## Restoration Research RFP Questions

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# RFP Questions from FY 25

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. BMP Effectiveness Monitoring: What is the effectiveness of stormwater best management practices (BMPs) implemented in the Maryland Stormwater Design Manual? Does the provision of the full treatment volume for the 1-year 24-hour design storm event provide pollutant removal performance per the design manual? Is that storage effective in reducing the water flow enough to protect stream channels?

Additionally, how effective is the BMP (or suite of BMPs) for reducing total suspended solids (TSS), total phosphorus (TP), or total nitrogen (TN)? We are particularly interested in green infrastructure practices as defined in the MDE’s Accounting Guidance for green stormwater infrastructure credits and additional information at: <https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/Final%20Determination%20Dox%20N5%202021/MS4%20Accounting%20Guidance%20FINAL%2011%2005%202021.pdf>.

How does the collection and conveyance system design impact BMP performance during high intensity storm events? How do subsoils/soil media composition, underdrain, and/or vegetative cover impact the effectiveness of the BMP (load/reduction relationship)?

1. Watershed Restoration Assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, impacts to biological community, a signal from the restoration activities even in a highly targeted, small watershed (having first order streams) can be measured relative to a control site (before vs. after restoration activities).

The following are related questions: What percentage of the impervious surface in a watershed must be treated with stormwater upland BMPs before a difference can be measured at the outfall? Does a BMP type or suite of BMPs (e.g., ESD practices, stormwater wetlands) influence that percentage? Does the location in the watershed where the BMPs are located and/or the concentration of impervious surface areas or forested areas (for tree planting projects) located in the watershed impact the restoration outcomes?

We recognize that this question is extensive, and reviewers will accept proposals that address just one component of this research question.

**Effectiveness of restoration practices at the project scale**

1. A) Biological Community Restoration (Physical and Chemical): Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). The reasons are not yet clear, but three hypotheses are high flows (impact benthic drift behaviors, suspended sediment tolerance, available carbon), the lack of source populations (research underway, “Assessing the feasibility of assisted macroinvertebrate colonization in achieving ecological uplift in restored streams”), and physiochemical habitat barriers (e.g., conductivity, temperature, and pollutants of emerging concern such as chloride and toxic substances among others). We seek a research team to test the influence of physical and chemical features on stream biota in stream restoration projects.

B) Biological Community Restoration (eDNA Literature Review): We may not be detecting changes in biological uplift (see A above). Recent research in this program, “Using eDNA Methods to Extend Biological Sampling and Identify Candidate Restorations for Species Reintroductions” (June 2024 presentation available at: <https://cbtrust.org/wp-content/uploads/3_Hilderbrand-2024-pooled-monitoring-annual-meeting-final.pdf>) uses eDNA to identify subtle changes (presence/absence) in more sensitive species/individuals. This approach addresses community composition changes that current biological sampling methods for macroinvertebrates and fish might miss. However, there are still some unresolved questions regarding these methods, some of which include 1) the appropriate distance for a control sample upstream of a restoration site; 2) sampling methods, especially, the sample volume needed to obtain a reliable assessment of taxa present in all stream/river types in Maryland; 3) how to decrease uncertainty in results by minimizing false positives and negatives; and 4) how to interpret eDNA findings given inherent levels of uncertainty in the results and gaps in our eDNA library. In addition, we need to connect eDNA sampling outputs with traditional methods, such as the Index of Biological Integrity (IBI) for benthics and fish, which are often tied to regulatory drivers.

To build on this research and enhance its utility for managers, we request a literature review that outlines the current state of the science, including a gap analysis. This information will help us prioritize the most critical research areas to meet our needs.

1. Climate change impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, growing season will lengthen, and other processes related to the Chesapeake community’s approved set of BMPs will change. As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., need to evaluate high intensity storms of varied frequencies (vs 24-hour event), conveyance limitations, etc.). This program supported three studies to address an earlier question about storm frequency duration and how this can impact BMP designs. While research findings are actively informing ongoing efforts to modernize stormwater management – such as Advancing Stormwater Resiliency in Maryland (A-Storm) initiative – funders this year are focusing on the need to better understand the vegetation choices and adjustments required for a changing climate.

The vegetation elements of the BMP design (e.g., plant palette and maintenance schedules) can impact both evapotranspiration (heat island) and pollutant removal efficiencies of the stormwater BMP. How will climate change (extreme heat and wind or storm intensity and duration) impact the vulnerability and ultimate performance of these plants? We know that precipitation patterns are changing and our suite of strategies, tools, and/or BMPs should expand. Therefore, funders are interested in a literature search for flood attenuation strategies and associated water quality benefit (loads reduced for TN, TP, TSS, etc.).

Additionally, we realize that restoration in coastal areas presents conditions where additional research efforts are needed (e.g., high water tables, tidal influence, and/or storm surge). *The ultimate use of this information would be to evaluate design criteria of these BMPs* (new or retrofits) that achieve the most effective treatment and conveyance strategies when comparing varied rainfall design storm scenarios.

1. Pollutants of Emerging Concern: Fecal indicator bacteria; chloride; temperature; and toxics, particularly polychlorinated biphenyls (PCBs) have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the research to date. Therefore, questions within this area are:

* 1. Bacteria and Chloride – To better inform choices of existing management options, funders participating in the Pooled Monitoring option in Maryland’s MS4 permit are interested in research that advances existing science related to the baseline conditions and sources of bacteria and/or chloride in urban streams. Funders are also interested in existing or novel sampling and analytical methods that could better quantify pollutants entering waterways and differentiate between the primary sources. Such research may include developing a relationship between *E. coli* eDNA and *E. coli* most probable number (MPN)/100 mL, the feasibility of using automated samplers for bacteria sampling in lieu of grab samples, and the relationship between chloride concentration and specific conductance. Ultimately, funders want to use this research to identify new and/or to enhance existing, management measures that reduce bacteria and chloride concentrations in receiving waters. Applicants should be aware of and build on two projects supported in 2024, “Use of molecular sewage indicator methods to reduce uncertainty in watershed remediation efforts and water contact recreation” and “Combining incubations, sensors, and molecular approaches to understand E. coli sources and wastewater contamination across the Anacostia River Watershed” with more details at: <https://cbtrust.org/grants/restoration-research/>.

Questions for researchers to address are:

1. What are the typical bacteria sources and their relative contributions for urban watersheds? Of interest are methods of sampling (e.g., autosampler vs. grab sampling), developing relationships between eDNA and actual counts of *E. coli* and *Enterococcus*, and researching and updating the proportional bacteria contributions to non-tidal stream systems from diverse sources. Funders are also looking for novel methods to quantify the bacteria sources.
2. What are the effects of salt reduction strategies on in-stream chloride concentrations and specific conductance in nontidal perennial streams?

Salt reduction strategies should align with the MS4 permit’s pollution prevention and good housekeeping control measures such as brine application. Funders are interested in the amount of salt delivered from the application point to the stream and the time this takes. Funders are also interested in the baseline conditions and the change from salt application. We realize that sample size, methods used, and replication could be costly and may be scalable. The funders will consider literature reviews and/or pilot efforts for one or both questions. The MDE monitoring guidelines may be used as reference and can be found here: <https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/Final%20Determination%20Dox%20N5%202021/2021%20MS4%20Monitoring%20Guideline%20Final%2011%2005%202021.pdf>.

* + 1. Thermal – What best management practice design and siting methods will reduce thermal impacts to streams, and in Maryland there is interest in Maryland’s Use III and IV streams (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf)), and to the watershed? Management practice design/strategy examples to test include various surface ponding and discharge structure configurations, variable media depths in filtering practices, use of submerged gravel wetlands, and specific stream restoration design features and types such as legacy sediment removal, stage zero/emergent wetlands, and other management strategies.

Applicants should be aware of and build on, if possible, the following projects: 1) supported in 2021, “Evaluation of watershed-scale impacts of stormwater management facilities on thermal loads to a Maryland Class IV stream using a high-frequency sensor network” as described in the 2024 forum presentation available at: [https://cbtrust.org/wp-content/uploads/2\_Welty-Miller-Restoration-Research-2024-v4.pdf](https://cbtrust.org/wp-content/uploads/2_Welty-Miller-Restoration-Research-2024-v4.pdf%20)  and the Maryland Water Monitoring Conference presentation titled “Thermal properties of different stormwater Best Management Practices” that is available at: <https://tinyurl.com/pnfdnc2h> and 2) supported in 2023, “Stormwater Thermal Reduction through Stormwater Filtration Media Layers” with more details at: <https://cbtrust.org/grants/restoration-research/>.

Current state (Maryland) modeling exercises in urban watersheds indicate that reductions in heated surface runoff and increases in riparian forest buffers are necessary to meet thermal water quality endpoints (68o F or 20o C for Use Class III streams). What is the thermal load to and the cumulative impact of thermal mitigation practices in urban and rural watersheds? If possible, explain how practices were combined to reduce thermal impacts to streams.

1. Toxics – Many regional water bodies have toxic substance impairments, particularly for PCBs. Some progress has been made in identifying the influence of specific land uses, industry types, and development age on toxic contaminant loadings. However, there are still many unknowns related to the fate, transport, capture, and impact of toxic pollutants. For instance, it is often unknown whether practices used to reduce sediment and nutrient loads can also reduce toxic contaminant loads, and for innovative stormwater designs specifically aimed at reducing toxic contaminants, it is unknown exactly how effective these practices can be. Additionally, given the lack of information on the impact of toxic contaminants on biota, it is possible that additional stressors are being overlooked in assessments such as Maryland’s Biological Stressor Identification analyses. Consequently, there could be significant gaps in management strategies to restore biological communities in streams. This research question was scaled back to focus on monitoring while the results from University of Maryland’s **“**Influence of historic and current land use practices on PCB contamination of soils and stormwater sediments in the Chesapeake Bay watershed” are underway. Research applicants should also be aware of and build on a project supported in 2024, “Development of a simplified approach of PCB loading estimation using a combination of passive sampling and sediment trapping” with more details at: <https://cbtrust.org/grants/restoration-research/>.

A frequent limitation to optimal stormwater monitoring protocols and design implementation is the availability of funds and personnel. Traditional practices, such as automated samplers, are efficient but can be costly and frequently difficult to install and maintain. Considering those challenges, what innovative techniques that are affordable and of simple installation and maintenance could the monitoring community use to measure PCBs concentrations during storm events in outfalls, pipes, BMPs, and/or inlets?

**Social science research questions to accelerate adoption of BMPs and help quantify targeted outcomes**

1. Practice adoption: The adoption of certain practices by individuals (residents, business owners, landowners, etc.) can play a large role in accomplishing big picture watershed restoration goals. Many practices can be adopted at the individual level, and many jurisdictions have developed programs to encourage them, such as rebate programs. However, the likelihood of adoption and barriers to adoption of those practices is not always known. If barriers to adoption and adoption rates were better known, the design of incentive programs could be optimized, and outcomes of those programs could be better quantified. While many practices need additional study, this program intends to focus on four key practices that are of particular interest to its MS4 members.

For one of the following four practices (tree planting, litter reduction, pet waste removal (which reduces bacteria contamination), reduction of flushing fats oils and grease (FOG) down drains (which can lead to sanitary sewer overflows)), quantify adoption rates under certain program/intervention design. Ideally, programs with different types and numbers of interventions, designed to address barriers to adoption, would be compared (e.g., program designs that test and involve in-person interaction (door knocking, workshops, demonstrations) versus remote interventions (e.g., email, mailer, phone call, door hanger). Program elements to be tested could include paid incentives and perception of the threat of enforcement action(s). What are the adoption rates of the practice under programs with different elements, which, when combined with existing information about BMP effectiveness, can lead to total loads reduced (of nutrients, sediment, bacteria, and/or litter)?

1. Focusing our social science research questions on impactful interventions and stewardship programs that can help us better meet our healthy water and healthy community outcomes, we pose the following questions:
	1. What social science interventions (beyond communication strategies) are most effective at increasing and sustaining adoption of maintenance behaviors, such as regular watering, mulching, pruning, and weed control by individual residents?
	2. What social science interventions are most effective at increasing local civic engagement in support of watershed stewardship programs and policies?
	3. What environmental stewardship practices resonate most with targeted communities in the watershed, and how can these communities’ perceived barriers to adoption inform the development of community-centric stewardship programs that provide relevant products and services to address perceived barriers to adoption?

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account the reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected are often not the same as the units measured to report the restoration work (often, for example, pounds of nitrogen reduced).

**The goal of this question is to encourage quantification, in some comparable metric, of the resources present prior to the activity compared to the resources available after restoration project installation, calculating net ecological impact after evaluation of individual functional components**. One way to explore the “positive” and “negative” impact is to have at least two resources using common metric(s) (e.g., vegetation biomass, pounds of pollutant reduced, a habitat metric) to determine the net change. Funders want to know if we use certain kinds of restoration practices or projects, do the net benefits (e.g., nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (e.g., tree loss and resulting habitat loss, etc.)?

Ultimately, we want to use the research findings to determine what practices and projects are best suited for our needs, to have a better understanding of the “trade-offs” when installing a practice, and to have greater confidence in our recommended practices and projects. Ensure your application clearly states to our second-round reviewers (regulators and managers who will use the results) how your research will support the best management practices we implement and/or recommend for implementation (e.g., through our policies, decision-making frameworks, practice manuals, etc.).

Resource trade-off examples include, but are not limited to, the following:

* Tree planting “success” for plant establishment, survival, and ecological benefit: Tree planting establishment efforts are common as both standalone projects (e.g., buffers) and components of other BMPs (e.g., stream restorations, stormwater bioretention, etc.). As practitioners, policymakers, and funders, the community wants to determine how to assess tree planting “success” to guide us for more sustainable, ecologically beneficial, and cost-effective plantings. Therefore, our top question is: **How do we measure tree planting project “success”?**

We want tree planting projects to be successful in terms of many factors such as site selection; site preparation; size, type, and/or density of plantings; project acceptance by community; survivability; ensuring equity\* is considered in our projects; and attaining ecological and habitat benefits all while demonstrating cost effectiveness. Researchers should consider the following sub-questions that get at the “success” of a project:

1. How does site selection, preparation (e.g., soil decompaction or amendment), and maintenance (including invasive management\*\*) impact the outcome of interest (tree survival, canopy cover, habitat)? Applicants should be aware of the recently completed project, “Reforestation Restoration Success – Measuring Early Forest Development After Land Disturbance with Soil Chemistry and Understory Vegetation” with final report at: <https://cbtrust.org/wp-content/uploads/Mid-Atlantic-Applied-Nucleation.pdf>.
2. Stream restoration often entails reconnecting the floodplain to the stream and raising groundwater levels. How does this change in floodplain connectivity and groundwater levels impact metrics such as tree survivability, shading, and riparian ecology?

Ultimately, we want to use this research to invest in tree plantings that optimize plant survival, shading/canopy goals, water quality goals, habitat goals, and community benefits, including equitable tree program delivery. We recognize there are many factors to consider, including time, in your experimental design.

\*Equity has been defined by various entities over the years and continues to be updated. For your reference the EPA defines environmental equity as “providing appropriate support to remove environmental disparities, which may include addressing systemic barriers.”

\*\*The Pooled Monitoring Initiative detailed “invasives” as a “resource trade-off in different types of restoration projects” in the FY 22 RFP where the project addressing this trade-off was supported (Virginia Tech led and project titled, “Identifying restoration practices and landscape variables that increase native plant establishment and mitigate plant invasion”). The FY 22 RFP “invasives” question is at <https://cbtrust.org/wp-content/uploads/Pooled-Monitoring-Initiatives-Restoration-Research-RFP_111021-1.pdf> (Q6) and invasives are a topic of interest.

* Stream restoration projects with tree removal: A recent Science and Technical Advisory Committee defined stream restoration as “an intervention to move a degraded ecosystem to a trajectory of recovery as informed by a reference condition considering local and global environmental change.” To date, many stream restoration practices in wooded areas, result in tree removal at the site for reasons such as: 1) construction site access; 2) for various methods of stream restoration in nontidal forested wetlands; 3) to accomplish legacy sediment removal; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation.

What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice (e.g., elements to consider include TN, TP, and TSS loads reduced and water quality criteria such as temperature, pH, conductivity, etc.)? Funders are interested in temporal changes over time.

* Equipment trade-offs: Often to implement restoration projects, some disturbance/negative impact is incurred during construction for access purposes and other construction activities. It has been suggested that using smaller equipment to construct stream restoration projects would lead to less impact (e.g., soil compaction and/or tree loss). However, using smaller equipment could result in the need for more disturbance (e.g., a great number of trips, more individual pieces of equipment, etc.) that could have a bigger impact due to construction. We are looking for a modeling exercise that would compare, for a hypothetical stream restoration project of a given size, the negative impacts of construction activities that used large vs. small construction equipment.
* Living shorelines:  Living shorelines are often designed with goals to reduce erosion; protect land; address risk from coastal storm damage (e.g., wave and flood protection); enhance habitat (e.g., fish and other wildlife, plants); and remove nutrients and sediment. Generally, living shoreline designs require more cross-shore space compared to shoreline armor projects, given that intertidal wetland vegetation must extend either into the subtidal or riparian zones. The design footprint (area) influences the effectiveness of the project from a habitat, nutrient, and erosion control perspective. There is a need to better understand resource tradeoffs associated with living shoreline designs, including how to evaluate and balance impacts to valuable upland and shallow water habitat. Additionally, it remains unclear how resiliency is considered in designs and what timeline is appropriate, particularly where there are resource tradeoff concerns. Finally, regulators want to use this research to better quantify the conversion (i.e., changes to function/service) of shallow water habitat to low and high marsh habitat and identify parameters/thresholds for success and/or failure.
	+ Funders are interested to know if and to what extent living shorelines achieve their stated goals and ask the following questions: Are there conditions in which living shorelines can improve resilience to flooding, especially where landscape position and elevations are low? Do living shoreline projects enhance habitat in high energy systems for as long as they persist, or what are the tradeoff value(s) if the wetlands cannot be effectively maintained?
	+ Funders are interested to better understand impacts to upland and aquatic functions/services associated with the placement of living shorelines and ask the following questions: How do different living shoreline design approaches and landscape position affect living shoreline co-benefits: flooding abatement, habitat enhancement, nutrient reduction, shoreline stabilization, invasive species (e.g., *Phragmites*) colonization, etc.? Where there is a need to balance impacts to shallow water and critical area resources, does a living shoreline design that incorporates upland habitat (i.e., marsh migration corridor) address stated project goals compared to designs that do not and if it does, what factors were important to consider?
	+ Funders are interested to know how and to what extent submerged aquatic vegetation (SAV) responds to different living shoreline techniques and ask the following questions: What are the impacts to SAV from placement of living shorelines, including direct and indirect impacts? Under what conditions are SAV likely to recover post-construction (i.e., what design techniques provide opportunity for SAV re-establishment either through replanting efforts or passive recovery)?

*Previous living shoreline research*: Note that an earlier project titled, “Long-term impacts of living shorelines to Sub Aquatic Vegetation (SAV) habitats in the Chesapeake Bay” (available at: <https://cbtrust.org/wp-content/uploads/Long-term-impacts-of-living-shorelines-to-SAV-habitats-in-Chesapeake-Bay_UMCES_March-2022.pdf>) addressed the trade-off for SAV and living shorelines, and while more research on this specific area of SAV-living shoreline interaction is of interest to funders, we shift focus this year to a more general efficacy topic.

*Potential sites to study*: The Maryland Department of Natural Resources is actively monitoring living shorelines with pre-restoration data at several sites. This monitoring includes assessments of vegetation, elevation surveys, and soil nutrient/carbon composition.  We encourage applicants to reach out to the program managers if interested in including these sites in your study. The Chesapeake Bay Trust and other Pooled Monitoring Advisory members also have sites available for study.

This research should allow restoration practitioners and permitters to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in decision making.

# RFP Questions from FY 24

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. BMP Effectiveness Monitoring: What is the effectiveness of stormwater best management practices implemented in the Maryland Stormwater Design Manual? Does provision of the full treatment volume for the 1-year 24-hour design storm event replicate woods in good condition reduce the water flow enough to protect stream channels? How effective is the BMP (or suite of BMPs) for reducing total suspended solids (TSS), total phosphorus (TP), or total nitrogen (TN)? How does the collection and conveyance system design impact BMP performance during high intensity storm events? How do soils and vegetative cover impact the effectiveness of the BMP (load/reduction relationship)?
2. Watershed Restoration Assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). The following are related questions: What percentage of the impervious surface in a watershed must be treated with stormwater BMPs before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, ESD practices, stormwater wetlands) influence that percentage? Does the location in the watershed where the BMPs are located and/or the concentration of impervious surface areas located in the watershed impact the restoration outcomes? Are there other conditions (e.g., atmospheric deposition, chlorides) precluding restoration efforts (BMPs) from achieving expected water quality improvements?

**Effectiveness of restoration practices at the project scale**

1. Biological Community Restoration: Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). The reasons are not yet clear, but three hypotheses are high flows (impact benthic drift behaviors, suspended sediment tolerance, available carbon), the lack of source populations (research underway, “Assessing the feasibility of assisted macroinvertebrate colonization in achieving ecological uplift in restored streams”), and physiochemical habitat barriers (e.g., conductivity, temperature, and pollutants of emerging concern such as chloride and toxic substances among others). We seek a research team to test the influence of physical and chemical features on stream biota in stream restoration projects.
2. Climate change impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, growing season will lengthen, and other processes related to the Chesapeake community’s approved set of BMPs will change. As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., need to evaluate high intensity storms of varied frequencies (vs 24-hour event), conveyance limitations, etc.). Applicants should be aware of and build on three studies supported in this program to address this question as well as two EPA supported projects with similar goals (detailed below).

Funders are looking for investigators to compare the modeled or measured outcomes of varied storm frequency and duration (and associated flood impacts, loading rates, and % loads reduced for TN, TP, TSS, etc.) of current stormwater BMPs to those of a new set of stormwater BMP design scenarios (e.g., evaluating water quality practices such as ESD implemented in a watershed where additional storage such as the 1 year 24-hour extended detention or peak management controls are provided). Additionally, funders realize that restoration in coastal areas presents conditions where additional research efforts are needed (e.g., high water tables, tidal influence, and/or storm surge). The ultimate use of this information would be to evaluate design criteria of these BMPs (new or retrofits) that achieve the most effective treatment and conveyance strategies when comparing varied rainfall design storm scenarios.

1. Pollutants of Emerging Concern: Fecal indicator bacteria; chloride; temperature; and toxics, particularly polychlorinated biphenyls (PCBs) have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the research to date. Therefore, questions within this area are:
	1. Bacteria and Chloride – To better inform choices of existing management options, funders participating in the Pooled Monitoring option in Maryland’s MS4 permit are interested in research that advances existing science related to the baseline conditions and sources of bacteria and/or chloride in urban streams. Funders are also interested in existing or novel sampling and analytical methods that could better quantify pollutants entering waterways and differentiate between the primary sources. Such research may include developing a relationship between *E. coli* eDNA and *E. coli* most probable number (MPN)/100 mL, the feasibility of using automated samplers for bacteria sampling in lieu of grab samples, and the relationship between chloride concentration and specific conductance. Ultimately, funders want to use this research to identify new and/or to enhance existing, management measures that reduce bacteria and chloride concentrations in receiving waters.

Questions for researchers to address are:

1. What are the typical bacteria sources and their relative contributions for urban watersheds? Of interest are methods of sampling (e.g., autosampler vs. grab sampling), developing relationships between eDNA and actual counts of *E. coli* and *Enterococcus*, and researching and updating the proportional bacteria contributions to non-tidal stream systems from diverse sources.
2. What are the effects of salt reduction strategies on in-stream chloride concentrations and specific conductance in nontidal perennial streams?

Salt reduction strategies should align with the MS4 permit’s pollution prevention and good housekeeping control measures such as brine application. Funders are interested in the amount of salt delivered from the application point to the stream and the time this takes. Funders are also interested in the baseline conditions and the change from salt application. We realize that sample size, methods used, and replication could be costly and may be scalable. The funders will consider literature reviews and/or pilot efforts for one or both questions. The MDE monitoring guidelines may be used as reference and can be found here: <https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/Final%20Determination%20Dox%20N5%202021/2021%20MS4%20Monitoring%20Guideline%20Final%2011%2005%202021.pdf>

* 1. Thermal – What best management practice design and siting methods will reduce thermal impacts to streams, and in Maryland there is interest in Maryland’s Use III and IV streams (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf)), and to the watershed? Management practice design/strategy examples to test include various surface ponding and discharge structure configurations, variable media depths in filtering practices, use of submerged gravel wetlands, and specific stream restoration design features and types such as legacy sediment removal, stage zero/emergent wetlands, and other management strategies.

Applicants should be aware of and build on, if possible, the project supported in 2021, “Evaluation of watershed-scale impacts of stormwater management facilities on thermal loads to a Maryland Class IV stream using a high-frequency sensor network” as described in the 2023 forum presentation available at: <https://cbtrust.org/wp-content/uploads/7_Welty-Miller-Restoration-Research-2023-v6.pptx.pdf> and the Maryland Water Monitoring Conference presentation titled “Thermal properties of different stormwater Best Management Practices” that is available at: <https://tinyurl.com/pnfdnc2h>.

Current state (Maryland) modeling exercises in urban watersheds indicate that reductions in heated surface runoff and increases in riparian forest buffers are necessary to meet thermal water quality endpoints (68o F or 20o C for Use Class III streams). What is the thermal load to and the cumulative impact of thermal mitigation practices in urban and rural watersheds? If possible, explain how practices were combined to reduce thermal impacts to streams.

* 1. Toxics – Many regional water bodies have toxic substance impairments, particularly for PCBs. Some progress has been made in identifying the influence of specific land uses, industry types, and development age on toxic contaminant loadings. However, there are still many unknowns related to the fate, transport, capture, and impact of toxic pollutants. For instance, it is often unknown whether practices used to reduce sediment and nutrient loads can also reduce toxic contaminant loads, and for innovative stormwater designs specifically aimed at reducing toxic contaminants, it is unknown exactly how effective these practices can be. There are also still uncertainties regarding how to monitor streams to determine if there are upland sources within a storm-sewershed. Additionally, given the lack of information on the impact of toxic contaminants on biota, it is possible that additional stressors are being overlooked in assessments such as Maryland’s Biological Stressor Identification analyses. Consequently, there could be significant gaps in management strategies to restore biological communities in streams. This research question was scaled back to focus on monitoring while the results from University of Maryland’s “Influence of historic and current land use practices on PCB contamination of soils and stormwater sediments in the Chesapeake Bay watershed” are underway.

A frequent limitation to optimal stormwater monitoring protocols and design implementation is the availability of funds and personnel. Traditional practices, such as automated samplers, are efficient but can be costly and frequently difficult to install and maintain. Considering those challenges, what innovative techniques that are affordable and of simple installation and maintenance could the monitoring community use to measure PCBs concentrations during storm events in outfalls, pipes, BMPs, and/or inlets?

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account the reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected is often not the same as the units measured to report the restoration work (often, for example, pounds of nitrogen reduced).

**The goal of this question is to encourage quantification, in some comparable metric, of the resources present prior to the activity compared to the resources available after restoration project installation, calculating net ecological impact after evaluation of individual functional components**. Your project should explore the “positive” and “negative” impact for at least two resources using common metric(s) (e.g., vegetation biomass, pounds of pollutant reduced, a habitat metric) to determine the net change. If possible, consider the economic valuation of the resource(s) or ecosystem service(s). With certain kinds of restoration projects or practices, do the net benefits (e.g., nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (e.g., tree loss and resulting habitat loss, etc.)?

Resource trade-off examples include, but are not limited to, the following:

* Tree planting “success” for plant establishment, survival, and ecological benefit: Tree planting establishment efforts are common as both standalone projects (e.g., buffers) and components of other BMPs (e.g., stream restorations, stormwater bioretention, etc.). As practitioners, policymakers, and funders, the community wants to determine how to assess tree planting “success” to guide us for more sustainable, ecologically beneficial, and cost-effective plantings. Therefore, our top question is: **How do we measure tree planting project “success”?**

We want tree planting projects to be successful in terms of many factors such as site selection; site preparation; size, type, and/or density of plantings; project acceptance by community; survivability; ensuring equity\* is considered in our projects; and attaining ecological and habitat benefits all while demonstrating cost effectiveness. Researchers should consider the following sub-questions that get at the “success” of a project:

1. How does site selection, preparation (e.g., soil decompaction or amendment), and maintenance (including invasive management\*\*) impact the outcome of interest (tree survival, canopy cover, habitat))?
2. Stream restoration often entails reconnecting the floodplain to the stream and raising groundwater levels. How does this change in floodplain connectivity and groundwater levels impact metrics such as tree survivability, shading, and riparian ecology?

Ultimately, we want to use this research to invest in tree plantings that optimize plant survival, shading/canopy goals, water quality goals, habitat goals, and community benefits, including equitable tree program delivery. We recognize there are many factors to consider, including time, in your experimental design.

\*Equity has been defined by various entities over the years and continues to be updated. For your reference the EPA defines environmental equity as “providing appropriate support to remove environmental disparities, which may include addressing systemic barriers.”

\*\*The Pooled Monitoring Initiative detailed “invasives” as a “resource trade-off in different types of restoration projects” in the FY 22 RFP where the project addressing this trade-off was supported (Virginia Tech led and project titled, “Identifying restoration practices and landscape variables that increase native plant establishment and mitigate plant invasion”). The FY 22 RFP “invasives” question is at <https://cbtrust.org/wp-content/uploads/Pooled-Monitoring-Initiatives-Restoration-Research-RFP_111021-1.pdf> (Q6) and invasives are a topic of interest.

* Stream restoration projects with tree removal: A recent Science and Technical Advisory Committee defined stream restoration as “an intervention to move a degraded ecosystem to a trajectory of recovery as informed by a reference condition considering local and global environmental change.” To date, many stream restoration practices in wooded areas, result in tree removal at the site for reasons such as: 1) construction site access; 2) for various methods of stream restoration in nontidal forested wetlands; 3) to accomplish legacy sediment removal; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation.

What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice (e.g., elements to consider include TN, TP, and TSS loads reduced and water quality criteria such as temperature, pH, conductivity, etc.)? Funders are interested in temporal changes over time.

* Living shorelines:  Living shorelines are often designed with goals to reduce erosion; protect land; address risk from coastal storm damage (e.g., wave and flood protection); enhance habitat (e.g., fish and other wildlife, plants); and remove nutrients and sediment. Generally, living shoreline designs require more cross-shore space compared to shoreline armor projects, given that intertidal wetland vegetation must extend either into the subtidal or riparian zones. The design footprint (area) influences the effectiveness of the project from a habitat, nutrient, and erosion control perspective. There is a need to better understand resource tradeoffs associated with living shoreline designs, including how to evaluate and balance impacts to valuable upland and shallow water habitat. Additionally, it remains unclear how resiliency is considered in designs and what timeline is appropriate, particularly where there are resource tradeoff concerns. Finally, regulators want to use this research to better quantify the conversion (i.e., changes to function/service) of shallow water habitat to low and high marsh habitat and identify parameters/thresholds for success and/or failure.
	+ Funders are interested to know if and to what extent living shorelines achieve their stated goals and ask the following questions: Are there conditions in which living shorelines can improve resilience to flooding, especially where landscape position and elevations are low? Do living shoreline projects enhance habitat in high energy systems for as long as they persist, or what are the tradeoff value(s) if the wetlands cannot be effectively maintained?
	+ Funders are interested to better understand impacts to upland and aquatic functions/services associated with the placement of living shorelines and ask the following questions: How do different living shoreline design approaches and landscape position affect living shoreline co-benefits: flooding abatement, habitat enhancement, nutrient reduction, shoreline stabilization, invasive species (e.g., *Phragmites*) colonization, etc.? Where there is a need to balance impacts to shallow water and critical area resources, does a living shoreline design that incorporates upland habitat (i.e., marsh migration corridor) address stated project goals compared to designs that do not and if it does, what factors were important to consider?
	+ Funders are interested to know how and to what extent submerged aquatic vegetation (SAV) responds to different living shoreline techniques and ask the following questions: What are the impacts to SAV from placement of living shorelines, including direct and indirect impacts? Under what conditions are SAV likely to recover post-construction (i.e., what design techniques provide opportunity for SAV re-establishment either through replanting efforts or passive recovery)?

*Previous living shoreline research*: Note that an earlier project titled, “Long-term impacts of living shorelines to Sub Aquatic Vegetation (SAV) habitats in the Chesapeake Bay” (available at: <https://cbtrust.org/wp-content/uploads/Long-term-impacts-of-living-shorelines-to-SAV-habitats-in-Chesapeake-Bay_UMCES_March-2022.pdf>) addressed the trade-off for SAV and living shorelines, and while more research on this specific area of SAV-living shoreline interaction is of interest to funders, we shift focus this year to a more general efficacy topic.

*Potential sites to study*: The Maryland Department of Natural Resources is actively monitoring living shorelines with pre-restoration data at several sites. This monitoring includes assessments of vegetation, elevation surveys, and soil nutrient/carbon composition.  We encourage applicants to reach out to the program manager if interested in including these sites in your study. The Chesapeake Bay Trust and other Pooled Monitoring Advisory members also have sites available for study.

This research should allow restoration practitioners and permitters to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in decision making.

# RFP Questions from FY 23

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. BMP Effectiveness Monitoring: What is the effectiveness of stormwater best management practices implemented to address the Environmental Site Design (ESD) sizing criteria in the Maryland Stormwater Design Manual for assessments in Maryland? Does provision of the full treatment volume for the 1-year 24-hour design storm event to address the ESD unified sizing criteria to replicate woods in good condition reduce the water flow enough to protect stream channels? How effective is the BMP (or suite of BMPs) for reducing total suspended solids (TSS), total phosphorus (TP), or total nitrogen (TN)? How do soils and vegetative cover impact the effectiveness of the BMP (load/reduction relationship)?
2. Watershed restoration assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). The following are related questions: What percentage of the impervious surface in a watershed must be treated with stormwater BMPs before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, ESD practices, stormwater wetlands) influence that percentage? Does the location in the watershed where the BMPs are located and/or the concentration of impervious surface areas located in the watershed impact the restoration outcomes?

**Effectiveness of restoration practices at the project scale**

1. Biological Community Restoration: Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). The reasons are not yet clear, but three hypotheses are high flows (impact benthic drift behaviors, suspended sediment tolerance, available carbon), the lack of source populations, and chemical habitat barriers (e.g., conductivity, temperature). We seek a research team to test the hypothesis that individual/species/community seeding/transplantation in urban/suburban restored streams (in which physical habitat conditions would predict them to occur) will result in benthic communities that are more similar to reference streams as compared to control restored sites in which individuals/species/communities were not transplanted. As part of this effort, researchers may also choose to test the chemical habitat hypothesis. The research will be aware of and build on, if appliable, a project supported in this program titled, “Using eDNA methods to extend biological sampling and identify candidate restorations for species reintroductions” and other relevant research.
2. Climate change impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, growing season will lengthen, and other processes related to the Chesapeake community’s approved set of BMPs will change (e.g., more drought conditions within the BMPs will cause microbe cell walls to deteriorate releasing those nutrients into the BMP). As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., need to evaluate high intensity storms of varied frequencies (vs 24-hour event), conveyance limitations, etc.). Applicants should be aware of and build on two studies supported in this program to address this question as well as an EPA supported project with similar goals (detailed below).

Funders are looking for investigators to compare the modeled or measured outcomes of varied storm frequency and duration (and associated flood impacts, loading rates, and % loads reduced for TN, TP, TSS, etc.) of current stormwater BMPs to those of a new set of stormwater BMP design scenarios (e.g., evaluating water quality practices such as ESD implemented in a watershed where additional storage such as the 1 year 24-hour extended detention or peak management controls are provided). The ultimate use of this information would be to evaluate design criteria of these BMPs (new or retrofits) that achieve the most effective treatment and conveyance strategies when comparing varied rainfall design storm scenarios.

1. Pollutants of Emerging Concern: Temperature; toxics, particularly polychlorinated biphenyls (PCBs); fecal indicator bacteria; and chloride have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the research to date. Therefore, questions within this area are:

* 1. Thermal – What best management practice design and siting methods will reduce thermal impacts to streams, and in Maryland there is interest in Maryland’s Use III and IV streams (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf)), and to the watershed? Management practice design/strategy examples to test include various surface ponding and discharge structure configurations, variable media depths in filtering practices, and specific stream restoration design features and types such as legacy sediment removal, stage zero/emergent wetlands, and other management strategies. Applicants should be aware of and build on, if possible, the project supported in 2021, “Evaluation of watershed-scale impacts of stormwater management facilities on thermal loads to a Maryland Class IV stream using a high-frequency sensor network” as described in the 2022 forum presentation available at: <https://cbtrust.org/wp-content/uploads/5_Welty-Miller-Restoration-Research-2022-v2.pdf>.

Current state (Maryland) modeling efforts indicate that a reduction in heated surface runoff in addition to riparian forest buffers to provide shading are necessary to meet thermal water quality endpoints (68o F or 20o C for Use Class III streams). What is the thermal load to and the cumulative impact of thermal mitigation practices in urban and rural watersheds? If possible, explain how practices were combined to reduce thermal impacts to streams.

* 1. Toxics – Many regional water bodies have toxic substance impairments, particularly for PCBs. Some progress has been made in identifying the influence of specific land uses, industry types, and development age on toxic contaminant loadings. However, there are still many unknowns related to the fate, transport, capture, and impact of toxic pollutants. For instance, it is often unknown whether practices used to reduce sediment and nutrient loads can also reduce toxic contaminant loads, and for innovative stormwater designs specifically aimed at reducing toxic contaminants, it is unknown exactly how effective these practices can be. There are also still uncertainties regarding how to monitor streams to determine if there are upland sources within a storm-sewershed. Additionally, given the lack of information on the impact of toxic contaminants on biota, it is possible that additional stressors are being overlooked in assessments such as Maryland’s Biological Stressor Identification analyses. Consequently, there could be significant gaps in management strategies to restore biological communities in streams. Questions i and ii of this section are only applicable to PCB studies.
	2. What are the removal capabilities of different stormwater management designs on reducing PCBs loads? We seek proposals that address either a) comparisons of traditional and innovative stormwater practices in this area (e.g., bioretention with traditional media vs. filters with variable media designs) or b) comparisons of effectiveness of different innovative techniques at reducing PCBs.
	3. A frequent limitation to optimal stormwater monitoring protocols and design implementation is the availability of funds and personnel. Traditional practices, such as automated samplers, are efficient but can be costly and frequently difficult to install and maintain. Considering those challenges, what innovative techniques that are affordable and of simple installation and maintenance could the monitoring community use to measure PCBs concentrations during storm events in outfalls, pipes, BMPs, and/or inlets?
	4. What is the toxicity of sediments, pore-water, and water column in urban streams? We are particularly interested in understanding the impact of toxic contaminants on stream biota.
1. Bacteria and Chloride – To better inform choices of existing management options, funders participating in the Pooled Monitoring option in Maryland’s MS4 permit are interested in research that advances existing science related to the baseline conditions and sources of bacteria and/or chloride in urban streams. Funders are also interested in existing or novel sampling and analytical methods that could better quantify pollutants entering waterways and differentiate between the primary sources. Such research may include developing a relationship between *E. coli* eDNA and *E. coli* most probable number (MPN)/100 mL, the feasibility of using automated samplers for bacteria sampling in lieu of grab samples, and the relationship between chloride concentration and specific conductance. Ultimately, funders want to use this research to identify new and/or to enhance existing, management measures that reduce bacteria and chloride concentrations in receiving waters.

Questions for researchers to address are:

1. What are the typical bacteria sources and their relative contributions for urban watersheds? Of interest are methods of sampling (e.g., autosampler vs. grab sampling), developing relationships between eDNA and actual counts of *E. coli* and *Enterococcus*, and researching and updating the proportional bacteria contributions to non-tidal stream systems from diverse sources.
2. What are the effects of salt reduction strategies on in-stream chloride concentrations and specific conductance in nontidal perennial streams (12-digit watershed(s))?

We realize that sample size, methods used, and replication could be costly and may be scalable. The funders will consider literature reviews and/or pilot efforts for one or both questions. The MDE monitoring guidelines may be used as reference and can be found here: <https://mde.maryland.gov/programs/water/StormwaterManagementProgram/Documents/Final%20Determination%20Dox%20N5%202021/2021%20MS4%20Monitoring%20Guideline%20Final%2011%2005%202021.pdf>

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account the reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected is often not the same as the units measured to report the restoration work (often, for example, pounds of nitrogen reduced).

The goal of this question is to encourage quantification, in some comparable metric, of the resources present prior to the activity compared to the resources available after restoration project installation, calculating net ecological impact after evaluation of individual functional components. Your project should explore the “positive” and “negative” impact for at least two resources using common metric(s) (e.g., vegetation biomass, pounds of pollutant reduced, a habitat metric) to determine the net change. If possible, consider the economic valuation of the resource(s) or ecosystem service(s). With certain kinds of restoration projects or practices, do the net benefits (nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (tree loss and resulting habitat loss, etc.)?

Include at least two resources for consideration, such as, but not limited to the following:

* Tree planting “success” for plant establishment, survival, and ecological benefit: Vegetation establishment efforts are common as both standalone projects (buffers, meadows, etc.) and components of other BMPs (stream restorations, stormwater bioretention, etc.). As practitioners, policymakers, and funders, the community wants to determine how to assess vegetation “success” to guide us for more sustainable, ecologically beneficial, and cost-effective plantings. Therefore, our top question is: **How do we measure tree planting project “success”?**

We want tree planting projects to be successful in terms of many factors such as site selection; site preparation; size, type, and/or density of plantings; people accepting the project; survivability; ensuring equity\* considered in our projects; attaining ecological and habitat benefits; and attaining water quality benefits estimated all while demonstrating cost effectiveness. Researchers should consider the following sub-questions that get at the “success” of a project:

1. How does site selection, preparation (e.g., soil decompaction or amendment), and maintenance (including invasive management\*\*) impact the outcome of interest (tree survival, pollutant load reduction/credit)? How do the financial expenses and labor involved with these different preparation and maintenance regimes compare with their respective outcomes?
2. How do the water quality credits compare to the modeled credits for tree planting projects (e.g., riparian buffer credits, upland tree planting credits, etc.)?
3. For tree planting projects related to stream restoration, how does the transition from forested communities to wetland communities impact soils, tree survivability, and shading of the stream? Stream restoration often entails reconnecting the floodplain to the stream and raising groundwater water levels. How does this change in floodplain connectivity and groundwater levels impact the previously mentioned metrics such as tree survivability, shading, and riparian ecology?

Ultimately, we want to use this research to invest in plantings that optimize plant survival, shading/canopy goals, water quality goals, habitat goals, and community benefits, including equitable tree program delivery. We recognize there are many factors to consider, including time, in your experimental design.

\*Equity has been defined by various entities over the years and continues to be updated. For your reference the EPA defines environmental equity as “providing appropriate support to remove environmental disparities, which may include addressing systemic barriers.”

\*\*The Pooled Monitoring Initiative detailed “invasives” as a “resource trade-off in different types of restoration projects” in the FY 22 RFP where the project addressing this trade-off was supported (Virginia Tech led and project titled, “Identifying restoration practices and landscape variables that increase native plant establishment and mitigate plant invasion”). The FY 22 RFP “invasives” question is at <https://cbtrust.org/wp-content/uploads/Pooled-Monitoring-Initiatives-Restoration-Research-RFP_111021-1.pdf> (Q6) and invasives are a topic of interest.

* Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation. What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice? Your effort should build on/compliment but not duplicate two projects on this topic funded in 2017; see past projects funded and final reports at [www.cbtrust.org/restorationresearch](http://www.cbtrust.org/restorationresearch).
* Living shorelines:  Living shoreline projects, by definition, require more cross-shore space than shoreline armor projects, given that the creation of a platform for intertidal wetland vegetation and potentially an associated sill, must extend either into the subtidal zone or into the riparian zone, especially with restoration in higher energy systems/areas that are becoming more prevalent for restoration.  Such extension means that existing conditions in either neighboring zone will be replaced with emergent wetland, and any new toe protection or other structures installed create disturbance. Living shorelines are designed with goals to reduce erosion, protecting land; improve resilience to flooding; enhance habitat (e.g., fish and other wildlife, plants); and remove nutrients and sediment. The footprint (area) of the project impacts the effectiveness of the project from a habitat and nutrient perspective, and sometimes an erosion control perspective. Funders are interested to know if and to what extent living shorelines achieve these goals; Do living shorelines abate erosion, improve resilience to flooding, and enhance habitat in high energy systems?

*Pre**vious living sh**oreline research*: Note that an earlier project titled, “Long-term impacts of living shorelines to Sub Aquatic Vegetation (SAV) habitats in the Chesapeake Bay” (available at: <https://cbtrust.org/wp-content/uploads/Long-term-impacts-of-living-shorelines-to-SAV-habitats-in-Chesapeake-Bay_UMCES_March-2022.pdf>) addressed the trade-off for SAV and living shorelines, and while more research on this specific area of SAV-living shoreline interaction is of interest to funders, we shift focus this year to a more general efficacy topic.

*Potential sites to study*: The Maryland Department of Natural Resources is actively monitoring living shorelines with pre-restoration data at several sites. This monitoring includes assessments of vegetation, elevation surveys, and soil nutrient/carbon composition.  We encourage applicants to reach out to the program manager if interested in including these sites in your study. The Chesapeake Bay Trust and other Pooled Monitoring Advisory members also have sites available for study.

This research should allow restoration practitioners and permitters to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in decision making.

# RFP Questions from FY 22

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. BMP Effectiveness Monitoring: What is the effectiveness of stormwater best management practices implemented to address the Environmental Site Design (ESD) sizing criteria in the Maryland Stormwater Design Manual for assessments in Maryland? Does provision of the full treatment volume for the 1-year 24-hour design storm event to address the ESD unified sizing criteria to replicate woods in good condition reduce the water flow enough to protect stream channels? How effective is the BMP (or suite of BMPs) for reducing total suspended solids (TSS), total phosphorus (TP), or total nitrogen (TN)?
2. Watershed restoration assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). The following are related questions: What percentage of the impervious surface in a watershed must be treated with stormwater BMPs before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, ESD practices, stormwater wetlands) influence that percentage?

**Effectiveness of restoration practices at the project scale**

1. Biological Community Restoration: Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). The reasons are not yet clear, but three hypotheses are high flows (impact benthic drift behaviors, suspended sediment tolerance, available carbon), the lack of source populations, and chemical habitat barriers (e.g., conductivity, temperature). We seek a research team to test the hypothesis that individual/species/community seeding/transplantation in urban/suburban restored streams (in which physical habitat conditions would predict them to occur) will result in benthic communities that are more similar to reference streams compared to control restored sites in which individuals/species/communities were not transplanted. As part of this effort, researchers may also choose to test the chemical habitat hypothesis. The research will build on a project supported in this program titled, “Using eDNA methods to extend biological sampling and identify candidate restorations for species reintroductions” and other similar, relevant research.
2. Climate change impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, growing season will lengthen, and other processes related to the Chesapeake community’s approved set of BMPs will change (e.g., more drought conditions within the BMPs will cause microbe cell walls to deteriorate releasing those nutrients into the BMP). As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., need to evaluate high intensity storms of varied frequencies (vs 24-hour event), conveyance limitations, etc.).

Funders are looking for investigators to compare the modeled or measured outcomes of varied storm frequency and duration (and associated flood impacts, loading rates, and % loads reduced for TN, TP, TSS, etc.) of current stormwater BMPs to those of a new set of stormwater BMP design scenarios (e.g., evaluating water quality practices such as ESD implemented in a watershed where additional storage such as the 1 year 24-hour extended detention or peak management controls are provided). The ultimate use of this information would be to evaluate design criteria of these BMPs (new or retrofits) that achieves the most effective treatment and conveyance strategies when comparing varied rainfall design storm scenarios. The research will build on a project supported in this program titled, “Climate Impacts to Restoration Practices,” with the final report available at: <https://cbtrust.org/grants/restoration-research/> (in the table) and recently supported (FY 21) project also titled, “Climate Impacts to Restoration Practices.” The research will build on recent, relevant research in the field such as RAND’s project titled, “Chesapeake Bay Climate Change – Informed IDF Curves” whose final report is available at: <https://cbtrust.org/wp-content/uploads/17726_RAND_Final-IDF-Curve-Report_July2021.pdf>, and other similar studies.

In addition, for stream restoration practices funders are looking for investigators to compare modeled or measured factors considered for stream restoration practices (e.g., criteria for site selection, design approach for habitat, or construction technique) under current conditions vs a new set of conditions (e.g., design element(s) improve habitat) to reduce the impacts of future climate change such as changing intensity duration frequency curves, frequency of storms, and/or periods of drought. Finally, a literature review that provides a synthesis of stream restoration siting criteria, design conditions, construction techniques/sequences, and/or other factors to manage for future climate impacts will be considered. The findings will support current stream restoration maintenance/upgrades and future stream restoration siting, designs, and/or construction practices.

1. Pollutants of Emerging Concern: Temperature; chloride; and toxics, particularly polychlorinated biphenyls (PCBs) and fecal coliform bacteria, have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the restoration community to date. Current research is ongoing for road salt/chlorides and this program will wait for those results before posing a future chloride focused research question. Therefore, questions within this area are:

1. Thermal – What best management practice design and siting methods will reduce thermal impacts to Maryland’s Use III and IV streams (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf))? Management practice design/strategy examples to test include various surface ponding and discharge structure configurations, variable media depths in filtering practices, and specific stream restoration design features and types such as legacy sediment removal, stage zero/emergent wetlands, and other management strategies.

Current state (Maryland) modeling efforts indicate that a reduction in heated surface runoff in addition to riparian forest buffers to provide shading are necessary to meet thermal water quality endpoints (68o F or 20o C for Use Class III streams). What is the cumulative impact of thermal mitigation practices in urban and rural watersheds? If possible, explain how practices were combined to reduce thermal impacts to streams.

1. PCBs – Many regional water bodies have PCB impairments. Some of these impairments result from *in situ* legacy sources and may naturally attenuate over time, while in other cases active sources of PCBs have been identified. The specific sources of PCBs are often unknown as are whether practices used to reduce nutrient loads can also reduce PCB loads.
	1. Are there significant differences in PCB loadings across different land use types, industry types, and eras of development?

Toxics, specifically PCBs –  Both "traditional" (e.g., Maryland Stormwater Design Manual Chapter 3 and 5 practices: <https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Pages/stormwater_design.aspx>) and innovative stormwater management techniques may reduce delivery of pollutants such as PCBs and other toxins to receiving waters.

1. What are the removal capabilities of different stormwater management designs on reducing toxic contaminant loads? We seek proposals that address either a) comparisons of traditional and innovative stormwater practices in this area (e.g., bioretention with traditional media vs. filters with variable media designs) or b) comparisons of effectiveness of different innovative techniques at reducing PCBs and other toxins.

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected is often not the same as the units measured to report the restoration work (often, for example, pounds of nitrogen reduced).

The goal of this question is to encourage quantification, in some comparable metric, of the resources present prior to the activity compared to the resources available after restoration project installation, calculating net ecological impact after evaluation of individual functional components. Your project should explore the “positive” and “negative” impact for at least two resources using common metric(s) (e.g., vegetation biomass, pounds of pollutant reduced, a habitat metric) to determine the net change. With certain kinds of restoration projects or practices, do the net benefits (nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (tree loss and resulting habitat loss, etc.)?

Include at least two resources for consideration, such as, but not limited to the following:

* Vegetation “success” for plant establishment, survival, and ecological benefit: Vegetation establishment efforts are common as both standalone projects (buffers, meadows, etc.) and components of other BMPs (stream restorations, stormwater bioretention, etc.). As practitioners, policymakers, and funders, the community wants to determine how to assess vegetation “success” to guide us for more sustainable, cost-effective, and ecologically beneficial plantings. The following are a list of types of considerations that could be investigated through a project: 1) How do we measure, or have we measured “success” in a way that can guide us to achieve more impactful future plantings? 2) How do planting stock type, location (e.g., private vs public land, urban vs rural, easements, etc.), adaptive management/maintenance, and planting density affect survival, growth rate, and ecological benchmarks such as percent shade or carbon sequestration?; 3) If we assess a tree planting’s “success” what reference site/condition(s) or standards is/are appropriate at different ages?; 4) How do we minimize impacts to the vegetation such as the impacts from deer and/or invasive species?; 5) How do we optimize plantings to achieve water quality goals, shading/canopy goals (for tree planting projects), habitat goals, and other similar goals?; and/or 6) What measures can be assessed remotely and which ones require field measurements? We recognize there are many factors to consider, including time, in your experimental design.
* Invasive species in stream restoration and tree planting projects: The act of restoration, in ecological terms, can be considered a disturbance. Colonization by invasive species following any disturbance is common and restoration practices are no different. In addition, managing invasives can be a costly component of post-project maintenance regimes. As a result, many in the practitioner community are looking for ways to implement restoration projects that result in less colonization by invasive species and to articulate whether an “acceptable” threshold for invasive species could be quantified and used as a management tool. Specifically, funders are looking for research comparing the value of different techniques in reducing invasive colonization in stream restoration and tree planting projects. Researchers choosing to address this question will be responsible for identifying or proposing one or more alternative methods, then testing them ideally with a paired BACI design (i.e., a suite of restoration projects in which traditional methods are used compared to a suite of restoration projects in which a new method to reduce invasive colonization is tested).
* Wetland trade-offs in stream restoration projects: Certain stream restoration practices can impact type and function of existing wetlands. Impacts can include changes to the wetland’s hydrology and plant community extent and distribution. What are the changes to the wetland community and does this result in a loss of wetland function compared to the benefit of the other elements of the restoration practice?
* Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation. What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice? Your effort should build on/compliment but not duplicate two projects on this topic funded in 2017; see past projects funded and final reports at [www.cbtrust.org/restorationresearch](http://www.cbtrust.org/restorationresearch).
* Construction impacts of stream restoration, consider both short- and long-term impacts: Some in the community are concerned that the act of project construction can have negative consequences on the resource(s). For example, construction equipment can compact soils, reducing infiltration and therefore water quality benefit. Certain alternative construction mechanisms may be available or adding a step of countering the soil compaction may help. Researchers choosing to address this question will be responsible for identifying or proposing alternative methods, then either modeling their effect on TN, TP, and TSS load reduction and/or habitat characteristics, or testing them empirically. In the alternative construction methods used to address this question, consider how the construction methods impact the construction time, restoration materials used, and cost.

This research should allow restoration practitioners and permitters to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in decision making.

# RFP Questions from FY 21

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. BMP Effectiveness Monitoring: What is the effectiveness of stormwater best management practices implemented to address the Environmental Site Design (ESD) sizing criteria in the Maryland Stormwater Design Manual for assessments in Maryland? Does provision of the full treatment volume for the 1-year 24-hour design storm event to address the ESD unified sizing criteria to replicate woods in good condition reduce the water flow enough to protect stream channels in Maryland? How effective is the BMP (or suite of BMPs) for reducing total suspended solids (TSS), total phosphorus (TP), or total nitrogen (TN)?
2. Watershed restoration assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). The following are related questions: What percentage of the impervious surface in a watershed must be treated with stormwater BMPs before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, ESD practices, stormwater wetlands) influence that percentage?

**Effectiveness of restoration practices at the project scale**

1. Biological Community Restoration: Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). The reasons are not yet clear, but three hypotheses are high flows (impact benthic drift behaviors, suspended sediment tolerance, available carbon), the lack of source populations, and chemical habitat barriers (e.g., conductivity, temperature). We seek a research team to test the hypothesis that individual/species/community seeding/transplantation in urban/suburban restored streams (in which physical habitat conditions would predict them to occur) will result in benthic communities that are more similar to reference streams compared to control restored sites in which individuals/species/communities were not transplanted. As part of this effort, researchers may also choose to test the chemical habitat hypothesis.
2. Climate change impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, growing season will lengthen, and other processes related to the Chesapeake community’s approved set of BMPs will change. As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., need to evaluate high intensity storms of varied frequencies (vs 24-hour event, conveyance limitations, etc.).

Funders are looking for investigators to compare the modeled or measured outcomes of varied storm frequency and duration (and associated flood impacts, loading rates, and % loads reduced for TN, TP, TSS, etc.) of current stormwater BMPs to those of a new set of stormwater BMP design scenarios (e.g., evaluating water quality practices such as ESD implemented in a watershed where additional storage such as the 1 year 24-hour extended detention or peak management controls are provided). The ultimate use of this information would be to evaluate design criteria of these BMPs (new or retrofits) that achieves the most effective treatment and conveyance strategies when comparing varied rainfall design storm scenarios. The research will build on a project supported in this program titled, “Climate Impacts to Restoration Practices,” with the final report available at: <https://cbtrust.org/grants/restoration-research/> (in the table).

In addition, for stream restoration practices funders are looking for investigators to compare modeled or measured outcomes (e.g., criteria for site selection, design approach for habitat, or construction technique) of stream restoration practices under current conditions vs a new set of conditions (e.g., design element(s) improve habitat) to reduce the impacts of future climate change such as changing intensity duration frequency curves, frequency of storms, and/or periods of drought. Finally, a literature review that provides a synthesis of stream restoration siting criteria, design conditions, construction techniques/sequences, and/or other factors to manage for future climate impacts will be considered. The findings will support current stream restoration maintenance/upgrades and future stream restoration siting, designs, and/or construction practices.

1. Pollutants of Emerging Concern: Temperature; chloride; toxics, particularly polychlorinated biphenyls (PCBs) and fecal coliform bacteria, have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the restoration community to date. Questions within this area are:

* 1. Thermal – What best management practice design and siting methods will reduce thermal impacts to Maryland’s Use III and IV streams (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf))? Management practice design/strategy examples to test include various surface ponding and discharge structure configurations, variable media depths in filtering practices, and specific stream restoration design features and types such as legacy sediment removal, stage zero/emergent wetlands, and other management strategies.

Current state (Maryland) modeling efforts indicate that a reduction in heated surface runoff in addition to riparian forest buffers to provide shading are necessary to meet thermal water quality endpoints (68o F or 20o C for Use Class III streams). What is the cumulative impact of thermal mitigation practices in urban and rural watersheds? If possible, explain how practices were combined to reduce thermal impacts to streams.

1. Road salt can negatively influence the performance of stormwater BMPs (e.g., nutrient removal and surface water runoff retention). Road salt in BMPs can mobilize heavy metals and other pollutants adsorbed to the BMP’s organic sediments. How do different levels of salt present in a BMP due to road application impact the BMP’s nitrogen removal efficiency and export rates out of the BMP of pollutants such as heavy metals? Funders are interested in the **salt loading** and its impact to the BMP’s function (temporal and spatial) as well as the practice types that are less/more effective. Funders are not interested in testing stormwater management types or designs for salt removal.
2. PCBs – Many regional water bodies have PCB impairments. Some of these impairments result from *in situ* legacy sources and may naturally attenuate over time, while in other cases active sources of PCBs have been identified. The specific sources of PCBs are often unknown as are whether practices used to reduce nutrient loads can also reduce PCB loads.
	1. Are there significant differences in PCB loadings across different land use types, industry types, and eras of development?

Toxics (specifically PCBs ) –  Both "traditional" (e.g., Maryland Stormwater Design Manual Chapter 3 and 5 practices: <https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Pages/stormwater_design.aspx>) and innovative stormwater management techniques may reduce delivery of pollutants such as PCBs and other toxins to receiving waters.

* 1. What are the removal capabilities of different stormwater management designs on reducing toxic contaminant loads? We seek proposals that address either a) comparisons of traditional and innovative stormwater practices in this area (e.g., bioretention with traditional media vs. filters with variable media designs) or b) comparisons of effectiveness of different innovative techniques at reducing PCBs and other toxins.

**Impact of construction activities on natural resources**

1. Work in the wet vs work in the dry for stream restoration: When permitting stream restoration, most regulatory agencies require practitioners to divert water around the stream section to be restored. Such diversion can be costly and can prolong the projects and therefore construction disturbance, leaving some to hypothesize that the net sediment impact of diverting is no “better” than that of a quicker project done with the stream flowing.

Funders seek to ask: What is the difference in effects on water quality (turbidity) and total sediment load delivered downstream between stream restoration work “in the wet” (construction without diverting the stream) vs work “in the dry” (construction accomplished through diversion of the water flow) for streams that are larger than 1st order (e.g., streams that will use at least a 6 inch pump, estimated for base flow of 5.1 ft3 per second)? All aspects of work in the wet vs work in the dry that affect sediment input must be considered, including:

* 1. Installation of a diversion when working in the dry, which may release sediment for some period of time at some high concentration (e.g., greater than the water quality standard of 150 NTU) during the installation;
	2. Removal of the diversion, which may also release sediment; and
	3. Duration of construction (hypothesized to be shorter for work in the wet).

This work will build on a previous study of this question in smaller-scale streams funded through this program. Preliminary results can be found [here](https://www.dropbox.com/sh/cct0yn0sjrexllx/AAC4sYpySghAvav6Qt4sxK5na?dl=0&preview=5a_Comparison+of+Dry+vs+Wet+17.0605.pptx) and the final report is [here](https://cbtrust.org/wp-content/uploads/Straughan-Env_Biological-and-Sediment-Disturbance.pdf). The management and regulatory communities have reason to hypothesize that larger streams may present different scenarios than smaller streams.

You will be required to articulate potential covariates, such as restoration type, restoration size, project duration, sediment type, substrate type, slope, stream size, stream flow, land use, drainage area, area disturbed, and other factors. Your experimental design must include the replication needed for scientifically defensible results, and you must justify the number of replicates chosen. You are encouraged to perform a power analysis to ensure that your sample size is large enough to detect the hypothesized difference. Reviewers will be sensitive to the degree of replication proposed.

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected is often not the same as the units measured to report the restoration work (often, for example, pounds of nitrogen reduced).

The goal of this question is to encourage quantification, in some comparable metric, of the resources present prior to the activity compared to the resources available after restoration project installation, calculating net ecological impact after evaluation of individual functional components. Your project should explore the “positive” and “negative” impact for at least two resources using common metric(s) (e.g., vegetation biomass, pounds of pollutant reduced, a habitat metric) to determine the net change.

With certain kinds of restoration projects or practices, do the net benefits (nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (tree loss and resulting habitat loss, etc.)?

Include at least two resources for consideration, such as, but not limited to the following:

* Wetland trade-offs in stream restoration projects: Certain stream restoration practices can impact type and function of existing wetlands. Impacts can include changes to the wetland’s hydrology and plant community extent and distribution. What are the changes to the wetland community and does this result in a loss of wetland function compared to the benefit of the other elements of the restoration practice?
* Invasive species in stream restoration and tree planting projects: The act of restoration, in ecological terms, can be considered a disturbance. Colonization by invasive species following any disturbance is common and restoration practices are no different. In addition, managing invasives can be a costly component of post-project maintenance regimes. As a result, many in the practitioner community are looking for ways to implement restoration projects that result in less colonization by invasive species and to articulate whether an “acceptable” threshold for invasive species could be quantified and used as a management tool. Specifically, funders are looking for research comparing the value of different techniques in reducing invasive colonization in stream restoration and tree planting projects. Researchers choosing to address this question will be responsible for identifying or proposing one or more alternative methods, then testing them ideally with a paired BACI design (i.e., a suite of restoration projects in which traditional methods are used compared to a suite of restoration projects in which a new method to reduce invasive colonization is tested).
* Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation. What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice? Your effort should build on/compliment but not duplicate two projects on this topic funded in 2017; see past projects funded and final reports at [www.cbtrust.org/restorationresearch](http://www.cbtrust.org/restorationresearch).
* Construction impacts of stream restoration, consider both short- and long-term impacts: Some in the community are concerned that the act of project construction can have negative consequences on the resource(s). For example, construction equipment can compact soils, reducing infiltration and therefore water quality benefit. Certain alternative construction mechanisms may be available or adding a step of countering the soil compaction may help. Researchers choosing to address this question will be responsible for identifying or proposing alternative methods, then either modeling their effect on TN, TP, and TSS load reduction and/or habitat characteristics, or testing them empirically. In the alternative construction methods used to address this question, consider how the construction methods impact the construction time, restoration materials used, and cost.

# RFP Questions from FY 20

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. Keep - Watershed restoration assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). The following are related questions: What percentage of the impervious surface in a watershed must be treated with stormwater best management practices (BMPs) before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, environmental site design (ESD) practices, stormwater wetlands) influence that percentage?
2. Keep - Stormwater management assessment: What is the effectiveness of stormwater management practices (implemented, for example, at a level required under the latest stormwater management regulations) on stream channel protection? What percentage of a catchment needs to be treated with ESD practices to reduce water flow enough to protect stream channels? Does the location of ESD practices within the catchment make a difference in protecting the stream banks?

**Effectiveness of restoration practices at the project scale**

1. Take off - Comparisons of water quality impact among stream restoration techniques, approaches (functions sought to be restored), or site conditions. While many studies present data on a single restoration technique in a single set of conditions, and sometimes at a single site without the replication needed to identify trends, fewer studies compare restoration effectiveness across restoration approaches, across different restoration techniques, or across a range of site conditions. Here we ask: How does water quality impact (defined here as change in nutrient and sediment loads) compare among different restoration approaches or techniques and/or (depending on ability to replicate) across site conditions? The types of restoration approaches in which we are interested are those that aim for different function (e.g., degree of floodplain reconnection, frequency of inundation, bank stabilization, etc.). Those approaches can be accomplished with several techniques or a mixture of multiple techniques, including regenerative stormwater conveyance (RSC), natural channel design (NCD), and stream valley restoration/legacy sediment removal. The site condition factors in which we are interested include differences in land use, % impervious cover, watershed condition, soil type, valley type, and/or watershed position (headwaters vs. downstream near the receiving waters).
2. Keep - Biological Community Restoration: Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). The reasons are not yet clear, but two hypotheses are the lack of source populations and chemical habitat barriers (e.g., conductivity, temperature). We seek a research team to test the hypothesis that individual/species/community seeding/transplantation in urban/suburban restored streams (in which physical habitat conditions would predict them to occur) will result in benthic communities that are more similar to reference streams compared to control restored sites in which individuals/species/communities were not transplanted. As part of this effort, researchers may also choose to test the chemical habitat hypothesis.
3. Keep – refine based on TT results - Climate change impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, growing season will lengthen, and other processes related to the Chesapeake community’s approved set of BMPs will change. As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., need to evaluate high intensity storms of varied frequencies (vs 24 hour event) to determine the design storm event that will be most effective for future climate change impacts such as flooding, increased pollution loading rates, and conveyance limitations).

Funders are looking for investigators to compare the modeled or measured outcomes of varied storm frequency and duration (and associated flood impacts, loading rates, and % loads reduced for TN, TP, TSS, etc.) of current stormwater BMPs to those of a new set of stormwater BMP standards (e.g., larger practices, different siting of the same practices (moving them upstream or downstream)). The ultimate use of this information would be to evaluate design criteria of these BMPs for more effective practices using an updated design storm.

In addition, for stream restoration practices funders are looking for investigators to compare modeled or measured outcomes (e.g., criteria for site selection, design approach for stability, design approach for habitat, or construction technique) of stream restoration practices under current conditions vs a new set of conditions (e.g., design element(s) to improve stability and/or improve habitat) to reduce the impacts of future climate change such as changing intensity duration frequency curves, frequency of storms, and/or periods of drought. Finally, a literature review that provides a synthesis of stream restoration siting criteria, design conditions, construction techniques/sequences, and/or other factors to manage for future climate impacts will be considered. The findings will support current stream restoration maintenance/upgrades and future stream restoration siting, designs, and/or construction practices.

1. Keep-Pollutants of Emerging Concern: Temperature; chloride; toxics, particularly polychlorinated biphenyls (PCBs); and fecal coliform bacteria, have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the restoration community to date. Questions within this area are:

* 1. Keep & refine-Thermal – What best management practice design and siting methods will reduce thermal impacts to Maryland’s Use III and IV streams (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf))?
	2. Ongoing research covers this one and perhaps cycle back on when we get the results- Chloride (Salt) – Which techniques of salt application to roadways will result in less loading to streams? What source reduction practice(s) can be used to reduce salt loading to streams?
	3. Keep & refine-PCBs – Many regional water bodies have PCB impairments. Some of these impairments result from *in situ* legacy sources and may naturally attenuate over time, while in other cases active sources of PCBs have been identified. The specific sources of PCBs are often unknown as are whether practices used to reduce nutrient loads can also reduce PCB loads.
		1. Are there significant differences in PCB loadings across different land use types, industry types, and eras of development?

Toxics (specifically PCBs) and bacteria –  Both "traditional" (e.g., Maryland Stormwater Design Manual Chapter 3 and 5 practices: <https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Pages/stormwater_design.aspx>), and innovative stormwater management techniques may reduce delivery of pollutants such as PCBs, other toxins, and bacteria to receiving waters.

* + 1. What are the removal capabilities of different stormwater management designs on reducing toxic contaminant loads? We seek proposals that address either a) comparisons of traditional and innovative stormwater practices in this area (e.g., bioretention with traditional media vs. filters with variable media designs) or b) comparisons of effectiveness of different innovative techniques at reducing PCBs, other toxics, and/or bacteria loads. The project could be focused at the larger "receiving waters" scale or the individual practice scale, and researchers should consider storm flows and base flows.
1. Add to #10 - Invasive species: The act of restoration, in ecological terms, can be considered a disturbance. Colonization by invasive species following any disturbance is common and restoration practices are no different. In addition, managing invasives can be a costly component of post-project maintenance regimes. As a result, many in the practitioner community are looking for ways to implement restoration projects that result in less colonization by invasive species and to articulate whether an “acceptable” threshold for invasive species could be quantified and used as a management tool. Specifically, funders are looking for research comparing the value of different techniques in reducing invasive colonization in stream restoration and tree planting projects. Researchers choosing to address this question will be responsible for identifying or proposing one or more alternative methods, then testing them ideally with a paired BACI design (i.e., a suite of restoration projects in which traditional methods are used compared to a suite of restoration projects in which a new method to reduce invasive colonization is tested).

**Impact of construction activities on natural resources**

1. Add to #10 - Minimizing Short- and Long-term Impacts of Stream Restoration Construction: Some in the community are concerned that the act of project construction can have negative consequences on the resource(s). For example, construction equipment can compact soils, reducing infiltration and therefore water quality benefit. Certain alternative construction mechanisms may be available, or adding a step of countering the soil compaction may help. Researchers choosing to address this question will be responsible for identifying or proposing alternative methods, then either modeling their effect on TN, TP, and TSS load reduction and/or habitat characteristics, or testing them empirically. In the alternative construction methods used to address this question, consider how the construction methods impact the construction time, restoration materials used, and cost.
2. Keep - Work in the wet vs work in the dry for stream restoration: When permitting stream restoration, most regulatory agencies require practitioners to divert water around the stream section to be restored. Such diversion can be costly and can prolong the projects and therefore construction disturbance, leaving some to hypothesize that the net sediment impact of diverting is no “better” than that of a quicker project done with the stream flowing.

Funders seek to ask: What is the difference in effects on water quality (turbidity) and total sediment load delivered downstream between stream restoration work “in the wet” (construction without diverting the stream) vs work “in the dry” (construction accomplished through diversion of the water flow) for streams that are larger than 1st order (e.g., streams that will use at least a 6 inch pump, estimated for base flow of 5.1 ft3 per second)? All aspects of work in the wet vs work in the dry that affect sediment input must be considered, including:

1. Installation of a diversion when working in the dry, which may release sediment for some period of time at some high concentration (e.g., greater than the water quality standard of 150 NTU) during the installation;
2. Removal of the diversion, which may also release sediment; and
3. Duration of construction (hypothesized to be shorter for work in the wet).

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Keep and make specific for stream restoration function - Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected is often not the same as the units measured to report the restoration work (often pounds of nitrogen reduced).

With certain kinds of restoration projects or practices, do the net benefits (nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (tree loss and resulting habitat loss, etc.)?

Include at least two resources for consideration, such as, but not limited to the following:

* Wetland trade-offs in stream restoration projects: Certain stream restoration practices can impact type and function of existing wetlands. Impacts can include changes to the wetland’s hydrology and plant community extent and distribution. What are the changes to the wetland community and does this result in a loss of wetland function compared to the benefit of the other elements of the restoration practice?
* Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation. What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice? Your effort should build on/compliment but not duplicate two projects on this topic funded in 2017; see past projects funded at [www.cbtrust.org/restorationresearch](http://www.cbtrust.org/restorationresearch).

# RFP Questions from FY 19

**Effectiveness of stormwater and stream restoration programs at the watershed/catchment scale**

1. Watershed restoration assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). A related question: What percentage of the impervious surface in a watershed must be treated with best management practices (BMPs) before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, environmental site design (ESD) practices, and stormwater wetlands) influence that percentage? We recognize that this question is extensive and reviewers will accept proposals that address just one component of this research question.
2. Stormwater management assessment: What is the effectiveness of stormwater management practices (implemented, for example, at a level required under the latest stormwater management regulations) on stream channel protection? What percentage of a catchment needs to be treated with ESD practices to reduce water flow enough to protect stream channels? Does the location of ESD practices within the catchment make a difference in protecting the stream banks?
3. Level of monitoring effort: Monitoring can be costly and money spent on monitoring is by definition not spent on pollution reduction implementation. What degree of representative sampling is required to determine levels of pollutant discharge at a county scale? What sample size is needed to capture variability? What is the cost of such a monitoring program? Can a reduced monitoring regime, either in terms of number of sampling stations or parameters measured at a station, or a factor such as % impervious surface treated in the region be used as a proxy?

**Effectiveness of restoration practices at the project scale**

1. Comparisons of water quality impact among stream restoration techniques, approaches (functions sought to be restored), or site conditions. While many studies present data on a single restoration technique in a single set of conditions, few studies compare restoration effectiveness across restoration approaches, across different restoration techniques, or across a range of site conditions. Here we ask: How does water quality impact (defined here as change in nutrient and sediment loads) compare among different restoration approaches or techniques and/or (depending on ability to replicate) across site conditions? The types of restoration approaches in which we are interested are those that aim for different function (e.g., degree of floodplain reconnection, frequency of inundation, bank stabilization, etc.). Those approaches can be accomplished with several techniques or a mixture of multiple techniques, including regenerative stormwater conveyance (RSC), natural channel design (NCD), and stream valley restoration/legacy sediment removal). The site condition factors in which we are interested include differences in land use, % impervious cover, watershed condition, soil type, valley type, and/or watershed position (headwaters vs. downstream near the receiving waters).
2. Climate impacts to restoration practice: Climate change models predict that frequency and intensity of rain events will increase, that growing season will lengthen, and that other processes related to the Chesapeake community’s approved set of BMPs will change. As a result, some suggest that standards for stormwater practices, stream restoration, and other BMPs should change (e.g., plan to treat a two-inch rain event versus a one-inch rain event; design stream restoration practices for more frequent storms).
3. Emerging Pollutants: Temperature and salt have been identified as “emerging pollutants” of concern by the restoration community, beyond the “traditional” pollutants of nitrogen, phosphorus, and sediment that have been the focus of much of the restoration community to date. Questions within this area are:
	1. Thermal – What best management practice design and siting methods will reduce thermal impacts to streams in Maryland’s Use III and IV watersheds (see the [Maryland Stormwater Design Manual Section 4.1](https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/www.mde.state.md.us/assets/document/chapter4.pdf))?
	2. Salt – Which techniques of salt application to roadways will result in less loading to streams? Which BMPs can be used to reduce salt loading to streams?
4. Invasive species: The act of restoration, in ecological terms, can be considered a disturbance. Colonization by invasive species following any disturbance is common, and restoration practices are no different. In addition, managing invasives can be a costly component of post-project maintenance regimes. As a result, many in the practitioner community are looking for ways to implement restoration projects that result in less colonization by invasive species and if an “acceptable” threshold for invasive species could be quantified and used as a management tool. Specifically, funders are looking for research comparing the value of different techniques in reducing invasive colonization in stream restoration and tree planting projects.

**Impact of construction activities on natural resources**

1. Minimizing Short- and Long-term Impacts of Stream Restoration Construction: Some in the community are concerned that the act of project construction can have negative consequences on the resource(s). For example, construction equipment can compact soils, reducing infiltration and therefore water quality benefit. Certain alternative construction mechanisms may be available, or adding a step of countering the soil compaction may help. Researchers choosing to address this question will be responsible for identifying or proposing alternative methods, then either modeling their effect on TN, TP, and TSS load reduction and/or habitat characteristics, or testing them empirically. In the alternative construction methods used to address this question, consider how the construction methods impact the construction time, restoration materials used, and cost.
2. Work in the wet vs work in the dry for stream restoration: When permitting stream restoration, most regulatory agencies require practitioners to divert water around the stream section to be restored. Such diversion can be costly and can prolong the projects and therefore construction disturbance, leaving some to hypothesize that the net sediment impact of diverting is no “better” than that of a quicker project done with the stream flowing. Funders seek to ask: What is the difference in effects on water quality (turbidity) and total sediment load delivered downstream between stream restoration work “in the wet” (construction without diverting the stream) vs. work “in the dry” (construction accomplished through diversion of the water flow) for streams that are larger than 1st order (e.g., streams that will use at least a 6 inch pump, estimated for base flow of 5.1 ft3 per second)? All aspects of work in the wet vs work in the dry that affect sediment input must be considered, including:
3. Installation of a diversion when working in the dry, which may release sediment for some period of time at some high concentration (e.g., greater than the water quality standard of 150 NTU) during the installation;
4. Removal of the diversion, which may also release sediment; and
5. Duration of construction (hypothesized to be shorter for work in the wet).

This work will build on a previous study of this question in smaller-scale streams funded through this program. Preliminary results can be found [here](https://www.dropbox.com/sh/cct0yn0sjrexllx/AAC4sYpySghAvav6Qt4sxK5na?dl=0&preview=5a_Comparison+of+Dry+vs+Wet+17.0605.pptx). The management and regulatory communities have reason to hypothesize that larger streams may present different scenarios than smaller streams.

You will be required to articulate potential covariates, such as restoration type, restoration size, project duration, sediment type, substrate type, slope, stream size, stream flow, land use, drainage area, area disturbed, and other factors. Your experimental design must include the replication needed for scientifically defensible results, and you must justify the number of replicates chosen. You are encouraged to perform a power analysis to ensure that your sample size is large enough to detect the hypothesized difference. Reviewers will be sensitive to the degree of replication proposed.

**Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common “currency”**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired “restored” condition) that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account reductions of certain functions (e.g., removing trees to create a wetland). One difficulty is that the units of the resource negatively affected is often not the same as the units measured to report the restoration work (often pounds of nitrogen reduced).

The goal of this question is to encourage quantification, in some comparable metric, of the resources present prior to the activity compared to the resources available after restoration project installation, calculating net ecological impact after evaluation of individual functional components. Your project should explore the “positive” and “negative” impact for at least two resources using common metric(s) (e.g., vegetation biomass, pounds of pollutant reduced, a habitat metric) to determine the net change.

Research Question: With certain kinds of restoration projects or practices, do the net benefits (nutrients, sediment, habitat, hydrology, biological resources) outweigh the net impacts (persistent and excessive iron floc mats, tree loss and resulting habitat loss, etc.)?

Include at least two resources for consideration, such as, but not limited to the following:

* Wetland trade-offs in stream restoration projects: Certain stream restoration practices can impact type and function of existing wetlands. Impacts can include changes to the wetland’s hydrology and plant community extent and distribution.
	+ What are the changes to the wetland community and does this result in a loss of wetland function compared to the benefit of the other elements of the restoration practice?
* Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation.
	+ What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice?
* Iron presence in stream restoration projects: Iron can occur naturally in the soil and the groundwater. Some hypothesize that stream restoration practices can lead to precipitation of iron compounds. Iron can precipitate in the presence of oxygen which can be introduced when a stream restoration practice is installed where hydrology reconnection is accomplished. Ironstone, carbon, and other materials could be used in stream restoration projects and could add iron to the system and/or change the form of iron leading to impacts in the system. Iron flocculate or mats can reduce macroinvertebrates. Iron in streams could also have additional negative impacts such as impacts to percolation, heavy metal, aesthetics, etc.
	+ What stream restoration techniques are associated with increases in iron concentration in the surface water, groundwater, and/or sediment and what are the impacts of this increased iron?

This research should allow restoration practitioners and permitters to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in decision making.

# RFP Questions from FY 18

**Effectiveness of restoration programs at the watershed/catchment-scale**

1. Watershed restoration assessment: What are the cumulative effects of watershed restoration activities within a watershed? Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). A related question: What percentage of the impervious surface in a watershed must be treated with best management practices (BMPs) before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, environmental site design (ESD) practices, and stormwater wetlands) influence that percentage? We recognize that this question is extensive and reviewers will accept proposals that address a component of this research question.
2. Stormwater management assessment: What is the effectiveness of stormwater management practices (implemented, for example, at a level required under the latest stormwater management regulations) on stream channel protection? What percentage of a catchment needs to be treated with environmental site design (ESD) practices to reduce water flow enough to protect stream channels? Does the location of ESD practices within the catchment make a difference in protecting the stream banks?
3. Level of monitoring effort: Monitoring is expensive and money spent on monitoring is by definition not spent on pollution reduction implementation. What degree of representative sampling is required to determine levels of pollutant discharge at a county scale? What sample size is needed to capture variability? What is the cost of such a monitoring program? Can a reduced monitoring regime, either in terms of number of sampling stations or parameters measured at a station, or a factor such as % impervious surface treated in the region be used as a proxy?

**Effectiveness of restoration practices at the project scale**

1. Comparisons of water quality benefit among restoration techniques, approaches (functions sought to be restored), or site conditions. While many studies present data on a single restoration technique in a single set of conditions, few studies compare restoration effectiveness across restoration approaches, across different restoration techniques, or across a range of site conditions. Here we ask: How does water quality benefit (defined here as reduction in nutrient and sediment loads) compare among different restoration approaches or techniques and/or (depending on ability to replicate) across site conditions? The types of restoration approaches in which we are interested are those that aim for different function (e.g., degree of floodplain reconnection, frequency of inundation, bank stabilization, etc.). Those approaches can be accomplished with several techniques or a mixture of multiple techniques, including regenerative stormwater conveyance (RSC), natural channel design (NCD), and stream valley restoration/legacy sediment removal). The site condition factors in which we are interested include differences in land use, % impervious cover, watershed condition, valley type, and/or watershed position (headwaters vs. downstream near the receiving waters).
2. Stability of restoration practices. Research is needed to better understand why and when stream restoration practices “fail” in order to reduce “failures” and increase “successes.” We recognize that there is no standard definition of “failure,” definition of “stability,” or agreed upon tolerance for stream material movement within or from a project. The investigator will have to define those for the purposes of his/her study approach. In addition, we recognize that sometimes designs intentionally do not promote fixed banks, which can be either “good” or “bad.” Sometimes, features are designed to aggrade sediment, but rapid aggradation can prevent vegetation establishment and reduce “success” from a biological perspective, if not a physical one.
	1. What are the flow conditions under which different in-stream channel structures that are currently used in stream restoration projects (e.g., vanes, step pools, constructed riffles, large woody debris) or approaches (e.g., RSCs, NCDs, stream valley restorations/legacy sediment removal, or a combination of those techniques that aim for the same degree of floodplain reconnection) function and remain stable? What are the energy tolerances beyond which the structures or approaches begin to fail? Even if structures or approaches remain stable within the restoration project area, do they have negative impact (lead to degradation) on other reaches?
	2. How well can various modelling approaches (1D vs 2D) predict the structural “success” or “failure” for the various stream restoration techniques and structures? What variables must be included in the models to make accurate predictions for stream restoration “success” or “failure” at the site?

**Construction Techniques**

1. What is the difference in effects on water quality (turbidity), total sediment load delivered downstream, riparian habitat, and other biological effects between stream restoration work “in the wet” (construction without diverting the stream) vs. work “in the dry” (construction accomplished through diversion of the water flow)? All aspects of work in the wet vs work in the dry that affect sediment input must be considered, including:
	1. Installing a diversion when working in the dry, which may release sediment for some period of time at some high concentration (e.g., > than the water quality standard of 150 NTU) during the installation.
	2. Removing the diversion, which may also release sediment
	3. Duration of construction (hypothesized to be shorter for work in the wet)

**Trade-offs in resource improvements incurred by restoration practices and creating net ecological uplift**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, deeming the existing condition to be inferior to the desired “restored” condition that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition that may not take into account reductions of certain functions.

The goal of this question is to encourage quantification of the resources present prior to the activity compared to quantification of the resources available after an “intervention” or activity, calculating net ecological impact after evaluation of individual functional components. With certain kinds of restoration projects or practices, are we maximizing certain benefits (nutrients, sediment, habitat, hydrology, and biological resources) at the expense of other benefits in an unacceptable way? This research should allow restoration practitioners to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in their decision making.

1. Wetland trade-offs in stream restoration projects: Certain stream restoration practices can impact type and function of existing wetlands. Impacts can include changes to the wetland’s hydrology and plant community extent and distribution.
2. Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation.

# RFP Questions from FY 17

**Effectiveness of restoration programs at the watershed/catchment-scale**

1. Watershed restoration assessment:  What are the cumulative effects of watershed restoration activities within a watershed?  Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). A related question: What percentage of the impervious surface in a watershed must be treated with best management practices (BMPs) before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, environmental site design (ESD) practices, and stormwater wetlands) influence that percentage? We recognize that this question is extensive and reviewers will accept proposals that address a component of this research question.
2. Stormwater management assessment: What is the effectiveness of stormwater management practices (implemented, for example, at a level required under the latest stormwater management regulations) on stream channel protection? What percentage of a catchment needs to be treated with ESD practices to reduce water flow enough to protect stream channels? Does location of ESD practices within the catchment make a difference in protecting the stream banks?
3. Level of monitoring effort: Monitoring is expensive and money spent on monitoring is by definition not spent on pollution reduction implementation. What degree of representative sampling is required to determine levels of pollutant discharge at a county scale? What sample size is needed to capture variability? What is the cost of such a monitoring program? Can a reduced monitoring regime, either in terms of number of sampling stations or parameters measured at a station, or a factor such as % impervious surface treated in the region be used as a proxy?
4. ESD research for plant ground cover versus mulch and for compost amendments versus soil replacement: Local governments aim to implement ESD practices that require low maintenance and provide high water quality treatment. However, there are often high maintenance requirements for ESD practices. To reduce this maintenance burden for ESD practices: 1) Can plant ground cover be used in place of traditional mulch and achieve the desired water quality benefits (e.g., remove TN, TP, TSS, sediment, toxics and/or trap pollution)? and 2) For soils that infiltrate: a) Can compost amendments be used instead of soil replacement?; b) What is the optimal compost amount to use?; and c) What are the decision factors based on *in situ* soils?

**Effectiveness of restoration practices at the project scale**

1. Comparisons of water quality benefit across restoration technique or site condition. While many studies present data on a single restoration technique in a single set of conditions, few studies compare restoration effectiveness across restoration approaches or across a range of site conditions. Here we ask: How does water quality benefit (defined here as reduction in nutrient and sediment loads) compare across restoration approaches of different types and/or (depending on ability to replicate) across site conditions? The types of restoration approaches in which we are interested are those that aim for different function (e.g., floodplain reconnection, frequency of inundation, bank stabilization, etc.) or that use different techniques (e.g., regenerative stormwater conveyance (RSC), natural channel design (NCD), stream valley restoration/legacy sediment removal). The site condition factors in which we are interested include differences in land use, % impervious cover, watershed condition, valley type, and/or watershed position (headwaters vs. downstream near the receiving waters).
2. Stability of restoration practices. Research is needed to better understand why and when stream restoration practices “fail” in order to reduce “failures” and increase “successes.” (We recognize that there is no standard definition of “failure,” definition of “stability,” or agreed upon tolerance for movement of stream materials within or from a project.) What are the flow conditions under which different in-stream channel structures that are currently used in Maryland stream restoration projects (e.g., vanes, step pools, constructed riffles, large woody debris) or approaches (e.g., RSCs, NCDs, stream valley restorations/legacy sediment removal, or a combination of those techniques that aim for the same degree of floodplain reconnection) function and remain stable? What are the energy tolerances beyond which the structures or approaches begin to fail?
3. Water quality of an urban tree: Although there are several guidance documents and recommendations for urban tree benefits, the empirical data to determine the stormwater benefits of urban trees of a variety of species are needed in the Mid-Atlantic region. Projects will be expected to fully quantify the stormwater treatment value (volume, TN, TP, and TSS) for an urban tree or stand of trees, with tree species, tree size, tree age, and soil volume as factors. The stormwater treatment value derived from empirical data will be compared to modeled stormwater treatment value (e.g., iTree, Maryland Assessment Scenario Tool, etc.). This study can be a combination of literature review, empirical data collection, and models.

**Trade-offs in resource improvements incurred by restoration practices and creating net ecological uplift**

1. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site by definition implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be *improved.* However, a value judgment is placed on the existing condition, deeming the existing condition to be inferior to the desired “restored” condition that is often not based on quantification. In addition, there is an accompanying value judgment on the proposed resulting condition which may not take into account reductions of certain functions. Therefore, resource protection "officials," many of whom find themselves "stove piped" or in aquatic resource "silos" as to their particular responsibilities, find themselves having to make value judgments about the existing condition and what is in need of improvement.

The goal of this question is to encourage quantification of the resources present prior to the activity compared to quantification of the resources available after an “intervention” or activity, calculating net ecological impact after evaluation of individual functional components. With certain kinds of restoration projects or practices, are we maximizing certain benefits (nutrients, sediment, habitat, hydrology, and biological resources) at the expense of other benefits in an unacceptable way? This research should allow restoration practitioners to more accurately calculate the resource’s functional uplift at a particular site in order to optimize system functions in their decision making.

1. Tree trade-offs in stream restoration projects: Certain stream restoration practices by necessity can result in removal of trees: 1) trees may need to be removed on a short-term basis for construction site access; 2) trees may be removed for various methods of stream restoration in nontidal forested wetlands; 3) trees may be removed to accomplish legacy sediment removal in which the stream banks are forested; and 4) trees, even when remaining after restoration, may experience mortality due to changes in hydrology leading to higher water levels/inundation. What is the water quality and habitat cost of tree removal of certain practices compared to the benefit of the other elements of the restoration practice?
2. Wetland trade-offs in stream restoration projects: Certain stream restoration practices can impact type and function of existing wetlands. Impacts can include changes to the wetland’s hydrology and plant community extent and distribution. What are the wetland impact losses compared to the benefits of stream restoration?
3. Submerged Aquatic Vegetation (SAV) trade-offs in living shoreline projects: Living shoreline projects, by definition, require more cross-shore space than shoreline armor projects, given that the creation of a platform for intertidal wetland vegetation and potentially an associated sill, must extend either into the subtidal zone or into the riparian zone. Such extension means that existing condition in either neighboring zone will be replaced with emergent wetland. With the resurgence of SAV in the Chesapeake, more living shoreline locations will have SAV habitat. How does impacting SAV compare to the benefit of creating intertidal wetland? Under what conditions (e.g., SAV coverage in an embayment) is an SAV impact tolerable? In addition, research shows that the sill can indirectly cause SAV loss to a nearby bed due to the sediment dropping out channelward of the sill and covering the SAV. How can indirect impacts of the sill on SAV loss be better predicted?

# RFP Questions from FY 16

**Effectiveness at accomplishing water quality and habitat goals –** Watershed/catchment-scale effects of restoration practices

1. Watershed Restoration Assessment:  What are the cumulative effects of watershed restoration activities within a watershed?  Of interest in the restoration community is whether, given the high temporal and spatial variability of nutrient concentrations and flows, a signal from the restoration activities even in a highly targeted, small watershed can be measured relative to a control site (before vs. after restoration activities). A related question: What percentage of the impervious surface in a watershed must be treated with best management practices (BMPs) before a difference can be measured at the outfall? Does BMP type (e.g., stream restoration, environmental site design (ESD) practices, and stormwater wetlands) influence that percentage?
2. Stormwater Management Assessment: What is the effectiveness of stormwater management practices (implemented, for example, at a level required under the latest stormwater management regulations) on stream channel protection? What percentage of a catchment needs to be treated with ESD practices to reduce water flow enough to protect stream channels? Does location of ESD practices within the catchment make a difference in protecting the stream banks?
3. Monitoring is expensive and money spent on monitoring is by definition not spent on pollution reduction implementation. What degree of representative sampling is required to determine levels of pollutant discharge at a county scale? What sample size is needed to capture variability? What is the cost of such a monitoring program? Can a reduced monitoring regime, either in terms of number of sampling stations or parameters measured at a station or a factor such as % impervious surface treated in the region be used as a proxy?

**Effectiveness at accomplishing water quality and habitat goals –** Differences among stream restoration techniques

1. What is the impact on nutrient and sediment loads (flow and concentration) and/or habitat and biological factors of different stream restoration approaches that aim for different function (e.g., floodplain reconnection, frequency of inundation, bank stabilization, etc.) or that use different techniques (e.g., regenerative stormwater conveyance (RSC), natural channel design (NCD), stream valley restoration/legacy sediment removal), keeping site conditions constant?

**Effectiveness at accomplishing water quality and habitat goals –** Trade-offs and creating net ecological uplift

1. Trade-offs – Do different design approaches result in a net ecological benefit considering all resources potentially impacted (nutrients, sediment, habitat, hydrology, and biological resources) relative to pre-project conditions? To answer this question, trade-offs (reductions in functions vs. increases in functions) would be considered. Are we maximizing certain benefits at the expense of other benefits?

**Effectiveness at accomplishing water quality and habitat goals –** Effects of site condition on outcomes of stream restoration technique(s):

1. What is the impact of site condition (such as land use, % impervious cover, watershed condition, existing habitat, and/or valley type) and/or watershed position (headwaters vs. downstream near the receiving waters) on the nutrient, sediment, habitat, and/or biological impacts of stream restoration approaches that aim for different function (e.g., floodplain reconnection, frequency of inundation, bank stabilization, etc.) or that use different techniques (e.g., RSC, NCD, stream valley restoration/legacy sediment removal)?

**Iron precipitation**

1. Iron can occur naturally in the soil and the groundwater. Some hypothesize that restoration practices can lead to precipitation of iron compounds. What stream restoration techniques are associated with increases in iron concentration in the surface water or sediment and how long do any increases persist? What is the impact of the iron on biological resources? Does the iron originate from the materials brought on site for stream restoration or does the iron originate from natural sources?

**Stability of stream restoration practices and elements of practices**

1. How well can various modelling approaches predict the structural “success” or “failure” for the various stream restoration techniques and structures? What variables must be included in the models to make accurate predictions for stream restoration “success” or “failure” at the site?
2. What are the flow conditions under which different in-stream channel structures (e.g., vanes, step pools, constructed riffles, large woody debris) or approaches (e.g., RSC, NCD, stream valley restoration/legacy sediment removal) function and remain stable? What are the energy tolerances beyond which the structures or approaches begin to fail?

# RFP Questions from FY 15

**Effectiveness at accomplishing water quality and habitat goals**

Differences among restoration techniques

1. What is the impact on nutrient and sediment loads (flow and concentration) of different stream restoration techniques (e.g., regenerative stormwater conveyance, natural channel design, valley restoration/legacy removal, other), keeping site conditions constant?
2. What is the impact on habitat and biological factors of different stream restoration techniques (e.g., regenerative stormwater conveyance, natural channel design, valley restoration/legacy removal, other), keeping site conditions constant?
3. Considering impacts on nutrients, sediment, habitat, hydrology, and biological resources of both short-term construction activities and long-term project function: Do different design types result in a net ecological benefit relative to pre-project conditions? To answer this question, trade-offs (reductions in function vs. increases in functions) would be considered.

Effects of site condition on outcomes of a restoration technique(s):

1. What is the impact of land use on the nutrient, sediment, habitat, and/or biological impacts of a restoration practice of a particular type (e.g., regenerative stormwater conveyance, natural channel design, stream valley restoration/legacy removal, other)? How does site condition, such as the land use, watershed condition, and/or valley type, determine water quality, habitat, and/or biological benefit?
2. What are the water quality, habitat, and/or biological impacts of a particular project type (regenerative stormwater conveyance, natural channel design, valley restoration/legacy removal), installed in the watershed headwaters versus downstream near the receiving waters?

**Construction techniques**

1. What is the difference in effects on water quality (turbidity), riparian habitat, and other biological effects between stream restoration work “in the wet” (construction without diverting the stream) vs. work “in the dry” (construction accomplished through diversion of the water flow)? You will be required to articulate potential covariates, such as project duration, sediment type, slope, stream size, gradient, stream flow, restoration type, drainage area, and other factors.
2. Iron can occur naturally in the soil and the groundwater. What restoration techniques are associated with increases in iron concentration in the surface water or sediment and for how long do any increases persist? What is the impact of the iron on biological resources? Does the iron originate from the materials brought on site for restoration or does the iron originate from natural sources (e.g., materials brought to the site for restoration may add to the natural background levels, may exacerbate the iron concentrations that occur naturally, may oxidize the iron during construction activity, and/or other factors)?

**Stability**

1. What design and construction factors, such as construction material type, material size, and/or extent of keying a structure into the bank, are correlated with structural instability for certain site conditions, such as soil type, hydrology, slope, flow, vegetation, and/or contributing drainage area? *Note*: This question acknowledges that there is debate in the community about the definition of the term “stability” and acceptable levels of movement of stream materials.