adaptive management planning includes identification of key risks and uncertainties influencing the mitigation sites and how these factors relate to the achievement of mitigation objectives, and development of possible contingency plan actions which could be implemented to address the influence of factors adversely affecting achievement of success criteria.

Until Year 1 success criteria have been demonstrated as achieved, the construction contractor will be responsible for implementing any adaptive management measures required. After Year 1 success criteria are achieved, USACE will resume responsibility for any adaptive management actions.

Primary risks and uncertainties which could influence project success include:

1. Flood events
2. Unusual weather
3. Settlement

If larger than expected flows are experienced into or out of Bluestone Lake, some displacement of the dike material could occur. If the rocky cover acreage were to drop, commercially resourced material could be used to replaced bedrock boulders which are lost.

Geotechnical analysis would be conducted prior to rock placement to determine the quantity and dimension of rock placement in order to achieve dikes of the required dimensions. However, if settlement occurs at a rate which significantly exceeds expectations such that the rocky cover acreage drops below the success criteria minimum, commercially resourced material could be used to rebuild the dikes to the appropriate dimensions.

Candidate Site:

Carol Brown Farm

1. Site Overview

Location

The Carol Brown Farm property site is located on the left descending bank of the New River, approximately 13 river miles downstream of the Bluestone Dam (Figure 5).

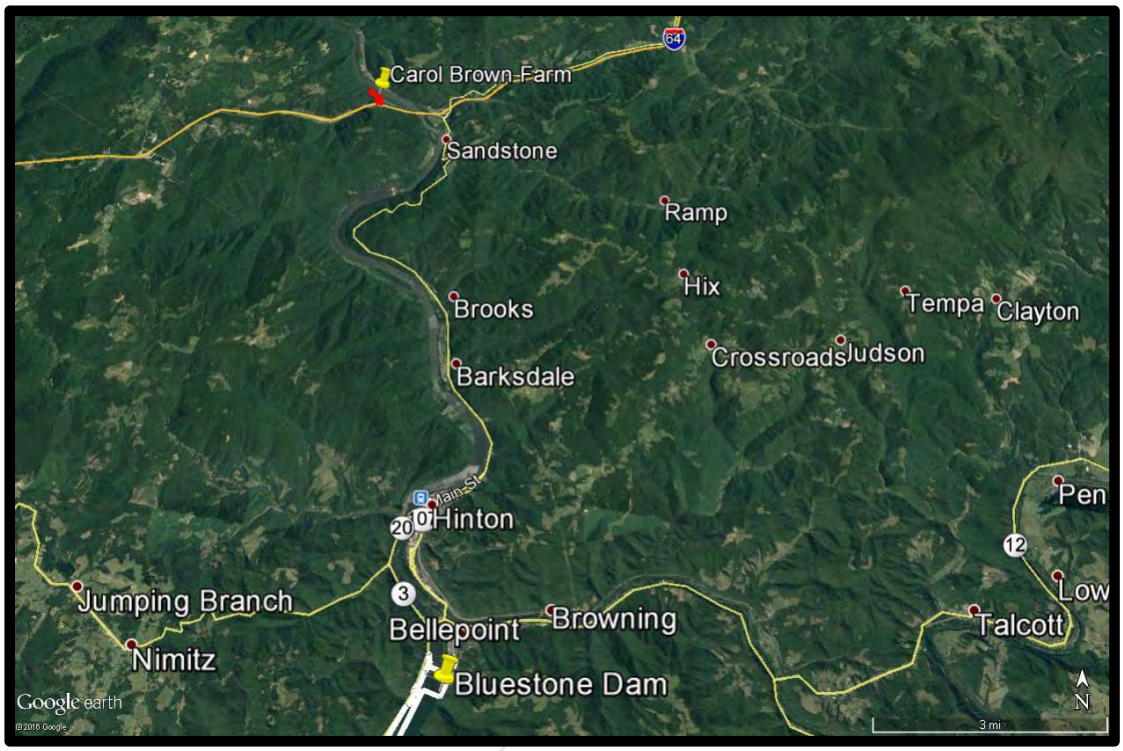

Figure 5: Location of Carol Brown Farm, outlined in red

Site Characteristics and Baseline Conditions

The Carol Brown Farm property is a 122.61-acre, largely wooded, private land parcel currently for sale within the service boundary of the New River Gorge National River (Figure 6). Within this parcel, there are approximately 16 acres which appear to have been previously cleared and are now primarily turf grass or other herbaceous vegetation. Farley's Creek, a perennial tributary of the New River, runs near the eastern edge of the property (shown in green in Figure 6). A primitive road runs through the property.

The site is relatively flat compared to adjacent terrain. Riverbank elevation in this area is approximately 1380 feet, while the site slopes up to approximately 1400 feet adjacent to I-64. Soils within the Carol Brown Farm property are classified as Combs series soils, which are occasionally flooded and support species such as sugar maple, beech, tuliptree, basswood, northern red oak, black walnut, eastern hemlock, ash, and gum.

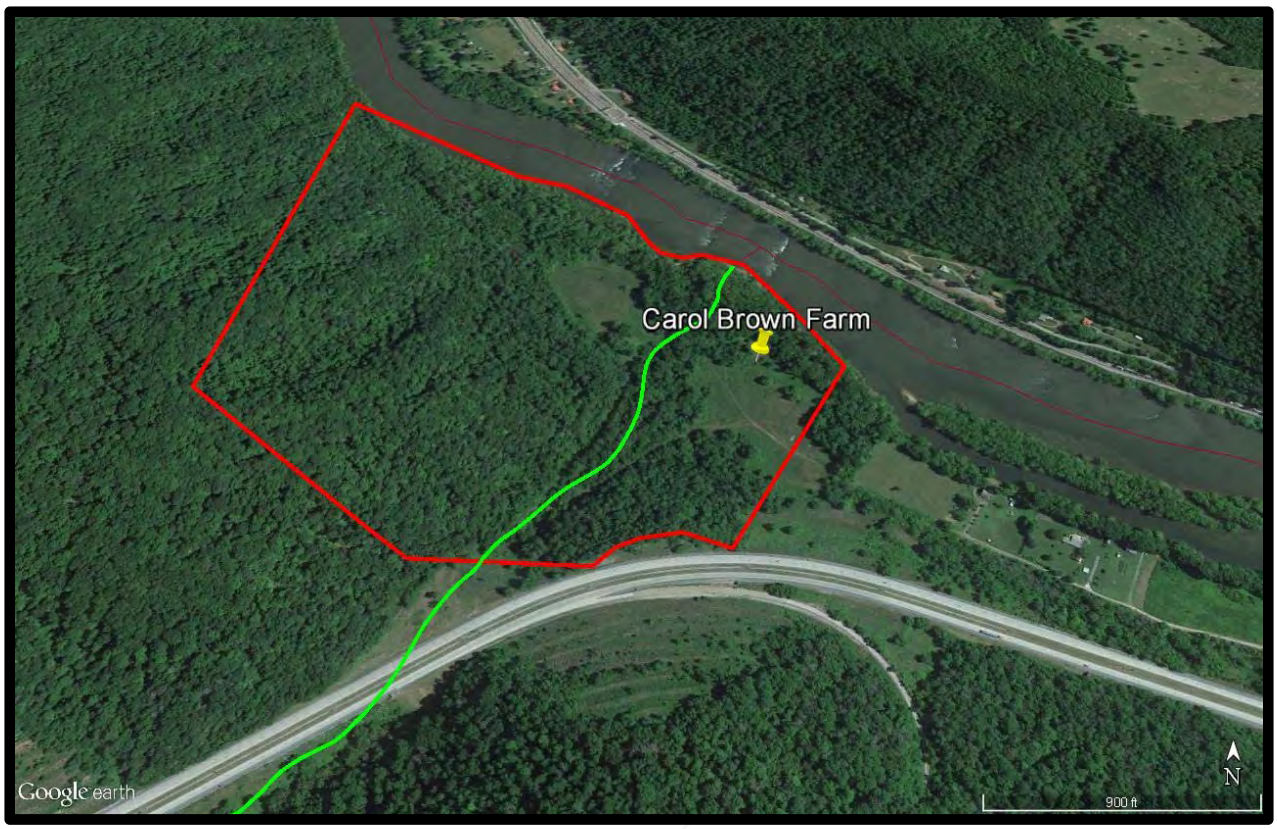

Figure 6: Carol Brown Farm Site Aerial Overview (Farley's Creek shown in green)

HEP Evaluation—Baseline Conditions

A habitat evaluation for the site was conducted in February 2017 No site visit has been conducted to date. Site data was collected by desktop review. Habitat Evaluation Procedures (HEP) were used to determine the baseline habitat conditions, using one of the terrestrial species models used for the Bluestone Dam Modification Impact HEP: mink.

Because the property is currently available for sale, it is presumed for the purposes of the model that the entire site would be cleared of tree and shrub cover in Year 0. Under this assumption, the 16 acres within the site that fall within 100 meters of the New River, which is the limit of the mink model, would be expected to provide 2.4 Habitat Units (HU) in Year 10. The limited habitat quality produced in the baseline condition would come from the continued presence of the New River and rock shoreline cover. The HEP workbook for this site is provided in Appendix A.

It is assumed that the portion of the New River adjacent to the Carol Brown Farm property currently meets near optimum habitat quality parameters under the smallmouth model (Habitat Suitability Index of 0.83) including monthly average turbidity, stream gradient, percent pools percent cover in the form of boulders, stumps, dead trees, and crevices or vegetation and rocks, water temperature and gravel, rubble, or boulder substrate. Thus, the 11.4 acres of adjacent river

habitat estimated to be directly influenced by the Carol Brown Farm property would produce 9.46 HUs.

Land Acquisition

The Carol Brown Farm property is a privately held parcel within the New River Gorge National River service area. The property would require fee simple acquisition or placement of a perpetual conservation servitude.

2. Mitigation Work Plan

Mitigation Objectives

The goal of the proposed mitigation at this site is preservation of the existing canopy and shrub cover and development of a canopy and/or shrub cover within existing cleared areas that can, by Year 10, increase the site's Habitat Suitability Index according to the mink HEP model. According to these models, the following criteria provide optimum habitat for mink:

- 75-100% tree and/or shrub canopy cover within 100 meters of river

Because tree canopy species typically take much longer than the restoration project's life (e.g. sugar maple maturity is estimated to be approximately 40 years in West Virginia, whereas the project life for this mitigation is 10 years), mitigation objectives and their related success criteria would be based on indicators of restoration trajectory and performance to encourage habitat structure that can reasonably be expected to successfully mature and provide optimum habitat for target riparian species.

Conceptual Ecological Enhancements

1. Restoration would be limited to those areas which are currently turf grass/ herbaceous vegetation; no existing trees would be impacted unless they are within the herbaceous vegetation areas and identified as invasive species. If invasive trees species are identified, individual trees will be mechanically removed.

2. If any gravel or other surfacing covers the existing road through the property, this material would be removed from the site and disposed of in accordance with applicable state and Federal solid waste laws.

3. Seedlings of canopy tree species and shrub species would be planted in a scattered pattern in plots no less than 10 feet by 10 feet and no greater than 12 feet by 12 feet. No less than five different canopy tree species and no less than three shrub species would be planted. Possible species which could be used are provided in Table 4. As the final mitigation plan is developed, consultation with arborists, botanists and resource agencies will tailor the planting list to those which are most suited to site conditions.

4. Maintenance activities would include mechanical vegetation control or use of herbicides to control competing vegetation on a semi-annual basis for the first five monitoring years, then on an as needed basis to minimize the presence of exotic species. Thinning may be used if necessary.

5. Approximately 116.6 acres of existing canopy cover would be preserved; no restoration would be conducted within this area.

Table 4: Tree and Shrub Species to be Planted

Tree Species		Shrub Species	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
White Oak	*Quercas alba*	Mapleleaf Viburnum	*Viburnum acerifolium*
Red Maple	*Acer rubrum*	Silky Dogwood	*Cornus obliqua*
Sycamore	*Platanus occidentalis*	Streamside Alder	*Alnus serrulata*
Tuliptree (Yellow poplar)	*Liriodendron tulipifera*	American Holly	*Ilex opaca*
Wild Black Cherry	*Prunus serotina*	Maleberry	*Lyonia ligustrina*
Pawpaw	*Asimina triloba*	Buttonbush	*Cephalanthus occidentalis*
River Birch	*Betula nigra*	Ninebark	*Physocarpus opulifolius*
Black Locust	*Robinia pseudoacacia*	Serviceberry	*Amelanchier arborea*
American Beech	*Fagus grandifolia*	American Hazelnut	*Corylus americana*
Yellow Buckeye	*Aesculus flava*	Winterberry	*Ilex verticillata*
White Basswood	*Tilia americana var. heterophylla*	Mountain Laurel	*Kalmia latifolia*
White Ash	*Fraxinus americana*	Spice Bush	*Lindera benzoin*
Hemlock	*Fraxinus americana*	Witch-hazel	*Hamamelis virginiana*
Hackberry	*Celtis Canadensis*	Black Elderberry	*Sambucus canadensis*
Red Oak	*Quercas rubra*		
Shagbark Hickory	*Carya ovate*		
Redbud	*Cercis canadensis*		

HEP Estimate of Restoration Gain

Within the 16 acres that fall within 100 meters of the New River, which is the limit of the mink model, 1.2 acres would be restored and 14.8 acres would be preserved. The potential HUs gained on this portion of the site would be produced by the increase in tree and shrub cover over 10 years within the restoration portion of the site, and preservation of the exiting canopy cover on

the remaining acreage. Tree cover within the restoration area would be expected to begin providing habitat value in Year 5, providing 30% cover and estimated to increase to 45% cover by Year 10. Deciduous shrub cover would begin providing habitat value in Year 1, providing 10% cover and estimated to increase to 50% cover in Year 10. Average tree height is estimated to be 5 feet in Year 3, increasing to 20 feet in Year 10. The increased and preserved mink habitat is estimated to produce a net gain in habitat value of 10.82 HUs in Year 10. Additionally, the preservation of existing riparian habitat would indirectly preserve 9.46 HUs within the portion of the New River adjacent to the Carol Brown Farm site. The HEP workbook for this site is provided in Appendix A.

3. Success Criteria

Preservation

The monitoring years in Table 5 refer to the end of the growing season after Year 0, which is the year that the land is acquired. For example, Year 1 will be measured at the end of the first growing season following the year that the land is acquired.

Table 5: Monitoring Years and Success Criteria

Monitoring Years	Success criteria
1, 5, 10	75-100% tree and/or shrub canopy cover within 100 meters of river

Restoration

The monitoring years in Table 6 refer to the end of the growing season after Year 0, which is the year that the plants are installed. For example, Year 1 will be measured at the end of the first growing season following the year that the plants are installed.

Table 6: Monitoring Years and Success Criteria

Monitoring Year	Success criteria
1	>75% survival of planted seedlings >200 woody species stems per acre < 5% non-native invasive species cover
3	>75% survival of planted seedlings >200 woody species stems per acre < 5% non-native invasive species cover
5	>200 woody species stems per acre < 5% non-native invasive species cover
10	>200 woody species stems per acre >25% tree canopy closure and/or >40% shrub canopy cover < 5% non-native invasive species cover

4. Monitoring Plan

A baseline monitoring report would be completed by the USACE or a consultant hired by USACE after final construction is complete, followed by monitoring reports by USACE or a USACE-consultant in Years 1, 3, 5 and 10 after the baseline report. The construction contractor will also be responsible for monitoring during the first year post-planting to ensure optimal survival, and will be responsible for meeting the year 1 success criteria. The USACE generated report will serve as a check on the contractor's monitoring and progress. This monitoring report schedule may be amended to account for delayed achievement in success criteria. For example, if re-planting is required to meet success criteria, an additional monitoring report will be completed for documentation of the new baseline after re-planting is complete. If success criteria are not met for a given year, additional monitoring reports will be required for at least two additional consecutive years until success criteria are met. If thinning of trees or shrubs are warranted, a monitoring report would be completed prior to the planned thinning and after one growing season after the thinning.

Permanent 50-foot radius monitoring plots would be established throughout the mitigation site, with at least 2 plots per 5 acres. The centerpoint of each plot will be marked with a permanent marker, and will be used as a permanent photo station. Monitoring activities will take place near the end of each growing season. Reports will be completed within 6 months of the monitoring activities, and will include the following items:

Baseline Monitoring Report:

- Description of mitigation activities completed and description of habitat and characteristics of the restored site.
    - Plan view of site showing planted areas, long-term monitoring sample plot locations, photo station locations
    - Inventory of all species planted, stock size planted, number of each species planted in each food plot.
- No less than 4 photographs in each cardinal direction from each photo station.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems or other notes pertinent to the success of the mitigation.
- A description of future planned maintenance and any recommended alteration or additions to the planned maintenance to address any conditions observed in the field.

Additional Monitoring Reports:

- Description and schedule of maintenance activities or adaptive management activities completed since last monitoring report
- Description of river elevations (annual high, low and average), known flood occurrences of mitigation site, summary of weather patterns since last monitoring report, noting any unusual occurrences (e.g. record low temperatures).
- No less than 4 photographs in each cardinal direction from each photo station.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems or other notes pertinent to the success of the mitigation.
- Within each plot, the following data would be recorded:
    - Number of living individuals planted in year zero and species composition
    - Number of woody stems present (planted or volunteer)
    - Percent cover of non-native invasive species (woody and herbaceous; all strata)
    - Percent cover of woody species (after year 5, provide percent cover for canopy trees and shrubs separately)
    - Average density of all native woody species
    - Percent cover of all native herbaceous species
    - Total number of each species present in canopy and shrub stratum
- A description of future planned maintenance and any recommended alteration or additions to the planned maintenance to address any conditions observed in the field.
- If re-planting or other adaptive management activities occurred, an inventory of number of each species planted and stock size should be provided. Reference should be made to the general location of these new plantings, with an aerial depiction of location.
- If timber management/thinning activities are planned for the site, a description of the techniques to be employed, number, location, species, diameter breast height (dBh)

and height of species removed would be included in the pre- and post-thinning monitoring reports.

5. Adaptive Management

As required under the Water Resources Development Act (WRDA) of 2007, Section 2036(a) and USACE implementation guidance, adaptive management would be included in mitigation planning for these sites. Adaptive management planning includes identification of key risks and uncertainties influencing the mitigation sites and how these factors relate to the achievement of mitigation objectives, and development of possible contingency plan actions which could be implemented to address the influence of factors adversely affecting achievement of success criteria.

Until Year 1 success criteria are met, the construction contractor will be responsible for implementing any adaptive management measures required, regardless of whether it takes longer than one year to meet the criteria. After Year 1 success criteria are achieved (regardless of whether it is one year after planting or more), USACE will resume responsibility for any adaptive management actions.

Primary risks and uncertainties which could influence project success include:

1. Invasive species
2. Herbivory
3. Abnormal hydrology/weather
4. Climate change

While the mitigation work plan includes what is reasonably assumed to be ample invasive species control as part of maintenance activities, the open field nature of the mitigation site prior to establishment of native species presents favorable conditions for intrusion by non-native species. If non-native exotic species cover cannot be kept below 5% in any of the monitoring plots, an increased frequency of invasive species control could be implemented or, if herbicides have previously been used, additional research could be completed to determine if more effective herbicide applications are available.

If herbivory is suspected to be causing higher than expected mortality of young plantings, plant guards could be installed on remaining plantings and utilized during replanting.

Species selected for planting within the restoration site are typically able to survive under a variety of hydrologic conditions, typically being found within moderately wet to moderately dry soils. Some are known to be reasonably drought tolerant. As the final mitigation plan is developed, consultation with arborists, botanists and resource agencies will tailor the planting list to those which are most suited to site conditions. However, if unusual weather patterns were to persist outside of the tolerable variances of the planted species, some plant loss could occur. Additional seedlings would be planted to compensate for loss due to extreme weather patterns. If

climate change or other factors produce persistent changes in weather patterns within the project area, the species of replanted individuals could be shifted to include more drought tolerant species or species which can tolerate wetter conditions, depending upon the circumstances. Such shifts would consider the overall succession trajectory of neighboring forested lands.

Candidate Site:

Lovern

1. Site Overview

Location

The Lovern site is located on the right descending bank of the New River, approximately 21 river miles upstream of the Bluestone Dam (Figure 7).

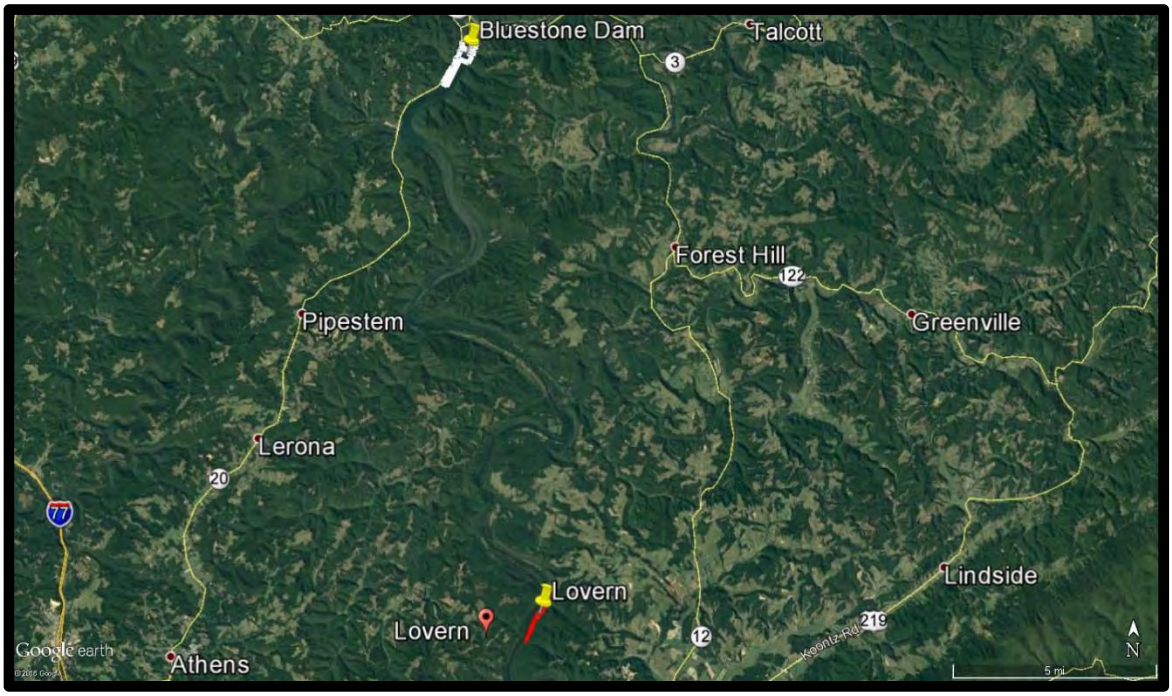

Figure 7: Location of Lovern Site, outlined in red

Site Characteristics and Baseline Conditions

The area to be potentially restored is a series of mowed/herbaceous areas comprising approximately 69 acres along the New River within the fee boundary of USACE (Figure 8). These areas are located 0-200 feet from the bankline of the river. The site is relatively flat compared to adjacent terrain. Riverbank elevation in this area is approximately 1440 feet, while the site slopes up to approximately 1450 feet. Aerial photography of this site seems to indicate that much of the non-forested land is currently used for hay production.

Soils within the Lovern site are classified as Chagrin series soils, which are subject to occasional overflow for short periods and support mixed hardwood species.

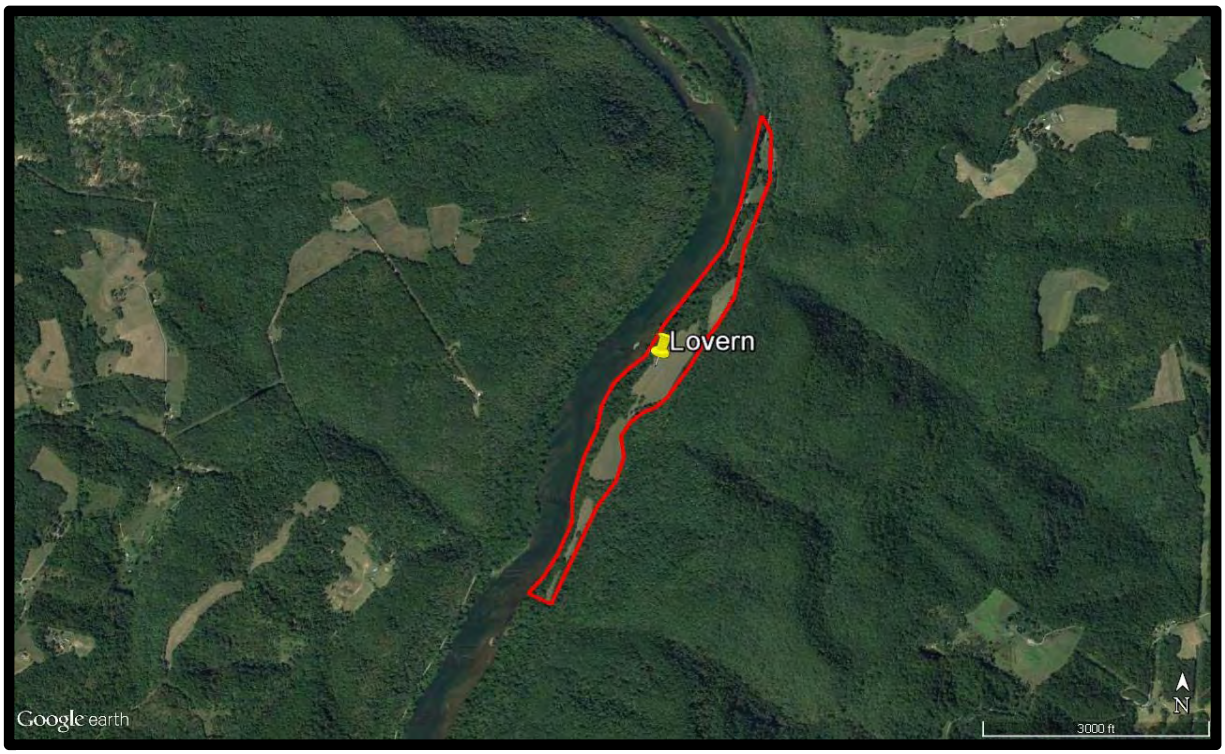

Figure 8: Lovern Site Aerial Overview

HEP Evaluation—Baseline Conditions

A habitat evaluation for the site was conducted in February 2017 No site visit has been conducted to date. Site data was collected by desktop review. Habitat Evaluation Procedures (HEP) were used to determine the baseline habitat conditions, using one of the terrestrial species models used for the Bluestone Dam Modification Impact HEP: mink.

It is presumed for the purposes of the model that the portion of the site that is currently wooded between the open fields and the river would be cleared of tree and shrub cover in Year 0. Under this assumption, the 52.5 acres within the site that fall within 100 meters of the New River, which is the limit of the mink model, would be expected to provide 7.88 Habitat Units in Year 10. The limited habitat quality produced in the baseline condition would come from the continued presence of the New River and rock shoreline cover. The HEP workbook for this site is provided in Appendix A.

It is assumed that the portion of the New River adjacent to the Lovern property currently meets near optimum habitat quality parameters under the smallmouth model (Habitat Suitability Index of 0.83) including monthly average turbidity, stream gradient, percent pools percent cover in the form of boulders, stumps, dead trees, and crevices or vegetation and rocks, water temperature

and gravel, rubble, or boulder substrate. Thus, the 45.9 acres of adjacent river habitat estimated to be directly influenced by the Lovern property would produce 38.09 HUs.

Land Acquisition

The property is within the USACE fee boundary. No land acquisition is required.

2. Mitigation Work Plan

Mitigation Objectives

The goal of the proposed mitigation at this site is preservation of the existing canopy and shrub cover and development of a canopy and/or shrub cover within existing cleared areas that can, by Year 10, increase the site's Habitat Suitability Index according to the mink HEP model. According to these models, the following criteria provide optimum habitat for mink:

- 75-100% tree and/or shrub canopy cover within 100m of river

Because tree canopy species typically take much longer than the restoration project's life (e.g. sugar maple maturity is estimated to be approximately 40 years in West Virginia, whereas the project life for this mitigation is 10 years), mitigation objectives and their related success criteria would be based on indicators of restoration trajectory and performance to encourage habitat structure that can reasonably be expected to successfully mature and provide optimum habitat for target riparian species.

Conceptual Ecological Enhancements

1. Restoration would be limited to those areas which are currently turf grass/herbaceous vegetation; no existing trees would be impacted unless they are within the herbaceous vegetation areas and identified as invasive species. If invasive trees species are identified, individual trees will be mechanically removed. If invasive herbaceous or shrub species are found within the areas to be planted, they would be mechanically removed or herbicides would be used.

2. Seedlings of canopy tree species and shrub species would be planted in a scattered pattern in plots no less than 10 feet by 10 feet and no greater than 12 feet by 12 feet. No less than five different canopy tree species and no less than three shrub species would be planted. Possible species which could be used are provided in Table 7. As the final mitigation plan is developed, consultation with arborists, botanists and resource agencies will tailor the planting list to those which are most suited to site conditions.

3. Maintenance activities would include mechanical vegetation control or use of herbicides to control competing vegetation on a semi-annual basis for the first five monitoring years,

then on an as needed basis to minimize the presence of exotic species. Thinning may be used if necessary.

4. Approximately 36 acres of existing canopy cover would be preserved; no restoration would be conducted within this area.

Table 7: Tree and Shrub Species to be Planted

Tree Species		Shrub Species	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
White Oak	*Quercas alba*	Mapleleaf Viburnum	*Viburnum acerifolium*
Red Maple	*Acer rubrum*	Silky Dogwood	*Cornus obliqua*
Sycamore	*Platanus occidentalis*	Streamside Alder	*Alnus serrulata*
Tuliptree (Yellow poplar)	*Liriodendron tulipifera*	American Holly	*Ilex opaca*
Wild Black Cherry	*Prunus serotina*	Maleberry	*Lyonia ligustrina*
Pawpaw	*Asimina triloba*	Buttonbush	*Cephalanthus occidentalis*
River Birch	*Betula nigra*	Ninebark	*Physocarpus opulifolius*
Black Locust	*Robinia pseudoacacia*	Serviceberry	*Amelanchier arborea*
American Beech	*Fagus grandifolia*	American Hazelnut	*Corylus americana*
Yellow Buckeye	*Aesculus flava*	Winterberry	*Ilex verticillata*
White Basswood	*Tilia americana var. heterophylla*	Mountain Laurel	*Kalmia latifolia*
White Ash	*Fraxinus americana*	Spice Bush	*Lindera benzoin*
Hemlock	*Fraxinus americana*	Witch-hazel	*Hamamelis virginiana*
Hackberry	*Celtis Canadensis*	Black Elderberry	*Sambucus canadensis*
Red Oak	*Quercas rubra*		
Shagbark Hickory	*Carya ovate*		
Redbud	*Cercis canadensis*		

HEP Estimate of Restoration Gain

Within the 52.5 acres that fall within 100 meters of the New River, which is the limit of the mink model, 17.9 acres would be restored and 34.6 acres would be preserved. The potential HUs gained on this portion of the site would be produced by the increase in tree and shrub cover over 10 years within the restoration portion of the site, and preservation of the exiting canopy cover on the remaining acreage. Tree cover within the restoration area would be expected to begin

providing habitat value in Year 5, providing 30% cover and estimated to increase to 45% cover by Year 10. Deciduous shrub cover would begin providing habitat value in Year 1, providing 10% cover and estimated to increase to 50% cover in Year 10. Average tree height is estimated to be 5 feet in Year 3, increasing to 20 feet in Year 10. The increased and preserved mink habitat is estimated to produce a net gain in habitat value of 34.03 HUs in Year 10. Additionally, the preservation of existing riparian habitat would indirectly preserve 38.09 HUs within the portion of the New River adjacent to the Lovern site. The HEP workbook for this site is provided in Appendix A.

3. Success Criteria

Preservation

The monitoring years in Table 8 refer to the end of the growing season after Year 0, which is the year that the land is acquired. For example, Year 1 will be measured at the end of the first growing season following the year that the land is acquired.

Table 8: Monitoring Years and Success Criteria

Monitoring Years	Success criteria
1, 5, 10	75-100% tree and/or shrub canopy cover within 100m of river

Restoration

The monitoring years in Table 9 refer to the end of the growing season after Year 0, which is the year that the plants are installed. For example, Year 1 will be measured at the end of the first growing season following the year that the plants are installed.

Table 9: Monitoring Years and Success Criteria

Monitoring Year	Success criteria
1	>75% survival of planted seedlings >200 woody species stems per acre < 5% non-native invasive species cover
3	>75% survival of planted seedlings >200 woody species stems per acre < 5% non-native invasive species cover
5	>200 woody species stems per acre < 5% non-native invasive species cover
10	>200 woody species stems per acre >25% tree canopy closure and/or >40% shrub canopy cover < 5% non-native invasive species cover

4. Monitoring Plan

A baseline monitoring report would be completed by the USACE or a consultant hired by USACE after final construction is complete, followed by monitoring reports by USACE or a USACE-consultant in Years 1, 3, 5 and 10 after the baseline report. The construction contractor will also be responsible for monitoring during the first year post-planting to ensure optimal survival, and will be responsible for meeting the year 1 success criteria. The USACE generated report will serve as a check on the contractor's monitoring and progress. This monitoring report schedule may be amended to account for delayed achievement in success criteria. For example, if re-planting is required to meet success criteria, an additional monitoring report will be completed for documentation of the new baseline after re-planting is complete. If success criteria are not met for a given year, additional monitoring reports will be required for at least two additional consecutive years until success criteria are met. If thinning of trees or shrubs are warranted, a monitoring report would be completed prior to the planned thinning and after one growing season after the thinning.

Within the land portion of the project, permanent 50-foot radius monitoring plots would be established throughout the mitigation site, with at least 2 plots per 5 acres. The centerpoint of each plot will be marked with a permanent marker, and will be used as a permanent photo station. Monitoring activities will take place near the end of each growing season. Reports will be completed within 6 months of the monitoring activities and will include the following items:

<u>Baseline Monitoring Report</u>:

- Description of mitigation activities completed and description of habitat and characteristics of the restored site.
    - Plan view of site showing planted areas, long-term monitoring sample plot locations, photo station locations
    - Inventory of all species planted, stock size planted, number of each species planted in each food plot.
- No less than 4 photographs in each cardinal direction from each photo station.
- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems or other notes pertinent to the success of the mitigation.
- A description of future planned maintenance and any recommended alteration or additions to the planned maintenance to address any conditions observed in the field.

<u>Additional Monitoring Reports:</u>

- Description and schedule of maintenance activities or adaptive management activities completed since last monitoring report
- Description of river elevations (annual high, low and average), known flood occurrences of mitigation site, summary of weather patterns since last monitoring report, noting any unusual occurrences (e.g. record low temperatures).
- No less than 4 photographs in each cardinal direction from each photo station.

- Narrative of observations made during monitoring activities which indicate the overall condition of the site, potential problems or other notes pertinent to the success of the mitigation.
- Within each land plot, the following data would be recorded:
    - Number of living individuals planted in year zero and species composition
    - Number of woody stems present (planted or volunteer)
    - Percent cover of non-native invasive species (woody and herbaceous; all strata)
    - Percent cover of woody species (after year 5, provide percent cover for canopy trees and shrubs separately)
    - Average density of all native woody species
    - Percent cover of all native herbaceous species
    - Total number of each species present in canopy and shrub stratum
- A description of future planned maintenance and any recommended alteration or additions to the planned maintenance to address any conditions observed in the field.
- If re-planting or other adaptive management activities occurred, an inventory of number of each species planted and stock size should be provided. Reference should be made to the general location of these new plantings, with an aerial depiction of location.
- If timber management/thinning activities are planned for the site, a description of the techniques to be employed, number, location, species, diameter breast height (dBh) and height of species removed would be included in the pre- and post-thinning monitoring reports.

5. Adaptive Management

As required under the Water Resources Development Act (WRDA) of 2007, Section 2036(a) and USACE implementation guidance, adaptive management would be included in mitigation planning for these sites. Adaptive management planning includes identification of key risks and uncertainties influencing the mitigation sites and how these factors relate to the achievement of mitigation objectives, and development of possible contingency plan actions which could be implemented to address the influence of factors adversely affecting achievement of success criteria.

Until Year 1 success criteria are met, the construction contractor will be responsible for implementing any adaptive management measures required, regardless of whether it takes longer than one year to meet the criteria. After Year 1 success criteria are achieved (regardless of whether it is one year after planting or more), USACE will resume responsibility for any adaptive management actions.

Primary risks and uncertainties which could influence project success include:

1. Invasive species
2. Herbivory
3. Abnormal hydrology/weather
4. Climate change

While the mitigation work plan includes what is reasonably assumed to be ample invasive species control as part of maintenance activities, the open field nature of the land-based mitigation site prior to establishment of native species presents favorable conditions for intrusion by non-native species. If non-native exotic species cover cannot be kept below 5% in any of the monitoring plots, an increased frequency of invasive species control could be implemented or, if herbicides have previously been used, additional research could be completed to determine if more effective herbicide applications are available.

If herbivory is suspected to be causing higher than expected mortality of young plantings, plant guards could be installed on remaining plantings and utilized during replanting in both the land and water sites.

Species selected for planting are typically able to survive under a variety of hydrologic conditions, typically being found within moderately wet to moderately dry soils. Some are known to be reasonably drought tolerant. As the final mitigation plan is developed, consultation with arborists, botanists and resource agencies will tailor the planting list for the land-based site to those which are most suited to site conditions. However, if unusual weather patterns were to persist outside of the tolerable variances of the planted species, some plant loss could occur. Additional seedlings would be planted to compensate for loss due to extreme weather patterns of changes in management of Bluestone Lake levels in both the land and water sites. If climate change or other factors produce persistent changes in weather patterns within the project area, the species of replanted individuals could be shifted to include more drought tolerant species or species which can tolerate wetter conditions, depending upon the circumstances. Such shifts would consider the overall succession trajectory of neighboring forested lands.

Appendix A: HEP Analyses

Bluestone Lake Boulder Reefs and Barker's Bottom HEP Analyses

Draft Report:

Lacustrine Habitat Evaluations for Selected Sites in the Bluestone Lake Impoundment of the New River

Bluestone Dam Safety Modification, Hinton, WV

W91237-16-D-002, Task Order 0011 MOD-01

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EXECUTIVE SUMMARY:

EnviroScience, Inc. was contracted by ECS-GEC JV. to perform a habitat evaluation of selected lacustrine zones of Bluestone Lake, Summers County, West Virginia. The evaluation will quantify baseline and future lacustrine habitat, and will assist in the selection of alternatives formulated to achieve restoration goals for Bluestone Lake. Sampling was conducted in January 2017 in selected reaches of Bluestone Lake that were the cumulative equivalent of 1-mi of stream. Five transects, including 26 sampling locations, were selected to assess habitat suitability of selected fish species, Smallmouth Bass and Common Shiner, using water quality parameters, bathymetric morphology, and qualitative sediment characterization.

Water chemistry data revealed levels of pH, dissolved oxygen, and temperature were typical of temperate reservoirs during winter months, and relatively low levels of turbidity. Substrates at most sites consisted of a combination of sand, silt, and mud. Along banks in the reaches sampled closest to the dam, substrates consisted of sand, gravel, and boulder material. Shoreline habitat was excellent in some parts of the lake, but was limited offshore. Bluestone Lake will benefit from additive habitat enhancement including the construction of boulder reefs to support target fish populations at locations within reaches BL1 and BL2. BL3 would benefit from the construction of weir dams along the left descending bank of the main channel in order to diversify in-stream habitats and increase suitable habitats for target fish populations. The placement of these potential structures is paramount so that they do not become embedded with smaller substrate particles like many habitats along the thalweg of the impoundment.

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1.0 INTRODUCTION

EnviroScience conducted an evaluation of in-stream habitat and water quality characteristics at selected locations in Bluestone Lake near Hinton, WV. The evaluation quantifies baseline and future lacustrine habitat, and will assist in the selection of alternatives formulated to achieve restoration goals for Bluestone Lake. The potential alternatives focused on to achieve these restoration goals include the construction of boulder-based reefs and weir dikes. The restoration value gained by the construction of these new structures was estimated based upon the quality of similar, previously constructed structures within Bluestone Lake.

The quantity of currently existing in-stream habitat and proposed habitat restoration is determined through the calculation of Habitat Units (HUs). HUs are calculated by multiplying a Habitat Suitability Index (HSI) value by the amounts of certain habitat types that are present with the assessed area. HSI values are calculated using equations that are formulated for focal species. Each focal species equation incorporates the presence or absence of measurable habitat characters that can be used to determine the species likelihood to occupy a given location. The focal species used for this project included Smallmouth Bass (*Micropterus dolomieu*) and Common Shiner (*Luxilus comutus*). These species were selected due to their previous use in an U.S. Fish and Wildlife Service assessment that was performed downstream of the Bluestone Lake dam (USFWS 2013).

2.0 METHODS

2.1. AQUATIC HABITAT EVALUATION FIELD SURVEY

2.1.1. Streambed Mapping

Side scan sonar was collected and geo-referenced (Starfish or Lowerance- type, 455 kHz or 800 kHz, depending on conditions and depth) with the goal of complete coverage mapping of the survey area. Data was collected along equi-spaced transects that were oriented parallel to flow.

2.1.2. Site and Station Selection

General Site locations were agreed upon in coordination with ECS-GEC and the USACE. In total,

three site areas, the equivalent of approximately 2mi of stream were assessed, BL1-BL3. Two transects were placed perpendicular to flow in BL1, the assessed reach closest to Bluestone Dam. One transect was placed perpendicular to flow in BL2, and two transects were placed in line with flow in BL3, the assessed reach furthest upstream from Bluestone Dam. Transect placement was pre-determined with input from USACE's proposed boulder cluster sites

Along each transect, six stations were identified for sampling in BL1 and BL2. BL3 transects had four sampling locations per transect. Station locations were placed equidistant along the length of the transect.

Existing boulder clusters were also identified and assessed to calculate HSI values. These HSI values were then used to calculate the number of HUs that could be created following the installation of new, upstream boulder clusters.

2.1.3. Infield Water Chemistry and Substrate Characterization

Water quality parameters were quantified using a calibrated YSI 600XL multi-parameter sonde, with a YSI 650MDS data display/logging system. Data were collected in 1ft intervals and adjusted to every meter due to uniformness of water quality data from the water surface to the stream bottom at each sampling station. Water parameters included temperature (°C), conductivity (uS/cm), dissolved oxygen (mg/L), and pH. Water turbidity was measured at each station using a Secchi disc and the distance was converted into NTU units. The depths at which the lowered disc disappeared when viewed from the shaded side of the boat and at which it reappeared upon raising were measured, and the mean of these depths was recorded as the Secchi depth. Summer temperatures for the assessed areas were approximated using historic stream temperature data collected the USGS stream gauge located downstream in Hinton, WV (Gauge #03184500). Results of infield water chemistry monitoring are presented in Tables 1 and 3.

At each station, a qualitative substrate evaluation was conducted using an underwater camera to determine substrate composition at each station. Substrate was characterized as Bedrock, Boulder, Boulder/Slabs, Cobble (large/small), Gravel (course/medium/fine), Sand, Hardpan, Detritus, Silt, Muck, or a combination of these with percentages of each noted. Results of substrate characterization are presented in Tables 1 and 3.

2.2. AQUATIC HABITAT EVALUATION DATA ANALYSIS

EnviroScience utilized the approved Habitat Evaluation Procedures to identify baseline and potential habitat units gained. When calculating HSI units for Smallmouth Bass, we used the Additional Habitat Model #2 for Lacustrine Habitat found in the *Habitat Suitability Information: Smallmouth Bass* bluebook report produced by the U.S. Fish and Wildlife Service (Edwards and Gebhart, 1983). When calculating HSI units for Common Shiner, we used the Additional Habitat Model #1 found in the *Habitat Suitability Information: Common Shiner* bluebook report produced by the U.S. Fish and Wildlife Service (Trial and Nelson, 1983).

Baseline Habitat Units (HU) were assessed for the current existing conditions. EnviroScience also assess the proposed uplift from the Conceptual Draft Mitigation Plans developed for Task 6 in the original SOW in HUs. The disposal HU was calculated using boulder cluster data collected during the Baseline HU field data collection. Data from two existing boulder clusters were collected during baseline data collection and incorporated into the Disposal HU data analysis.

3.0 RESULTS

3.1. HABITAT EVALUATION

EnviroScience personnel completed sampling on January 4-6, 2017. Transect specific data are summarized below in order from the most downstream transect to the most upstream transect and presented in their entirety in Figures 1, 2, and 3 and Tables 1 and 3.

3.1.1. BL1-DP2

Six sampling stations were created along this transect (Figures 2.1 and 3.1; Tables 1 and 3). Depths along the transect ranged from 0.5m to 9.5m in depth. Recorded depths were deepest along the left descending bank. Water clarity ranged from 1.1 to 0.5m (14.89 – 25.85 NTU). Temperatures ranged from 5.3 – 5.9 C. Dissolved oxygen ranged from 88.9 – 91.3% (11.13 – 11.59 mg/L). Specific conductance ranged from 224.1 – 244.6 µS/cm^{c} and pH ranged from 7.85-7.96 SU. Substrates along transect BL1-DP2 ranged from boulder to silt/mud. The primary substrates along both banks (Sampling Stations BL1-DP2-1 and 6) were comprised of a combination of boulder and cobble material. Dominant substrates along Sampling Stations BL1-DP2-2 through 4 consisted of silt and mud. Gravel and mud were the dominant substrates observed at sampling station BL1-DP2-5.

3.1.2. BL1-DP1

Six sampling stations were created along this transect (Figures 2.1 and 3.1; Tables 1 and 3). Depths along the transect ranged from 0.7m to 5.8m in depth. Recorded depths were deepest along the left descending bank. Water clarity ranged from 1.5 to 0.7m (14.02 – 20.43 NTU). Temperatures ranged from 6.1 – 6.7 C. Dissolved oxygen ranged from 90.0 – 92.5% (11.01 – 11.33 mg/L). Specific conductance ranged from 219.1 – 235.4 µS/cm[c] and pH ranged from 7.85 – 7.93 SU. Substrates along transect BL1-DP1 ranged from boulder to silt/mud. The primary substrates along both banks (Sampling Stations BL1-DP1-1 and 6) were comprised of a combination of boulder and cobble material. Dominant substrates along Sampling Stations BL1-DP1-2 through 4 consisted of silt and mud. Gravel and mud were the dominant substrates observed at sampling station BL1-DP1-5.

3.1.3. BL2-DP

Six sampling stations were created along this transect (Figures 2.2 and 3.2; Tables 1 and 3). Depths along the transect ranged from 0.8m to 8.8m in depth. Recorded depths were generally level across the transect except for the Sampling Stations positioned closest to each bank. Water clarity ranged from 1.2 to 0.7m (11.99 – 20.43 NTU). Temperatures ranged from 6.2 – 6.4 C. Dissolved oxygen ranged from 89.4 – 94.6% (11.05 – 11.6 mg/L). Specific conductance ranged from 231.2 – 240.4 µS/cm[c] and pH ranged from 7.89 – 7.94 SU. Substrates along transect BL2-DP ranged from boulder to silt/mud. The primary substrates along the right descending bank (Sampling Stations BL2-DP-1) was comprised of a combination of boulder and cobble material. Dominant substrates along Sampling Stations BL2-DP-2, 3, 4, and 6 consisted of silt and mud. Gravel and mud were the dominant substrates observed at sampling station BL2-DP-5.

3.1.4. BL3-DPA

Four sampling stations were created along this transect (Figures 2.3 and 3.3; Tables 1 and 3). Depths along the transect ranged from 0.5 m to 1.8 m in depth. Water clarity ranged from 1.6 to 0.5m (11.46 – 25.85 NTU). Temperatures ranged from 6.0 – 6.3 C. Dissolved oxygen ranged from 92.1 – 95.1% (11.45 – 11.72 mg/L). Specific conductance ranged from 235.9 – 240.8 µS/cm[c] and pH ranged from 7.89 – 7.94 SU. The primary substrates along the four sampling stations was mud and sand.

3.1.5. BL3-DPB

Four sampling stations were created along this transect (Figures 2.3 and 3.3; Tables 1 and 3). Depths along the transect ranged from 0.8 m to 3 m in depth. Water clarity ranged from 1.75 to 0.8m (10.77 – 18.61 NTU). Temperatures ranged from 6.0 – 6.1 C. Dissolved oxygen ranged from 92.1 – 93.4% (11.45 – 11.57 mg/L). Specific conductance ranged from 235.0 – 240.8 µS/cm[c] and pH ranged from 7.9 – 7.93 SU. The primary substrates along the four sampling stations was sand.

3.1.6. REEF-DP

One sampling station was created at an existing boulder reef (Figure 1; Tables 1 and 3). The depth at the existing reef reached 7.5m. Water clarity was recorded at 0.8m (18.61 NTU). Temperatures ranged from 5.0 – 5.2 C. Dissolved oxygen ranged from 90.9 – 91.5% (11.57 – 11.64 mg/L). Specific conductance ranged from 271.2 – 273.9 µS/cm[c] and pH ranged from 7.82 – 7.84 SU. The primary substrates at the sampling station was boulder.

3.1.7. HSI and HU Calculations

HSI values for smallmouth bass ranged from 0.25 to 1 (Table 2). Lowest HSI values for the species were observed in BL3 where reservoir depths were shallowest and substrates consisted almost entirely of sand. The highest average HSI values were observed along transects BL1-DP2 and BL2. The higher values along these transects were driven by the presence of larger substrates, i.e. gravel and boulder.

HSI values were averaged and attributed to the substrate type as determined following performing a bottom-hardness analysis of the assessed reaches based on data collected the bathymetric analysis. Areas mapped as “hard” were ground-truthed using direct observations of substrate composition at sampling sites along the created transects and side scan imagery. In total, 14.40 HUs (ac) of habitat were calculated to exist with the areas of “hard” substrate and 187.94 HUs were calculated to exist in areas of “soft” substrate.

HSI values for common shiner were the same across all assessed transects (Table 4). Because in-stream habitats could not be differentiated in such a way that was distinguishable by the HSI equation used for common shiner, HSI values were equally attributed to all in-stream habitats. As a result, 209.86 HUs of common shiner habitat were calculated to exist within the assessed reaches of the New River. However, as will be discussed further below, this HU calculation is not

a realistic representation of suitable habitat area for the species within the study area.

4.0 DISCUSSION

The water quality and substrate variables that were measured and observed as part of this project were all within ranges that were to be expected given the time of year and locations in which samples were taken. Most water quality parameters were relatively constant across sampling locations. Small variations in some factors, including turbidity, can easily be attributed to several factors. The turbidity values at some locations are bound by the depths of the locations in which the samples are taken. Because the river bottom was visible from the surface at these locations, it is reasonable to assume NTU values would be lower if reservoir depths were greater at these locations. Although it could be assumed that the NTU values at these locations should be lower, we used the observed values and wanted to note that these values to do not necessarily represent the NTU values that would be calculated if turbidity had been recorded in another manner. Additionally, NTU values were also typically lower, but not drastically so, along the portion of the transect that intersected the historic river channel, the most “riverine” remaining portion of the impoundment.

In-stream substrates were also observed to be what is typically expected of an impounded stream. Smaller substrates, i.e. silt, sand, and mud, have embedded the deeper portions of the impoundment and larger substrates are observed along the bank areas. As a result, habitats with larger substrates along the banks regularly received higher HSI scores than areas within the middle of the lake that were dominated by smaller substrates. This tendency was not observed in Site BL3. However, it is not advisable to make a direct comparison between BL1-2 and BL3 due to the presence of the island in BL3. The island creates a location of decreasing stream flow that results in smaller substrate particles falling out of the water column.

Despite calculating large numbers of HUs in each of the assessed areas for both smallmouth bass and common shiner, it is important to place these numbers in the proper ecological context. The HSI formulas used to calculate HUs for each species were simplified and based habitat “suitability” on only a few characters. By doing this, habitat characteristics that are crucial to population survival for both species can be placed on the same level as other characteristics that are less critical. This simplified equation for calculating HSI values was evident in both species that were evaluated for this project. The calculations suggest that there are more than 187 ac of “suitable” soft substrate habitat, which, in reality, would be marginal at best for both species. But,

most obvious disagreement between HU calculated habitat and real-world, occupiable habitat exists in the assessment performed for common shiner. All sampling locations received a HSI score of 0.75 for the species. However, little to no actual instream habitat exists for the species within the assessed area due to the lack of riffle/pool complexes that the species typically inhabits. Although this habitat characteristic is included in the HSI calculations for the species, it is placed at the same level of importance of 3 water characters that were all successfully met for the area, thus decreasing the "value" of the only physical habitat character used in the equation.

The limiting factor for smallmouth bass populations in the assessed area is the presence of physical substrate habitats that would be occupied by the species. The amount of occupiable habitat can easily be increased through the installation of boulder-based structures, such as stand-alone reefs or weir walls. Based upon the field data collected during this project, and incorporating location suggestions from the U.S. Army Corps of Engineers, we have provided suggested locations for the placement of such structures within each of the assessed stream reaches (Figures 4.1 and 4.2).

Of particular note is that we recommend moving the placement of the boulder cluster along transect BL1-DP1 from the right descending bank to the left descending bank. We make this recommendation based upon the presence of a confluence with a creek just upstream of the transect and what appears to be quantities of smaller substrate, i.e. silt and sand, deposition at the confluence of this creek and the reservoir. We are concerned that the deposition in this area would lead to any reef structure placed along the right descending bank becoming inundated with sediments and losing its functionality.

The installation of these structures would lead to an increase in 2.8 HUs of high quality habitat throughout the assessed areas (Table 2). Please note that these calculations are based upon proposed reef and weir dimensions provided by GEC and USACE. Placement of these structures is paramount to avoid placing them in areas that would become inundated with smaller substrates that would bury the structure and make them essentially un-usable by the focal fish species. If constructed properly, the new stand-alone reefs and weir walls could increase the amount of high-quality, usable HUs within the assessed reach by almost 20%.

5.0 LITERATURE CITED

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Trial, J. G. and P. C. Nelson. 1983. Habitat Suitability Information: Common Shiner. U.S. Fish and Wildlife Service, Habitat Evaluation Procedures Group, Fort Collins, Colorado. 33pp.

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TABLES

	Raw Data					Equation Condition Met? (1 = yes; 0 = no)				
Sample Station	**Turbidity (NTU)**	**>1m deep (m)**	**21-29C Summer Temps**	**Substrate**		**< 25HTU**	**>1m deep**	**21-29C Summer Temps**	**Gravel, Rubble, or Boulder Substrate?**	**Habitat Suitability Index**
REEF-DP	18.61	7	26.5	Boulder		1	1	1	1	1
BL1-DP1-1	18.61	0.8	26.5	Sand		1	0	1	0	0.5
BL1-DP1-2	14.01	3	26.5	Mud		1	1	1	0	0.75
BL1-DP1-3	18.61	5	26.5	Silt		1	1	1	0	0.75
BL1-DP1-4	20.43	7.3	26.5	Silt		1	1	1	0	0.75
BL1-DP1-5	20.43	8.7	26.5	Mud		1	1	1	0	0.75
BL1-DP1-6	20.43	8.8	26.5	Gravel		1	1	1	1	1
BL1-DP2-1	24.85	0.5	26.5	Boulder		1	0	1	1	0.75
BL1-DP2-2	18.61	5.1	26.5	Silt		1	1	1	0	0.75
BL1-DP2-3	17.14	6	26.5	Silt		1	1	1	0	0.75
BL1-DP2-4	18.61	9	26.5	Silt		1	1	1	0	0.75
BL1-DP2-5	14.9	9.5	26.5	Gravel		1	1	1	1	1
BL1-DP2-6	14.9	2.7	26.5	Boulder		1	1	1	1	1
BL2-DP-1	20.43	1	26.5	Boulder		1	0	1	1	0.75
BL2-DP-2	15.92	5.1	26.5	Mud		1	1	1	0	0.75
BL2-DP-3	11.99	5.3	26.5	Mud		1	1	1	0	0.75
BL2-DP-4	12.58	5.1	26.5	Mud		1	1	1	0	0.75
BL2-DP-5	12.58	5.8	26.5	Gravel		1	1	1	1	1
BL2-DP-6	13.62	1.7	26.5	Boulder		1	1	1	1	1
BL3-DPA-1	11.46	1.8	26.5	Mud		1	1	1	0	0.75
BL3-DPA-2	25.85	0.5	26.5	Sand		0	0	1	0	0.25
BL3-DPA-3	25.85	0.5	26.5	Sand		0	0	1	0	0.25
BL3-DPA-4	25.85	0.5	26.5	Sand		0	0	1	0	0.25
BL3-DPB-1	10.77	3	26.5	Sand		1	1	1	0	0.75
BL3-DPB-2	7.91	2.9	26.5	Sand		1	1	1	0	0.75
BL3-DPB-3	15.92	1	26.5	Sand		1	0	1	0	0.5
BL3-DPB-4	18.61	0.8	26.5	Sand		1	0	1	0	0.5

Table 1. Field data, equation conditions, and Habitat Suitability Index Scores for Smallmouth Bass (*Micropterus dolomieu*) at selected locations in Bluestone Lake near Hinton, WV, January 2017.

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Area	Overall Size (ac)	Stream Composition (ac)		HSI Score	HUs (ac)
BL1	98.86	Hard	5.82	0.917	5.34
		Soft	93.04	0.719	66.87
BL1 Proposed*	98.86	Hard	7.06	0.917 + 1	6.58
		Soft	91.80	0.719	66.00
BL2 Existing	112.56	Hard	10.35	0.875	9.06
		Soft	102.21	0.850	86.87
BL2 Proposed**	112.56	Hard	10.97	0.875 + 1	9.68
		Soft	101.59	0.85	86.34
BL3 Existing	68.39	Hard	0	0	0
		Soft	68.39	0.500	34.20
BL3 Proposed***	68.39	Proposed Dikes	0.94	1.000	0.94
		Soft	67.45	0.500	33.73
Existing REEF	N/A	Hard	0.08	1.000	342

* assumes installation of 2 boulder reefs

** assumes installation of 1 boulder reefs

*** assumes installation of 0.94 acres of dike construction

Table 2. Existing and proposed HU quantities for Smallmouth Bass (*Micropterus dolomieu*) for selected locations in Bluestone Lake near Hinton, WV, January 2017.

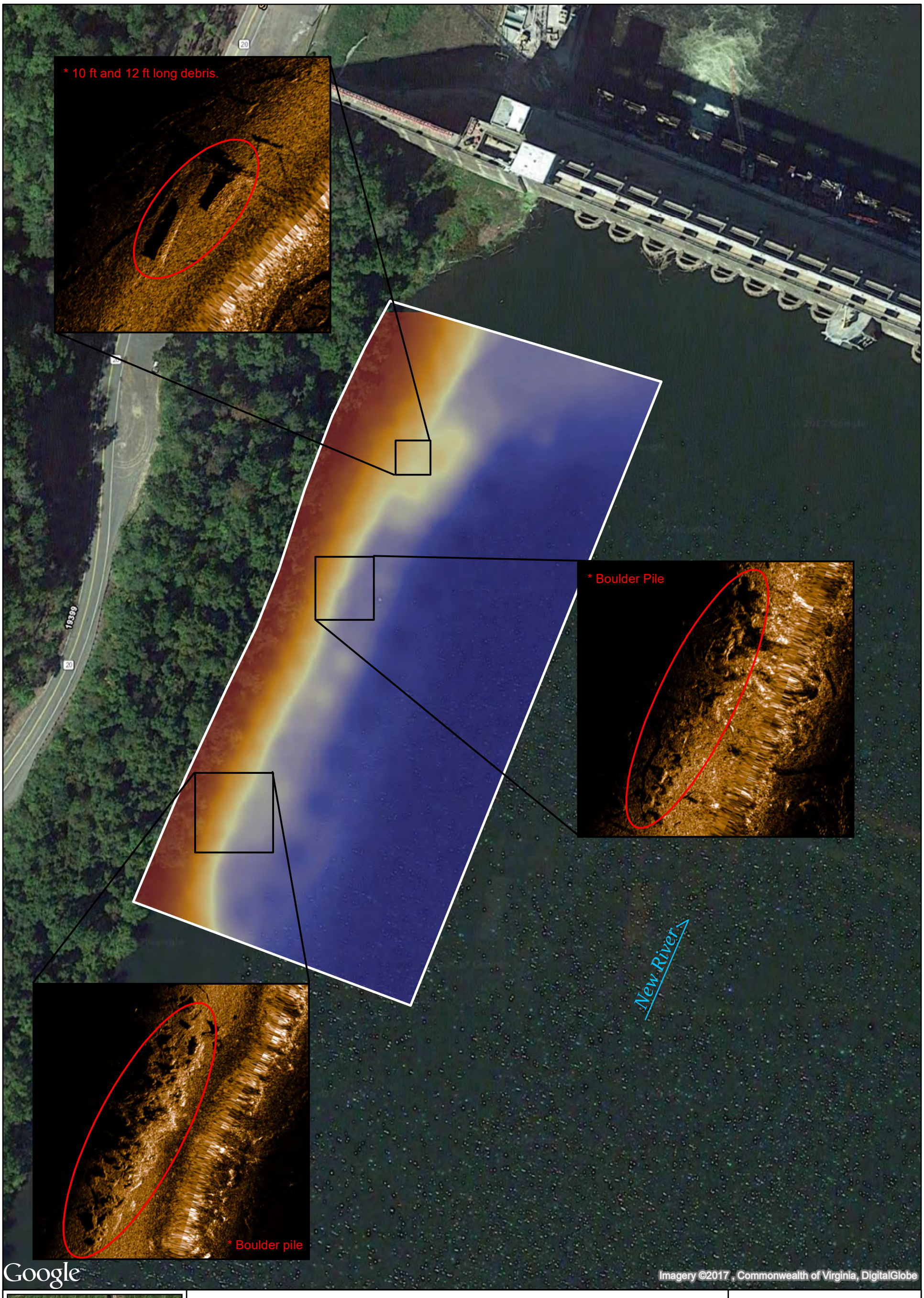
	Raw Data					Equation Condition Met? (1 = yes; 0 = no)				
Sample Station	**Turbidy (NTU)**	**Riffle/Pool?**	**<25C Summer Temps**	**pH**		**< 30HTU**	**Riffle/Pool?**	**<25C Summer Temps**	**pH between 6.5 and 8.5**	**Habitat Suitability Index**
REEF-DP	18.61	Pool	23	7.83		1	0	1	1	0.75
BL1-DP1-1	18.61	Pool	23	7.93		1	0	1	1	0.75
BL1-DP1-2	14.01	Pool	23	7.9		1	0	1	1	0.75
BL1-DP1-3	18.61	Pool	23	7.9		1	0	1	1	0.75
BL1-DP1-4	20.43	Pool	23	7.89		1	0	1	1	0.75
BL1-DP1-5	20.43	Pool	23	7.88		1	0	1	1	0.75
BL1-DP1-6	20.43	Pool	23	7.88		1	0	1	1	0.75
BL1-DP2-1	25.85	Pool	23	7.96		1	0	1	1	0.75
BL1-DP2-2	18.61	Pool	23	7.88		1	0	1	1	0.75
BL1-DP2-3	17.14	Pool	23	7.86		1	0	1	1	0.75
BL1-DP2-4	18.61	Pool	23	7.87		1	0	1	1	0.75
BL1-DP2-5	14.9	Pool	23	7.88		1	0	1	1	0.75
BL1-DP2-6	14.9	Pool	23	7.88		1	0	1	1	0.75
BL2-DP-1	20.43	Pool	23	7.93		1	0	1	1	0.75
BL2-DP-2	15.92	Pool	23	7.92		1	0	1	1	0.75
BL2-DP-3	11.99	Pool	23	7.91		1	0	1	1	0.75
BL2-DP-4	12.58	Pool	23	7.92		1	0	1	1	0.75
BL2-DP-5	12.58	Pool	23	7.93		1	0	1	1	0.75
BL2-DP-6	13.62	Pool	23	7.93		1	0	1	1	0.75
BL3-DPA-1	11.46	Pool	23	7.91		1	0	1	1	0.75
BL3-DPA-2	25.85	Pool	23	7.89		1	0	1	1	0.75
BL3-DPA-3	25.85	Pool	23	7.94		1	0	1	1	0.75
BL3-DPA-4	25.85	Pool	23	7.92		1	0	1	1	0.75
BL3-DPB-1	10.77	Pool	23	7.92		1	0	1	1	0.75
BL3-DPB-2	7.91	Pool	23	7.91		1	0	1	1	0.75
BL3-DPB-3	15.92	Pool	23	7.91		1	0	1	1	0.75
BL3-DPB-4	18.61	Pool	23	7.93		1	0	1	1	0.75

Table 3. Field data, equation conditions, and Habitat Suitability Index Scores for Common Shiner (*Luxilus comutus*) at selected locations in Bluestone Lake near Hinton, WV, January 2017.

Area	Overall Size (ac)	Stream Composition (ac)		HSI Score	HUs (ac)
BL1	98.86	Riffle/Pool	0	0.000	0
		Other	98.86	0.750	74.15
BL2	112.56	Riffle/Pool	0	0.000	0
		Other	112.56	0.750	84.42
BL3	68.39	Riffle/Pool	0	0	0
		Other	68.39	0.750	51.30

Table 4. Existing HU quantities for Common Shiner (*Luxilus comutus*) for selected locations in Bluestone Lake near Hinton, WV, January 2017.

FIGURES



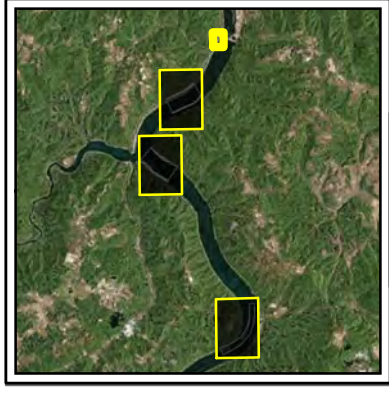


Figure 1 - REEF. Bathymetric Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Depths

0 ft. — 34 ft.

0 50 100 200 Feet

0 12.5 25 50 Meters

REEF

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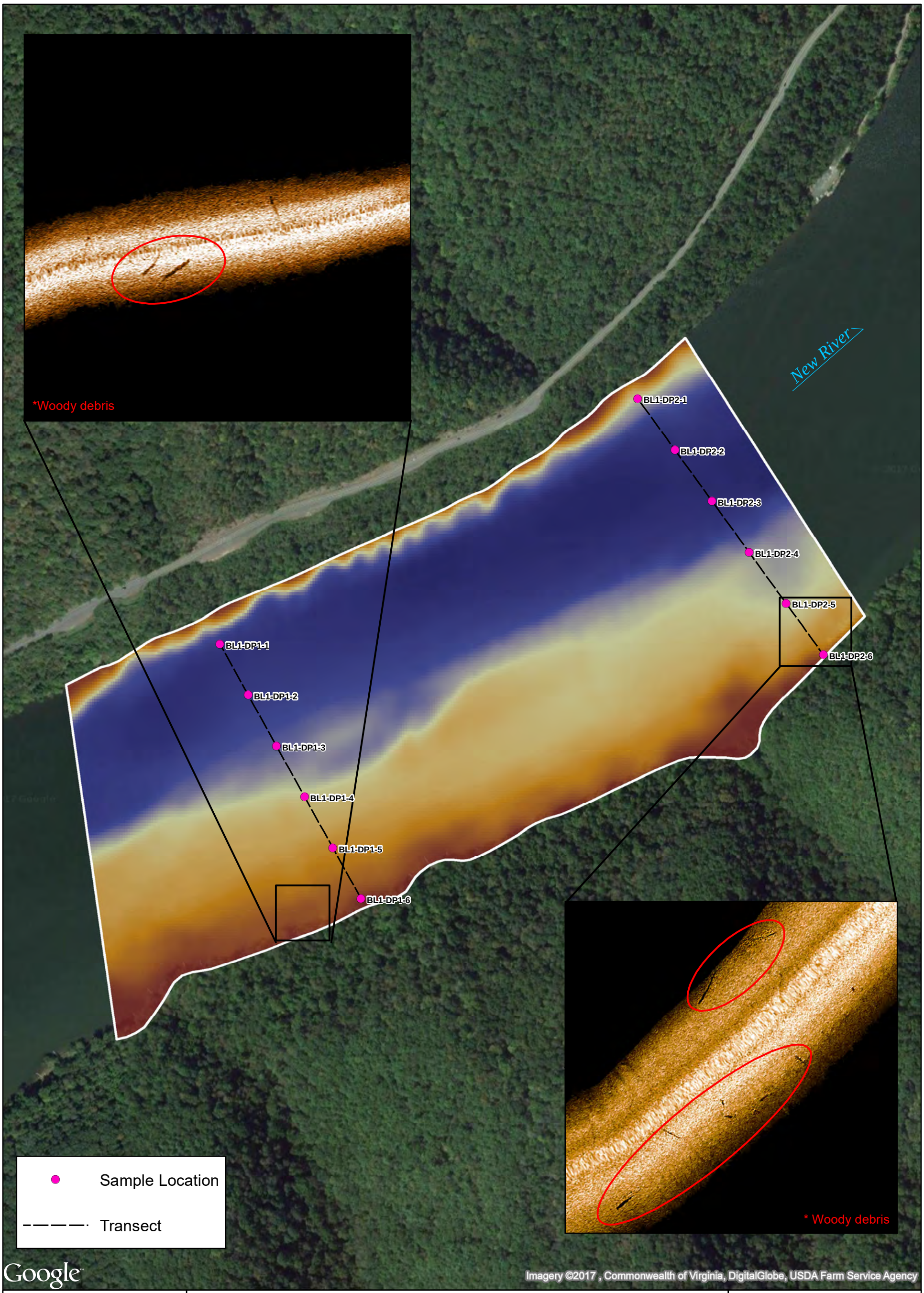
Basemap courtesy of Google Earth.



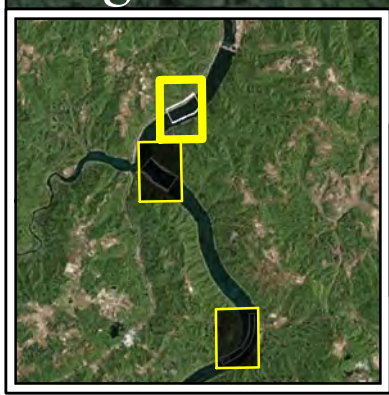


Figure 2.1 - BL1. Bathymetric Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Depths

0 ft. — 34 ft.

0 200 400 800 Feet

0 50 100 200 Meters

BL1

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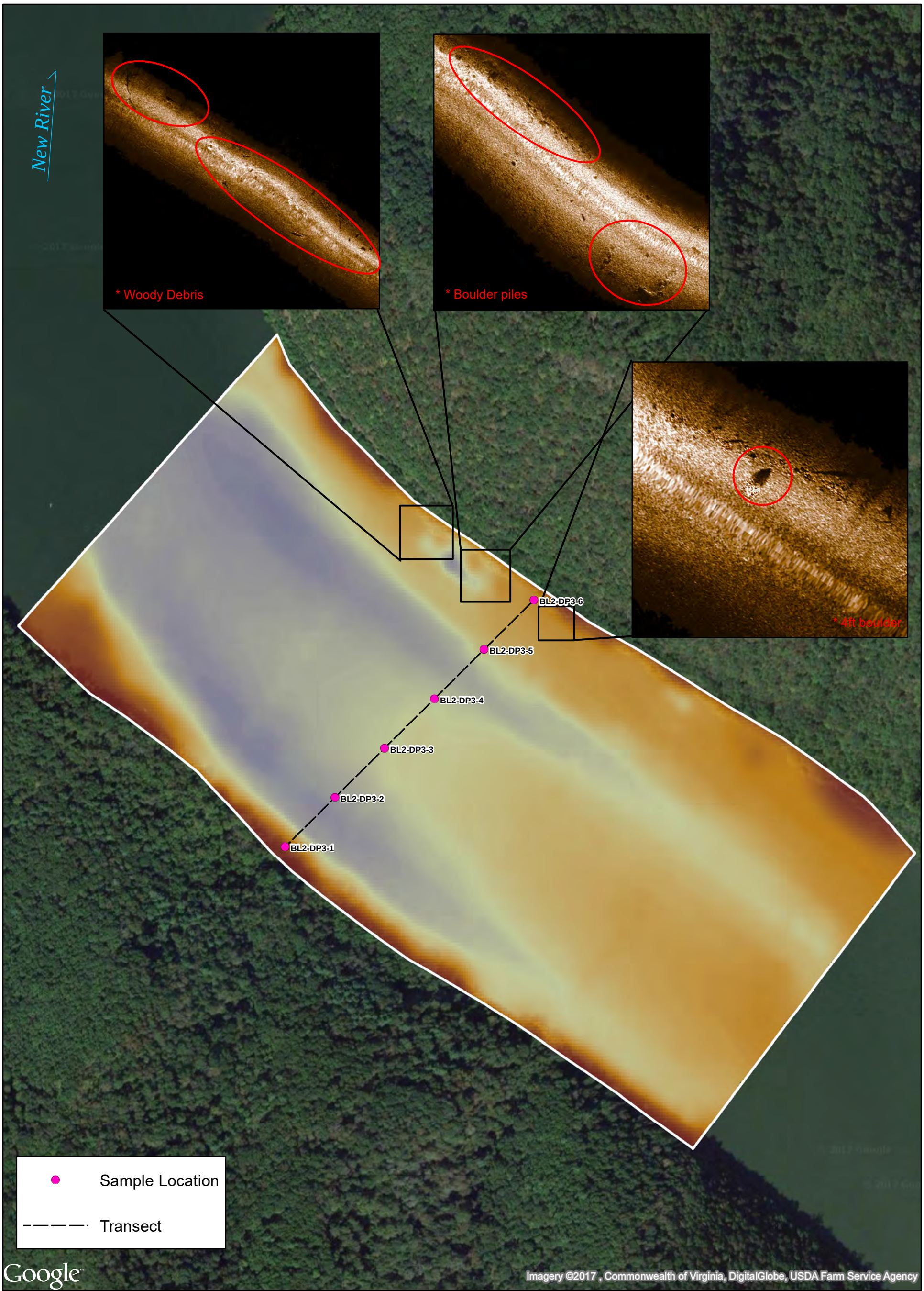
Basemap courtesy of Google.



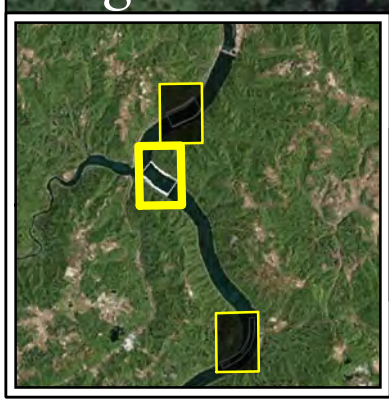


Figure 2.2 - BL2. Bathymetric Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Depths

0 ft. — 34 ft.

0 200 400 800 Feet

0 50 100 200 Meters

BL2

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Basemap courtesy of Google.

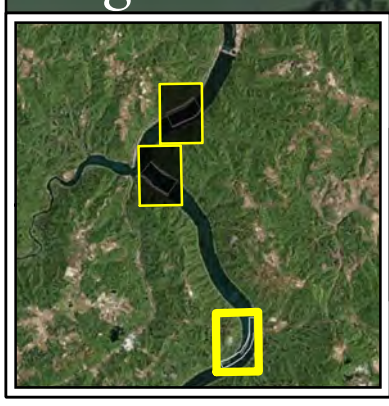

Figure 2.3 - BL3. Bathymetric Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Depths

0 ft. — 34 ft.

0 200 400 800 Feet

0 50 100 200 Meters

BL3

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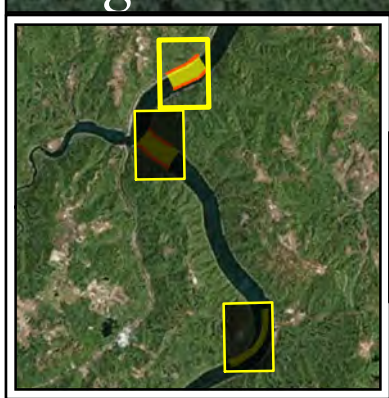

Figure 3.1. Substrate Composition Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Sample Location — Transect — Cobble/Boulder — Soft Habitat

0 200 400 800 Feet

0 50 100 200 Meters

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2.1

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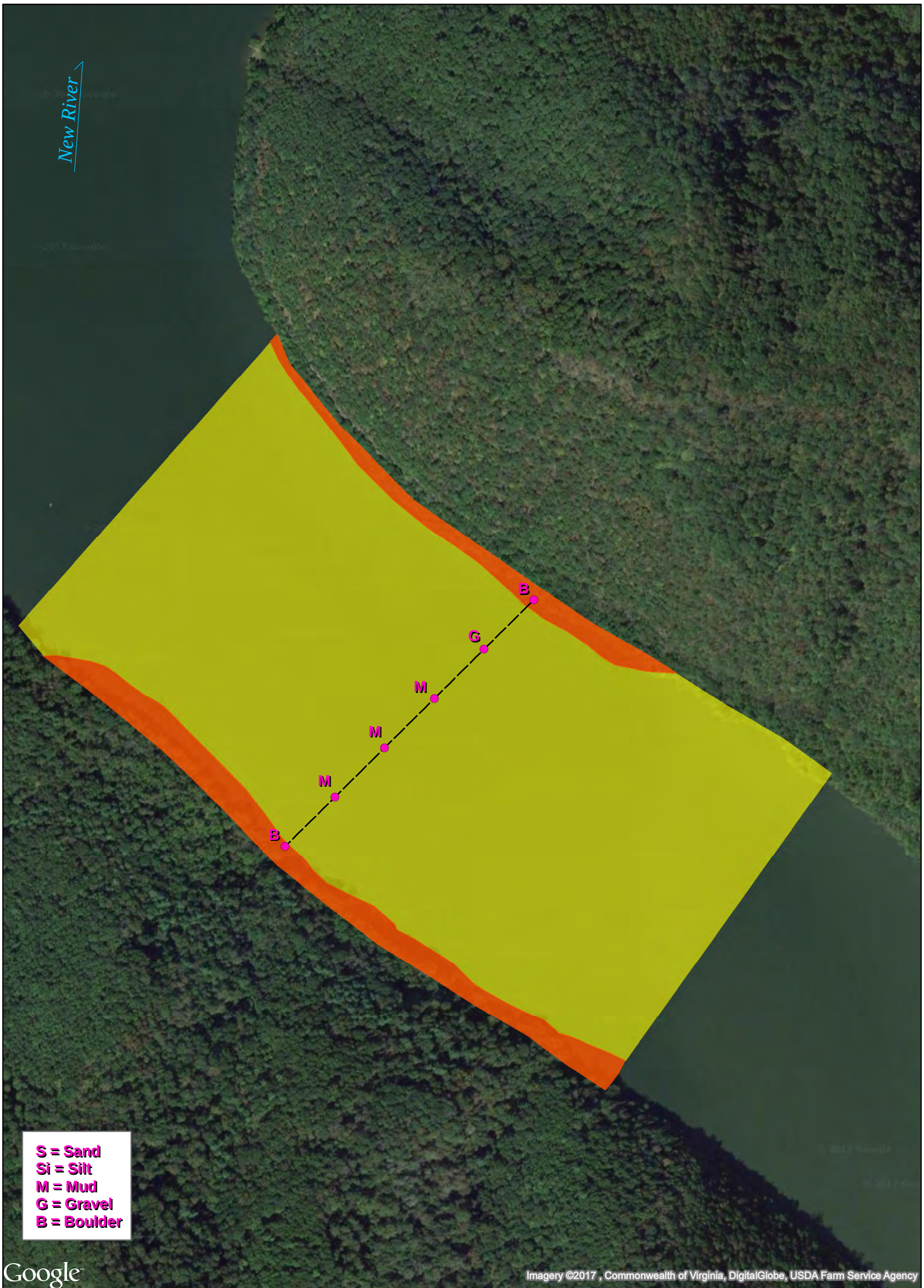
Basemap courtesy of Google Earth.



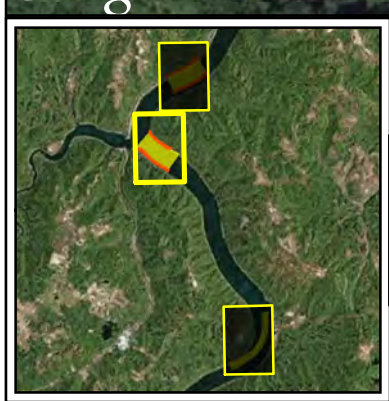


Figure 2.3. Substrate Composition Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Sample Location — Transect — Cobble/Boulder — Soft Habitat

0 200 400 800 Feet

0 50 100 200 Meters

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2.2

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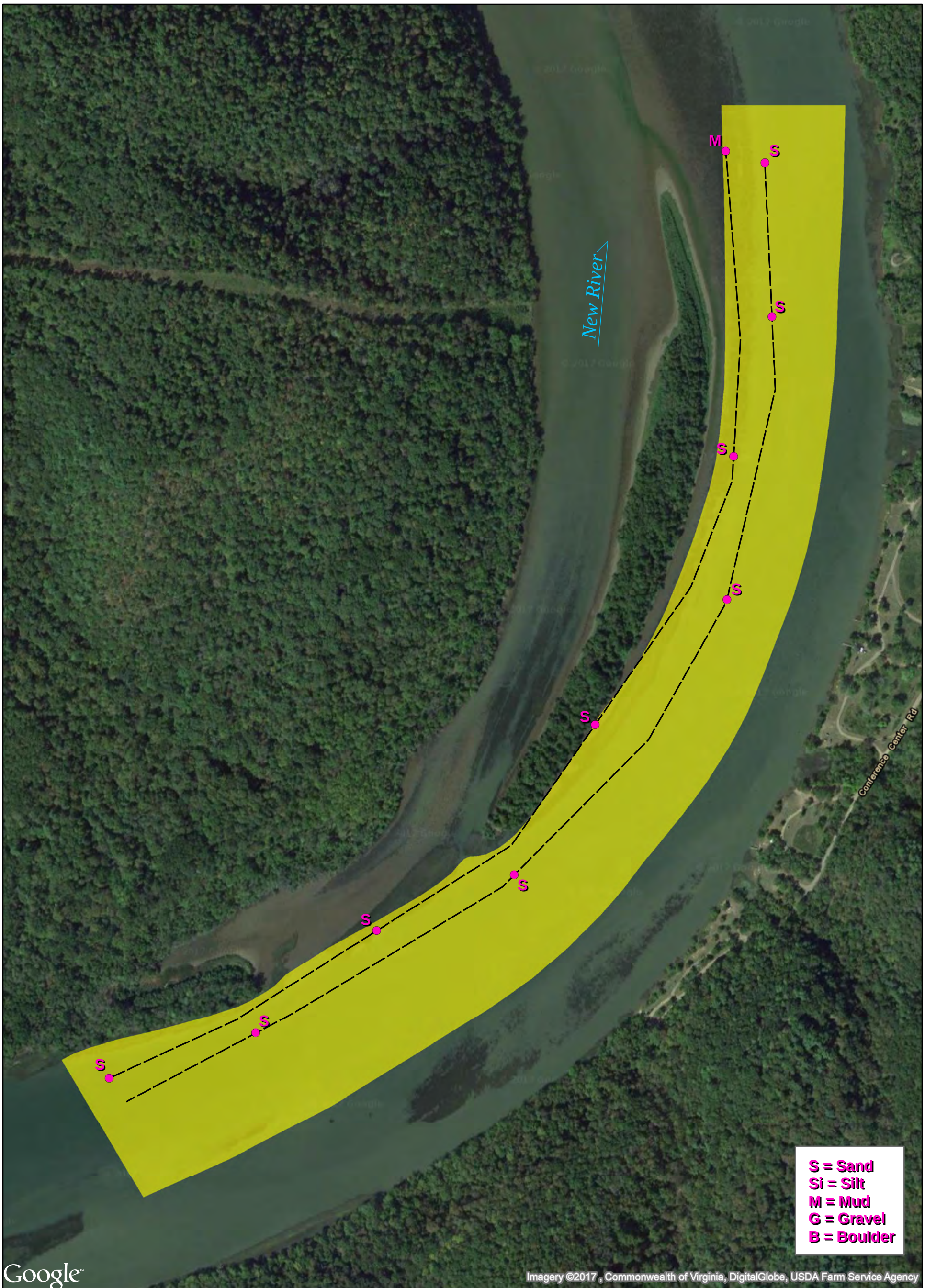

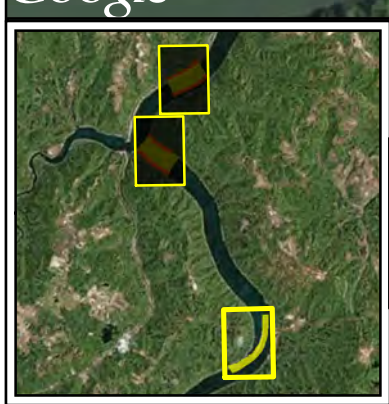

Figure 3.3. Substrate Composition Map of the Lacustrine Habitat Evaluation for Selected Sites in the Bluestone Lake Impoundment of the River.

Sample Location | Transect | Cobble/Boulder | Soft Habitat

0 200 400 800 Feet

0 50 100 200 Meters

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2.3

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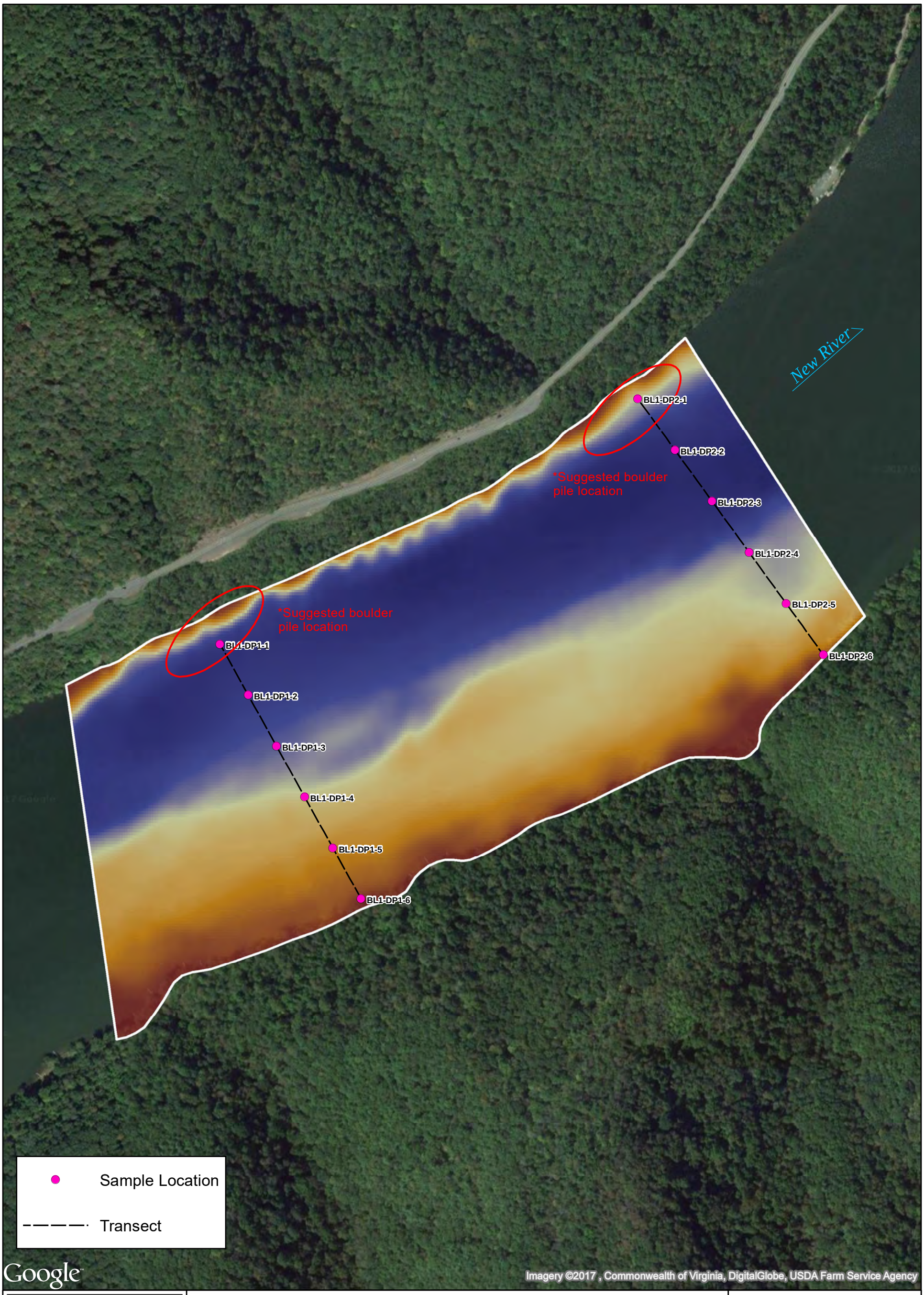
Basemap courtesy of Google Earth.



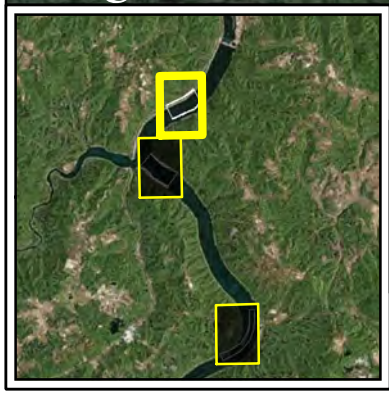


Figure 4.1 - L1. Suggested Boulder Reef Locations for Selected Sites in the Bluestone Lake Impoundment of the River.

Depths

0 ft. — 34 ft.

0 200 400 800 Feet

0 50 100 200 Meters

BL1

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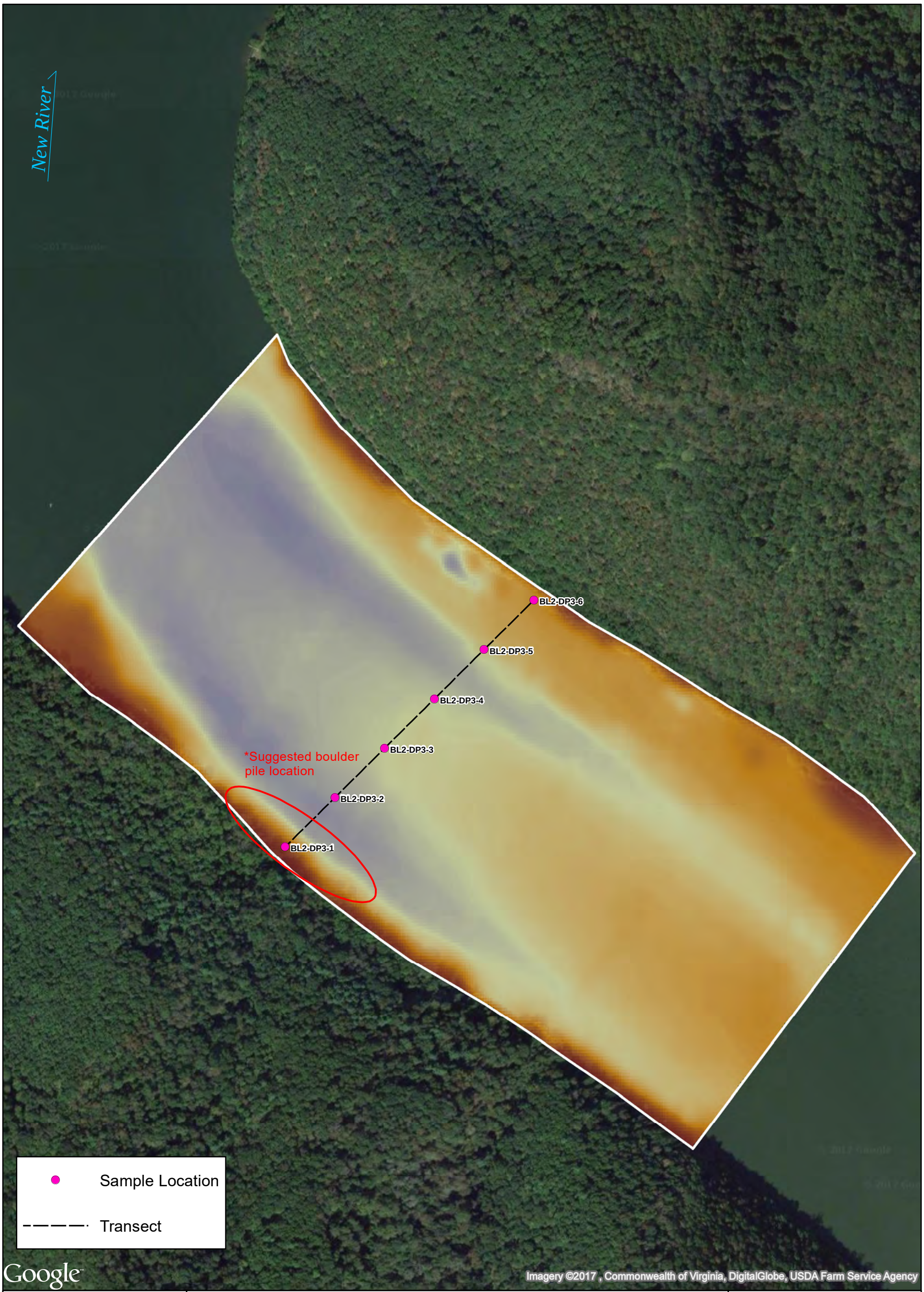

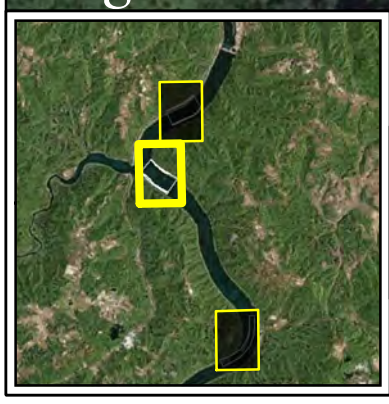

Figure 4.2 - L1.Suggested Boulder Reef Locations for Selected Sites in the Bluestone Lake Impoundment of the River.

Depths

0 ft. — 34 ft.

0 200 400 800 Feet

0 50 100 200 Meters

BL2

EnviroScience
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Date: 1/19/2017 Path: P:\10_Projects\GIGEC\9282_Bluestone_Dam\GIS\Aquatic\Bathymetric.mxd

Basemap courtesy of Google.

Carol Brown Farm HEP Analysis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2							Without Project							
3														
4	Plot Number	Mitigation Type	% Cover of all Trees	% Shrub Canopy Cover	% Shoreline Cover	% of year with water present	% Emergent Herbaceous Cover	% Cover within 100m of Wetland	Avg. Height of Overstory trees	Tree Canopy Volume/Area of Ground Surface	Number of Snags 4 to 10 Inches/ Acre	% Decidous Shrub Crown Cover	% Decisous Shrub Cover Comprised of Hydrophytic Shrubs	Average Height of Decidous Shrubs
5	Target Year 0	Restoration	0	0	70	100	0	0	0	0	0	0	0	0
6		Preservation	0	0	70	100	0	0	0	0	0	0	0	0
7														
8	Target Year 1	Restoration	0	0	70	100	0	0	0	0	0	0	0	0
9		Preservation	0	0	70	100	0	0	0	0	0	0	0	0
10														
11	Target Year 3	Restoration	0	0	70	100	0	0	0	0	0	0	0	0
12		Preservation	0	0	70	100	0	0	0	0	0	0	0	0
13														
14	Target Year 5	Restoration	0	0	70	100	0	0	0	0	0	0	0	0
15		Preservation	0	0	70	100	0	0	0	0	0	0	0	0
16														
17	Target Year 10	Restoration	0	0	70	100	0	0	0	0	0	0	0	0
18		Preservation	0	0	70	100	0	0	0	0	0	0	0	0
25														
26							With Project							
27														
28	Plot Number	Mitigation Type	% Cover of all Trees	% Shrub Canopy Cover	% Shoreline Cover	% of year with water present	% Emergent Herbaceous Cover	% Cover within 100m of Wetland	Avg. Height of Overstory trees	Tree Canopy Volume/Area of Ground Surface	Number of Snags 4 to 10 Inches/ Acre	% Decidous Shrub Crown Cover	% Decisous Shrub Cover Comprised of Hydrophytic Shrubs	Average Height of Decidous Shrubs
29	Target Year 0	Restoration	0	0	70	100	0	0	0	0	0	0	0	0
30		Preservation	85	30	70	100	0	90	50	0	2	30	25	4.5
31														
32	Target Year 1	Restoration	0	10	70	100	0	10	0	0	0	10	50	1
33		Preservation	85	30	70	100	0	90	50	0	2	30	25	4.5
34														
35	Target Year 3	Restoration	0	40	70	100	0	40	5	0	0	40	50	2.5
36		Preservation	85	30	70	100	0	90	50	0	2	30	25	4.5
37														
38	Target Year 5	Restoration	30	45	70	100	0	45	10	0	0	45	50	3
39		Preservation	85	30	70	100	0	90	50	0	2	30	25	4.5
40														
41	Target Year 10	Restoration	45	50	70	100	0	50	20	0	0	50	50	4
42		Preservation	85	30	70	100	0	90	50	0	2	30	25	4.5

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
2	**Without Project**															
3			Mink						HSI							
4	Plot Number	Cover Type	**SIV1** - % of Year with Water Preser	**SIV2** - % Tree Canopy Cover	**SIV3** - % Shrub Canopy Cover	**SIV4** - % Canopy Cover of Emergent Herb. Veg.	**SIV5** - % Cover of Trees and Shrubs within 100M of Wetland Edge	**SIV6** - % Shoreline Cover	Water	Forested <= 1000 Acres	Forested >= 1000 Acres	River and Lake Cover Types	**HSI - Lowest of Life Requisites**	Average HSI by Cover Type	Acreage	Habitat Units (HUs)
5	Target Year 0	Restoration	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		1.2	0.31749
6		Preservation	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		14.8	3.915712
7																
8	Target Year 1	Restoration	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		1.2	0.31749
9		Preservation	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		14.8	3.915712
10																
11	Target Year 3	Restoration	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		1.2	0.31749
12		Preservation	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		14.8	3.915712
13																
14	Target Year 5	Restoration	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		1.2	0.31749
15		Preservation	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		14.8	3.915712
16																
17	Target Year 10	Restoration	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		1.2	0.31749
18		Preservation	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		14.8	3.915712
19																
25																
26	**With Project**															
27			Mink						HSI							
28	Plot Number	Cover Type	**SIV1** - % of Year with Water Preser	**SIV2** - % Tree Canopy Cover	**SIV3** - % Shrub Canopy Cover	**SIV4** - % Canopy Cover of Emergent Herb. Veg.	**SIV5** - % Cover of Trees and Shrubs within 100M of Wetland Edge	**SIV6** - % Shoreline Cover	Water	Forested <= 1000 Acres	Forested >= 1000 Acres	River and Lake Cover Types	**HSI - Lowest of Life Requisites**	Average HSI by Cover Type	Acreage	Habitat Units (HUs)
29	Target Year 0	Restoration	1.00	0.10	0.10	0.00	0.10	0.70	1.00	0.15	0.20	0.26	0.26		1.2	0.31749
30		Preservation	1.00	1.00	0.46	0.00	1.00	0.70	1.00	1.00	1.00	0.84	0.84		14.8	12.38257
31																
32	Target Year 1	Restoration	1.00	0.10	0.22	0.00	0.22	0.70	1.00	0.27	0.32	0.39	0.39		1.2	0.470914
33		Preservation	1.00	1.00	0.46	0.00	1.00	0.70	1.00	1.00	1.00	0.84	0.84		14.8	12.38257
34																
35	Target Year 3	Restoration	1.00	0.10	0.58	0.00	0.58	0.70	1.00	0.63	0.68	0.64	0.64		1.2	0.764618
36		Preservation	1.00	1.00	0.46	0.00	1.00	0.70	1.00	1.00	1.00	0.84	0.84		14.8	12.38257
37																
38	Target Year 5	Restoration	1.00	0.46	0.64	0.00	0.64	0.70	1.00	0.82	1.00	0.67	0.67		1.2	0.803194
39		Preservation	1.00	1.00	0.46	0.00	1.00	0.70	1.00	1.00	1.00	0.84	0.84		14.8	12.38257
40																
41	Target Year 10	Restoration	1.00	0.64	0.70	0.00	0.70	0.70	1.00	0.85	1.00	0.70	0.70		1.2	0.84
42		Preservation	1.00	1.00	0.46	0.00	1.00	0.70	1.00	1.00	1.00	0.84	0.84		14.8	12.38257

Carol Brown (Without Project)
Summary of Variable Suitability Indices
and Habitat Units in Year 10

TARGET YEARS		Year 10		SUBTOTAL
		Restoration	Preservation	
Mink				
% year w/ surface water	SIV_1	1.00	1.00	
% tree canopy cover (all trees)	SIV_2	0.10	0.10	
% shrub canopy cover	SIV_3	0.10	0.10	
% emergent veg. canopy cover	SIV_4	0.00	0.00	
% tr. & shr. cover within 100m	SIV_5	0.10	0.10	
% shoreline cover	SIV_6	0.70	0.70	
Water Value		1.00	1.00	
Palustrine Forested Value		0.15	0.15	
Riverine Value		0.26	0.26	
HSI		0.15	0.15	
Acreage		1.20	14.80	
Habitat Units		0.18	2.22	**2.40**

Carol Brown (With Project)
Summary of Variable Suitability Indices
and Habitat Units in Year 10

TARGET YEARS		Year 10		SUBTOTAL
		Restoration	Preservation	
Mink				
% year w/ surface water	SIV_1	1.00	1.00	
% tree canopy cover (all trees)	SIV_2	0.64	1.00	
% shrub canopy cover	SIV_3	0.70	0.46	
% emergent veg. canopy cover	SIV_4	0.00	0.00	
% tr. & shr. cover within 100m	SIV_5	0.70	1.00	
% shoreline cover	SIV_6	0.70	0.70	
Water Value		1.00	1.00	
Palustrine Forested Value		0.85	1.00	
Riverine Value		0.70	0.84	
HSI		0.70	0.84	
Acreage		1.20	14.80	
Habitat Units		0.84	12.38	**13.22**

Mitigation Lift at Year 10 (With Project minus Without Project)	**10.82**

Indirect Aquatic Benefit

	Linear ft	Square ft	Acres
Length	2,000		
Width	250		
		500000	11.47842

	HSI	Acres	HU
Smallmouth Bass	0.83	11.4	9.462

Lovern HEP Analysis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2	**Without Project**															
3			Mink						HSI							
4	Plot Number	Cover Type	**SIV1** - % of Year with Water Preser	**SIV2** - % Tree Canopy Cover	**SIV3** - % Shrub Canopy Cover	**SIV4** - % Canopy Cover of Emergent Herb. Veg.	**SIV5** - % Cover of Trees and Shrubs within 100M of Wetland Edge	**SIV6** - % Shoreline Cover	Water	Forested <= 1000 Acres	Forested >= 1000 Acres	River and Lake Cover Types	**HSI - Lowest of Life Requisites**	Average HSI by Cover Type	Acreage	Habitat Units (HUs)
5	Target Year 0	Restoration	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		17.9	5.399751
6		Preservation	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		34.6	10.43751
7	Target Year 1	Restoration	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		17.9	5.399751
8		Preservation	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		34.6	10.43751
9	Target Year 3	Restoration	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		17.9	5.399751
10		Preservation	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		34.6	10.43751
11	Target Year 5	Restoration	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		17.9	5.399751
12		Preservation	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		34.6	10.43751
13	Target Year 10	Restoration	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		17.9	5.399751
14		Preservation	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		34.6	10.43751
19																
20	**With Project**															
21			Mink						HSI							
22	Plot Number	Cover Type	**SIV1** - % of Year with Water Preser	**SIV2** - % Tree Canopy Cover	**SIV3** - % Shrub Canopy Cover	**SIV4** - % Canopy Cover of Emergent Herb. Veg.	**SIV5** - % Cover of Trees and Shrubs within 100M of Wetland Edge	**SIV6** - % Shoreline Cover	Water	Forested <= 1000 Acres	Forested >= 1000 Acres	River and Lake Cover Types	**HSI - Lowest of Life Requisites**	Average HSI by Cover Type	Acreage	Habitat Units (HUs)
23	Target Year 0	Restoration	1.00	0.10	0.10	0.00	0.10	0.91	1.00	0.15	0.20	0.30	0.30		17.9	5.399751
24		Preservation	1.00	1.00	0.58	0.00	1.00	0.91	1.00	1.00	1.00	0.95	0.95		34.6	33.0063
25	Target Year 1	Restoration	1.00	0.10	0.22	0.00	0.22	0.91	1.00	0.27	0.32	0.45	0.45		51.3	22.95353
26		Preservation	1.00	1.00	0.58	0.00	1.00	0.91	1.00	1.00	1.00	0.95	0.95		68	64.86787
27	Target Year 3	Restoration	1.00	0.10	0.58	0.00	0.58	0.91	1.00	0.63	0.68	0.73	0.73		84.7	61.53442
28		Preservation	1.00	1.00	0.58	0.00	1.00	0.91	1.00	1.00	1.00	0.95	0.95		101.4	96.72944
29	Target Year 5	Restoration	1.00	0.46	0.64	0.00	0.64	0.91	1.00	0.82	1.00	0.76	0.76		118.1	90.12818
30		Preservation	1.00	1.00	0.58	0.00	1.00	0.91	1.00	1.00	1.00	0.95	0.95		134.8	128.591
31	Target Year 10	Restoration	1.00	0.64	0.70	0.00	0.70	0.91	1.00	0.85	1.00	0.80	0.80		151.5	120.9156
32		Preservation	1.00	1.00	0.58	0.00	1.00	0.91	1.00	1.00	1.00	0.95	0.95		168.2	160.4526

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2							Without Project							
3														
4	Plot Number	Mitigation Type	% Cover of all Trees	% Shrub Canopy Cover	% Shoreline Cover	% of year with water present	% Emergent Herbaceous Cover	% Cover within 100m of Wetland	Avg. Height of Overstory trees	Tree Canopy Volume/Area of Ground Surface	Number of Snags 4 to 10 Inches/ Acre	% Decidous Shrub Crown Cover	% Decisous Shrub Cover Comprised of Hydrophytic Shrubs	Average Height of Decidous Shrubs
5	Target Year 0	Restoration	0	0	91	100	0	0	0	0	0	0	0	0
6		Preservation	0	0	91	100	0	0	0	0	0	0	0	0
7	Target Year 1	Restoration	0	0	91	100	0	0	0	0	0	0	0	0
8		Preservation	0	0	91	100	0	0	0	0	0	0	0	0
9	Target Year 3	Restoration	0	0	91	100	0	0	0	0	0	0	0	0
10		Preservation	0	0	91	100	0	0	0	0	0	0	0	0
11	Target Year 5	Restoration	0	0	91	100	0	0	0	0	0	0	0	0
12		Preservation	0	0	91	100	0	0	0	0	0	0	0	0
13	Target Year 10	Restoration	0	0	91	100	0	0	0	0	0	0	0	0
14		Preservation	0	0	91	100	0	0	0	0	0	0	0	0
19														
20							With Project							
21														
22	Plot Number	Mitigation Type	% Cover of all Trees	% Shrub Canopy Cover	% Shoreline Cover	% of year with water present	% Emergent Herbaceous Cover	% Cover within 100m of Wetland	Avg. Height of Overstory trees	Tree Canopy Volume/Area of Ground Surface	Number of Snags 4 to 10 Inches/ Acre	% Decidous Shrub Crown Cover	% Decisous Shrub Cover Comprised of Hydrophytic Shrubs	Average Height of Decidous Shrubs
23	Target Year 0	Restoration	0	0	91	100	0	0	0	0	0	0	0	0
24		Preservation	90	40	91	100	0	90						
25	Target Year 1	Restoration	0	10	91	100	0	10	0	0	0	10	50	1
26		Preservation	90	40	91	100	0	90						
27	Target Year 3	Restoration	0	40	91	100	0	40	5	0	0	40	50	2.5
28		Preservation	90	40	91	100	0	90						
29	Target Year 5	Restoration	30	45	91	100	0	45	10	0	0	45	50	3
30		Preservation	90	40	91	100	0	90						
31	Target Year 10	Restoration	45	50	91	100	0	50	20	0	0	50	50	4
32		Preservation	90	40	91	100	0	90						

Lovern (Without Project)
Summary of Variable Suitability Indices
and Habitat Units in Year 10

TARGET YEARS		Year 10		SUBTOTAL
		Restoration	Preservation	
Mink				
% year w/ surface water	SIV_1	1.00	1.00	
% tree canopy cover (all trees)	SIV_2	0.10	0.10	
% shrub canopy cover	SIV_3	0.10	0.10	
% emergent veg. canopy cover	SIV_4	0.00	0.00	
% tr. & shr. cover within 100m	SIV_5	0.10	0.10	
% shoreline cover	SIV_6	0.91	0.91	
Water Value		1.00	1.00	
Palustrine Forested Value		0.15	0.15	
Riverine Value		0.30	0.30	
HSI		0.15	0.15	
Acreage		17.90	34.60	
Habitat Units		2.69	5.19	**7.88**

Lovern (With Project)
Summary of Variable Suitability Indices
and Habitat Units in Year 10

TARGET YEARS		Year 10		SUBTOTAL
		Restoration	Preservation	
Mink				
% year w/ surface water	SIV_1	1.00	1.00	
% tree canopy cover (all trees)	SIV_2	0.64	1.00	
% shrub canopy cover	SIV_3	0.70	0.58	
% emergent veg. canopy cover	SIV_4	0.00	0.00	
% tr. & shr. cover within 100m	SIV_5	0.70	0.70	
% shoreline cover	SIV_6	0.91	0.91	
Water Value		1.00	1.00	
Palustrine Forested Value		0.85	0.85	
Riverine Value		0.80	0.80	
HSI		0.80	0.80	
Acreage		17.90	34.60	
Habitat Units		14.29	27.62	**41.90**

Mitigation Lift at Year 10 (With Project minus Without Project)	**34.03**

Indirect Aquatic Benefit

	Linear ft	Square ft	Acres
Length	8,000		
Width	250		
		2000000	45.9136823

	HSI	Acres	HU
Smallmouth Bass	0.83	45.9	38.097