Coordinating Water Quality Monitoring, Interpretation, and Funding to assess the Impacts of Agricultural Conservation Practices on Water Quality in the Chesapeake Bay Watershed

Executive Summary and Report

Prepared by the Natural Resources Conservation Service, U.S. Environmental Protection Agency, and U.S. Geological Survey Federal Water Quality Monitoring Team

December 22, 2021

Coordinating Water Quality Monitoring, Interpretation, and Funding to assess the Impacts of Agricultural Conservation Practices on Water Quality in the Chesapeake Bay Watershed

Executive Summary and Report

Prepared by the Natural Resources Conservation Service (NRCS)-U.S. Environmental Protection Agency (EPA)-U.S. Geological Survey (USGS) Federal Water Quality Monitoring Team

Executive Summary

In August 2020, NRCS and EPA launched three teams to continue and enhance communication and coordination of NRCS and EPA funding in the Chesapeake Bay watershed for agricultural conservation practice implementation and water quality monitoring: Agricultural Conservation Funding Team, Water Quality Monitoring Team, and Local Workshop Team.

This report summarizes the federal Water Quality Monitoring Team's activities and recommendations on how NRCS, EPA, and USGS could further coordinate water-quality monitoring, interpretation, and funding to assess the impact of agricultural conservation-practice implementation on the quality of local streams and rivers in the Chesapeake Watershed. The report identifies both near-term and longer-term recommendations to enhance coordination of water quality monitoring and interpretation, and engaging stakeholders to apply the results.

The Team conducted a review of programs pertaining to monitoring water quality of rivers and streams in the Chesapeake Bay Watershed; tools for consolidating water quality monitoring data for easy use by partners; data analysis and interpretation activities to link agricultural conservation practice implementation to trends in water quality in agricultural watersheds; and initiatives to measure the effectiveness of agricultural conservation practices.

Based on its review of current water-quality monitoring and analysis activities, the Team concluded that there are efforts underway to help address our objectives:

- There is a strong long-term effort in place to monitor nutrient and sediment loads and trends through the Chesapeake Bay Program (CBP) Non-Tidal Monitoring Network.
- There are additional monitoring programs conducted by EPA and jurisdictions to assess the conditions, and identify impairments, of local waterways.
- There are useful on-line tools that allow partners to further examine and use water quality monitoring data, including *How's my Waterway*, *Chesapeake Bay Watershed Data Dashboard*, and the *Story Map for the Nontidal Network*.
- There are long-term activities underway to evaluate the link between implementing agricultural conservation practices and the response of nutrients and sediment in the watershed and loads to the Bay. Some of the efforts include the NRCS Showcase Watersheds, National Water Quality Initiative, and USGS Chesapeake Bay Studies working with CBP data analysts.
- Efforts continue to refine estimates of how effective agricultural conservation practices are at reducing nutrients and sediment loadings from agricultural lands, including NRCS

Conservation Effects Assessment Project, USGS Chesapeake Bay Studies, Chesapeake Bay Program Best Management Practices expert panels.

A major challenge identified by the Team was the need for enhanced monitoring at finer scales to better connect implementation of management practices with water quality and sediment changes. Existing monitoring programs were designed to answer specific technical questions (across a range of spatial scales) that do not directly address water quality response to agricultural conservation practices.

The Team organized recommendations around three objectives, which include:
Objective 1: Identify watersheds with the greatest needs and opportunities for monitoring the impacts of conservation work on water quality of local streams and rivers.

- **Recommendation:** Develop criteria to identify watersheds that can show water-quality response to conservation practices. Criteria would consider watersheds with (1) existing long-term monitoring and (2) extensive implementation of conservation practices or a planned increase in practices.
- **Recommendation:** Identify watersheds in each state that meet the above criteria.

Objective 2: Identify opportunities to further coordinate federal and state water quality monitoring programs, and interpretation of results, to assess the impacts of agricultural conservation practices on the water quality in the Chesapeake Watershed.

- **Recommendation:** Evaluate data from current and past monitoring efforts in watersheds identified from objective 1. Determine if and how existing data can be utilized to assess water quality response to agricultural conservation practices.
- **Recommendation:** Summarize current interpretation efforts and how they align with watersheds identified in objective 1. Identify gaps between watersheds and interpretation efforts.
- **Recommendation:** Develop a coordinated, multi-partner effort to enhance long-term monitoring and interpretation. The resources needed for these efforts should be identified with options to fund the efforts.

Objective 3: Identify approaches to improve communication of findings, and engage policy makers and stakeholders, to inform implementation decisions.

- **Recommendation:** Take stock of existing information, how it is used to communicate findings to stakeholders, and what materials and/or engagement mechanisms are successful.
- **Recommendation:** Improve coordination between agencies to enable information sharing across different audiences/stakeholders such as NRCS Program Managers, Field Staff, Jurisdictions, and Producers.
- **Recommendation:** Develop new communication materials and engagement strategies based on recommendations above.

Section 1: Introduction

Background on Federal Coordination Teams

In August 2020, NRCS and EPA launched three teams to continue and enhance communication and coordination of NRCS and EPA funding in the Chesapeake Bay watershed for agricultural conservation practice implementation and water quality monitoring: Agricultural Conservation Funding Team, Water Quality Monitoring Team, and Local Workshop Team.

Federal Water Quality Monitoring Team

The purpose of the federal Water Quality Monitoring Team is to coordinate water quality monitoring and analysis activities to assess the impacts, and challenges, of voluntary agricultural conservation practices on the quality of local streams, rivers, and the Chesapeake Bay. Farmers in the Chesapeake Bay watershed have implemented extensive voluntary conservation measures that have reduced nutrient and sediment loadings to local waters and the Chesapeake Bay. Producers want to make sure that these conservation measures are working – not only for their business and farm efficiency, but also for improving the quality of local streams and the Chesapeake Bay. Likewise, federal and state agencies want to ensure their investments in conservation measures are helping to meet the Chesapeake Bay jurisdictions' agricultural nutrient and sediment reduction goals to restore the Chesapeake Bay.

Participants

NRCS: Kasey Taylor, State Conservationist (DE) (Co-Chair of Team); Stacey Bradshaw, Soil Conservationist (VA); Dr. Elliott Kellner, Chesapeake Bay NRCS Science Advisor (WV); Edwin Martinez-Martinez, State Conservationist (VA); EPA Region 3: Kelly Shenk, Agriculture Advisor (Co-Chair); Dr. Emily Trentacoste, Chesapeake Bay Program Office; Bill Richardson, Standards and TMDLs, Water Division; USGS: Scott Phillips, Chesapeake Bay Coordinator (Co-chair); Mark Nardi, MD-DE-DC Water Science Center, Ken Hyer, Associate Chesapeake Bay Coordinator.

Purpose of the Report

This report summarizes the federal Water Quality Monitoring Team's issues, objectives, outcomes, activities, and recommendations. This report provides recommendations on how NRCS, EPA, and USGS could further coordinate water quality monitoring, interpretation, and funding to assess the impact of agricultural conservation-practice implementation on the quality of local streams, rivers, and the tidal Chesapeake Bay. The report identifies both near-term and longer-term recommendations to enhance coordination of water quality monitoring and interpretation, and engaging stakeholders to apply the results.

Issues

The existing federal and state monitoring programs in the Bay watershed monitor nutrient and sediment across multiple sites in the Chesapeake watershed. However, most of the long-term monitoring has been developed to answer different technical questions and is frequently not designed to directly relate effects of conservation actions for reducing nutrient and sediment contributions to water quality conditions in streams and rivers. The CBP partners want to enhance monitoring and data interpretation to better understand the water quality response, and other ecosystem benefits, from agricultural conservation efforts. The information is critical since the Chesapeake jurisdictions are focusing most of their efforts over the next 5 years on employing agricultural practices to reduce nutrients and sediment delivered to the Chesapeake Bay to meet water quality standards.

Objectives The Team's objectives are:

- Objective 1: Identify watersheds with the greatest needs and opportunities for monitoring the impacts of conservation work on local streams and rivers.

- Objective 2: Identify opportunities to further coordinate federal and state water quality monitoring programs, and interpretation of results, to assess the impacts of agricultural conservation practices on water quality in the Chesapeake Bay Watershed.

- Objective 3: Identify approaches to improve communication of findings, and engage policy makers and stakeholders, to inform implementation decisions.

The Team carried out the following activities to address these objectives:

- **Provided summaries of monitoring and analysis activities** underway that could be used to assess the effects of agricultural conservation practices on the health of local streams and the Chesapeake Bay. The Team also learned about other monitoring efforts across the Nation, such as the Great Lakes, that could be adapted for use in the Chesapeake Bay watershed to fill any data gaps. (Section 2 of report and Appendix 1)

- **Identified data gaps and proposed recommendations for each objective** including enhancing long term federal and state water quality monitoring programs, and expanding interpretation of results, to assess the impacts, and challenges, of agricultural conservation practices on the water quality of the Chesapeake Bay Watershed. (Section 3 of report)

- **Prepared a concise executive summary of the report that includes recommendations** for how to address gaps in current monitoring and analyses to share with senior leadership of federal agencies involved in the effort. (Executive Summary)

Section 2: Synopsis of Activities Reviewed

The Team conducted a review of programs pertaining to monitoring water quality of groundwater, streams, and the Chesapeake Bay; tools for consolidating water quality monitoring data for easy use by partners; data analysis and interpretation activities to link agricultural conservation practice implementation to trends in water quality in agricultural watersheds; and initiatives to measure the effectiveness of agricultural conservation practices. This review allowed the Team to take stock of all activities underway, identify what is working well, and identify gaps to fill. A synopsis of monitoring and interpretation activities reviewed by the Team is in Attachment 1.

Findings: Based on its review of current water-quality monitoring and analysis activities, the Team concluded that there are efforts to help address our objectives:

- There is a strong effort in place to monitor nutrient and sediment loads and trends through the CBP Non-Tidal Monitoring Network.

- There are additional monitoring programs conducted by EPA and jurisdictions to assess the conditions, and identify impairments, of local waterways.
- There are useful on-line tools that allow partners to further examine and use water quality monitoring data, including *How's my Waterway*, *Chesapeake Bay Watershed Data Dashboard*, and the *Story Map for the Nontidal Network*.
- There are activities underway to evaluate the link between implementing agricultural conservation practices and the response of nutrients and sediment in the watershed and loads to the Bay. Some of the efforts include the NRCS Showcase Watersheds, National Water Quality Initiative, and USGS Chesapeake Bay Studies working with CBP data analysts.
- Efforts continue to refine estimates of how effective agricultural conservation practices are at reducing nutrients and sediment loadings from agricultural lands, including NRCS Conservation Effects Assessment Project, USGS Chesapeake Bay Studies, Chesapeake Bay Program Best Management Practices expert panels.

A major challenge identified by the Team was the need for enhanced monitoring at finer scales to better connect implementation of management practices with water quality and sediment changes in the Chesapeake Watershed. Existing monitoring programs were designed to answer specific technical questions (across a range of spatial scales) that do not directly address water quality response to agricultural conservation practices. Table 1 summarizes the scale and objective of existing monitoring activities and highlights the gap in monitoring at the small stream scale.

Table 1: Chesapeake Bay Monitoring Programs – Scale, Objective, and Quality

STUDY SCALE	**MONIOTING PROGRAM**	**OBJECTIVE**	**QUALITY OF CURRENT NETWORK**
Large Rivers (4th order and larger)	1) Nontidal Monitoring Network 2) State Monitoring Networks	1) Integrated trends in water quality across the Chesapeake watersheds 2) Identify impairments of water quality standards	1) Good (100+ station long-term monitoring network) 2) Good (Extensive statewide networks exist)
Streams (2-3rd order)	1) NRCS-USGS Showcase Watershed monitoring	1) Integrated changes of water quality in ag watersheds with substantial ag conservation practice implementation	1) Fair (Relatively few monitoring sites exist)
Small streams (zero-1st order)	1) None identified	1) Evaluate the effects of ag conservation practice	1) Poor (lack of monitoring)

		implementation and other landscape change	
Edge-of-field studies	1) USDA/NRCS Studies 2) University Research	1) Evaluating the efficacies of individual ag conservation practices	1) Fair (because none currently ongoing) 2) Fair (based on historical efforts)

The current monitoring in the Chesapeake Bay watershed does not focus on smaller order streams where changes from agricultural conservation practices are most likely to be detected. For example, lower order streams (i.e. 1st to 4th order) comprise approximately 97% of total stream length in the U.S. (Poff et al., 2006), but are rarely directly monitored by federal and state programs, which are often focused on larger riverine systems. Notably, lower order streams may be more sensitive to and reflective of land use impacts from contributing drainage areas (Ator et al., 2020), relative to larger streams/rivers that integrate mass and energy fluxes from a large diverse landscape (Fig. 1), and thereby complicate and confound efforts to identify mechanistic drivers of observed water quality regimes. Furthermore, although many state and federal water quality monitoring programs utilize opportunistic sampling schedules (e.g. monthly, seasonally) for limited study durations (e.g. 1-5 years), such approaches may be incapable of fully capturing the hydroclimatic and biogeochemical variability of hydrologic systems, and thus may introduce error into model predictions and estimates. Therefore, long-term comprehensive characterization of water quality regimes, and specifically the quantification of land use impacts on such regimes, requires monitoring across a range of relevant spatial and temporal scales (e.g. field-watershed and daily to decadal, respectively).

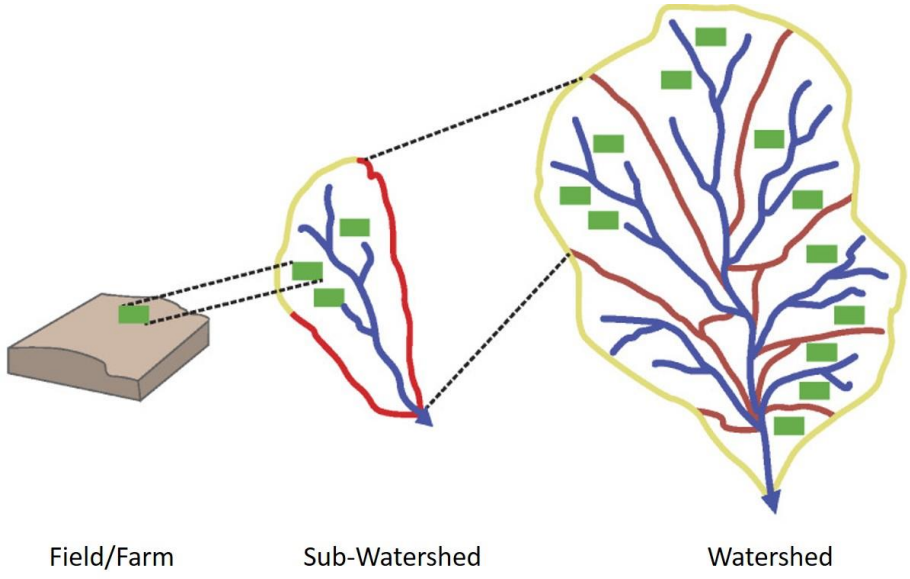

Figure 1. Diagram illustrating relevant scales for water quality monitoring (adapted from Golden and Hoghooghi, 2018).

Section 3: Information gaps and associated recommendations

The Team identified gaps and developed recommendations to improve efforts to address the three objectives, which are summarized in Table 2.

Table 2: Summary of Gaps and Recommendations for monitoring, interpretation, and communication	
Objective 1: Identify watersheds with the greatest needs and opportunities for monitoring the impacts of conservation work on water quality of local streams and rivers.	
Gaps	***Recommendations***
We do not have criteria to identify watersheds for enhanced monitoring to detect nutrient and sediment responses to agricultural conservation practices. Criteria need to consider the scales, both spatial and temporal, for monitoring to detect water quality changes due to agricultural practices. Criteria are also lacking to consider additional benefits to soil health, stream condition, and habitat.	Develop criteria to identify watersheds that can show water quality response to conservation practices. Criteria would consider watersheds with (1) existing long-term monitoring and (2) extensive implementation of conservation practices or a planned increase in practices. Describe the specific spatial scales for monitoring and associated frequency of data collection. Consider if other criteria should be developed for benefits to soil health, stream condition, and habitat.
We lack a list of watersheds that meet the criteria from the recommendation above.	Identify watersheds in each state that meet above criteria. Two types of watersheds would be identified by applying the above criteria: (1) those with existing long-term monitoring where conservation has been focused; and (2) watersheds with planned increases in conservation efforts where baseline and long-term monitoring can be established to assess water-quality and stream response.
Objective 2: Identify opportunities to further coordinate federal and state water quality monitoring programs, and interpretation of results, to assess the impacts of agricultural conservation practices on water quality in the Chesapeake Bay Watershed.	
Gaps	***Recommendations***
We need to evaluate how existing monitoring data could be used to assess water quality response to agricultural practices in the identified watersheds.	Evaluate data from current and past monitoring efforts in watersheds identified from objective 1. Determine if and how existing data can be utilized to assess water-quality response to agricultural conservation practices. Identify gaps between watersheds that are identified and current monitoring efforts.
We lack a summary of data-interpretation efforts that focus on water quality response in streams to implementation of agricultural conservation practices.	Summarize current interpretation efforts and how they align with watersheds identified in objective 1. Identify gaps between watersheds and interpretation efforts.

We lack a coordinated effort to further monitor, interpret, and produce findings about the relation between agricultural conservation practices and water quality response, and to other services (such as soil health, stream condition, and habitat)	Develop a coordinated, multi-partner long-term effort to enhance monitoring and interpretation. The resources needed for these efforts should be identified with options to fund the efforts. Funding options should include integrating existing programs and identifying funding gaps that need to be addressed.
Objective 3: Communicate findings, and engage policy makers and stakeholders, to inform implementation decisions	
Gaps	***Recommendations***
Existing findings about water quality response to conservation practices are not widely known to all stakeholders.	Take stock of existing information, how it is used to communicate findings to stakeholders, and what materials and/or engagement mechanisms are successful.
We lack a defined structure or mechanisms to coordinate efforts among agencies in engaging policy managers and stakeholders to apply findings.	Improve coordination between agencies to enable information sharing across different audiences/stakeholders such as NRCS Program Managers, Field Staff, Jurisdictions, and Producers.
We need to better understand and implement the most effective communication materials for different audiences.	Develop new communication materials and engagement strategies based on recommendations above.

Description of Recommendations.

Objective 1: Identify watersheds with the greatest needs and opportunities for monitoring the impacts of conservation work on local streams and rivers.

Recommendation: Develop criteria to identify watersheds that can show water quality response to conservation practices.

Criteria should be developed for identifying watersheds that have adequate information to show impacts of agricultural conservation practices on water quality. Based on previous efforts, the criteria may include: adequate existing or past water quality monitoring data that can serve as a baseline; a high density of voluntary conservation practices that aim to reduce nutrient and sediment loads; watersheds where there is a concerted focus by NRCS, States, and other conservation partners to accelerate implementation of priority conservation practices; watersheds that are dominated by agricultural land use or forested land use (i.e. control watersheds); and small watersheds draining 1st to 4th order streams.

The criteria should also consider the design for optimal monitoring to detect water quality response to conservation practices. One established design is paired watershed studies, having a "treatment" watershed (with increased conservation practices) and having "control" watershed (without an increase in implementation) to compare water quality responses. Another important

design consideration is scale-nested (e.g. farm-watershed scale; see Fig. 1) watershed studies, which can facilitate the isolation and quantification of water quality impacts from agricultural land use practices (Hubbart et al, 2019). Other watershed monitoring designs should be explored for developing criteria.

Finally, the criteria could include additional benefits from conservation efforts, such as improvements to stream condition and habitat. However, these additional benefits were not a focus of this report.

Recommendation: Identify watersheds in each state that meet above criteria.

To better characterize water quality responses to agricultural conservation practice implementation, a limited number of agricultural basins will be selected for enhanced long-term monitoring. These enhanced monitoring efforts will be conducted in small agricultural watersheds with (1) substantial existing implementation and monitoring, as well as (2) some smaller agricultural watersheds with substantial planned conservation implementation. Implementation efforts will include a broad range of voluntary conservation efforts, which may include both NRCS and other partner implementation activities.

To most directly characterize the water quality responses to implementation activities, the watersheds considered for this effort should include zero to first-order agricultural watersheds that are free of mixed land uses, as well as other planned major land-use changes. At these smaller scales, advanced monitoring systems that include continuous monitoring and automated samplers will be needed to perform the detailed monitoring required. Newer analytical tools may be needed to analyze the continuous timeseries data and to more directly link water quality response to implementation efforts. We will also need to consider timescales of response in these small watersheds, as local land use, hydrology, and geology may affect how rapidly these systems respond to conservation practice implementation.

Some existing watersheds that should be considered include the NRCS Showcase watersheds (Smith Creek, VA; Upper Chester, MD; and Conawego Creek, PA) which were established in 2010. NRCS has worked with producers to increase practices in these watersheds. USGS established monitoring of baseline conditions; and has continued monitoring in these watersheds over the past decade, to assess water-quality changes to agricultural practices. Also, existing paired watershed studies and those with a next scale-approach (described in previous recommendation) would be valuable to consider.

Objective 2: Identify opportunities to further coordinate federal and state water quality monitoring programs, and interpretation of results, to assess the impacts of agricultural conservation practices water quality Chesapeake Bay Watershed.

Recommendation: Evaluate data from current and past monitoring efforts in watersheds identified from objective 1.

In those identified watersheds, summarize current/ongoing and past water quality monitoring efforts and assess if data from these efforts could be utilized to connect agricultural conservation

efforts to water quality response. Thousands of water quality data points have been collected over the last decade for different purposes throughout the watershed, many of which may have been collected in the watersheds identified for this effort. These data have likely been collected using different methods and strategies depending on the original purpose (e.g. one-time grab samples or short-term sequential monitoring). It is currently unknown if these data could be useful for analyzing the connection between conservation practices and water quality response in chosen watersheds, such as establishing baseline conditions. Data considered should include monitoring conducted by citizen-science or non-traditional partners that is of known quality. This recommendation will determine what monitoring data are available in the watersheds identified in Objective 1, describe how those data may or may not be used for analysis, and determine if there are additional monitoring gaps to fill.

Recommendation: Summarize current interpretation efforts and how they align with watersheds identified in objective 1.

Develop summaries of findings from recent interpretation efforts. Identify primary gaps and questions that need to be addressed. Evaluate current studies that link agricultural conservation to water quality response, and any existing summaries of lessons learned on the topic.

Recommendation: Develop a coordinated, multi-partner effort to enhance monitoring and interpretation, including options for funding efforts.

Expand water quality monitoring in agricultural watersheds identified in objective 1 to fill gaps in order to measure the impact of agricultural conservation practices on local water quality. Future monitoring programs should include small watersheds draining 1st to 4th order streams, to more effectively characterize the water quality effects of specific agricultural practices. Continuous, automated hydrologic monitoring should be coupled to regular (weekly, monthly) stream sample collection to capture hydrologic and biogeochemical variability and comprehensively characterize the associated water quality regime.

The resources needed for these efforts should be identified with options to fund the efforts. Funding options should include integrating existing programs and identifying funding gaps that need to be addressed.

Objective 3: Communicate findings, and engage policy makers and stakeholders, to inform implementation decisions

Recommendation: Take stock of existing information and how it is used to communicate findings to users.

Identify the existing stakeholder engagement mechanisms, channels and materials used to deliver information on the connection between agricultural conservation practices and water quality. EPA, NRCS and USGS undertake efforts to engage with stakeholders to discuss impacts of agricultural conservation measures on water quality. However, this information does not always reach the appropriate stakeholders, and many stakeholders whose participation is necessary to implement agricultural conservation practices are not aware of the information or results. This could be due to the channels through which the information is being delivered or due to the mechanism and materials used to deliver the information. This recommendation would involve summarizing the type of information that is currently delivered to

stakeholders by EPA, NRCS, and USGS, who those stakeholders are, the channels and/or mechanisms used for engagement, and the materials and tools used to deliver information. Once this information is known, it is recommended to assess which engagement mechanisms have been successful, and which have not.

Recommendation: Improve coordination between agencies to enable information sharing across different audiences/stakeholders such as NRCS Program Managers, Field Staff, Jurisdictions, and Producers.

Currently, our agencies utilize different channels to engage key audiences on agricultural conservation practices and water quality. The purpose of this recommendation is to better understand collectively the different channels used, improve coordination between agencies, and integrate information being brought to these audiences. Develop improved approaches to communicate findings and engage key audiences: NRCS Program Managers, Field Staff, Jurisdictions, and Producers. Federal Coordination could include:

- Leadership Meetings: Hold quarterly federal coordination meetings with USGS, EPA, NRCS Regional Conservationists, and the six State Conservationists in the Chesapeake Bay watershed.
- Technical Meetings: Present water quality monitoring and analysis findings at NRCS Local Working Groups so they can help inform funding decisions for the following fiscal year.
- Have the meetings result in action-orienented items for stakeholders to consider. Some of the actions will involve federal partners but other stakeholders may be better suited to take messages/actions forward to local stakeholders. An example is to use conservation districts to communicate items. Also consider NGOs, states, private entities, and networks of ChesapeakeBay funders as other examples to communicate actions.
- Future efforts to collect, analyze, interpret, and disseminate relevant water quality information should strengthen and leverage partnerships between federal agencies and land grant universities. For example, research centers and cooperative extension units are uniquely capable of generating and delivering the type of data currently needed via existing/planned field research infrastructures and partnership networks in local communities. Furthermore, research centers and cooperative extension units can engage in activities considered outside the scope of federal agency charters (e.g. outreach/advocacy, pursuit of additional funding sources).

Recommendation: Develop new communication materials and engagement strategies based on recommendations above.

The two recommendations in Objective 3 above will result in a bettter understanding of the audiences that need to be engaged around agricultural conservation and water quality, which agencies are engaging with them, the type of information currently being shared, and which engagement and delivery mechanisms and materials have been most successful. This will also identify primary gaps and questions that need to be addressed in delivering information to stakeholders. The findings from the previous two recommendations would be used to identify new materials (e.g. summaries, presentations, tools, etc.) that should be generated for successful engagement with stakeholders. These materials should build off or utilize existing work, should be developed from a user-centered perspective, and should be targeted to the audiences. The audiences for which materials may need to be developed will be identified in the recommendations above, but could include: NRCS Program Managers, Field Staff, and Producers**.**

References

Ator, S. W., Blomquist, J. D., Webber, J. S., & Chanat, J. G. (2020). Factors driving nutrient trends in streams of the Chesapeake Bay watershed. Journal of Environmental Quality, 49(4), 812-834.

Golden, H. E., & Hoghooghi, N. (2018). Green infrastructure and its catchment-scale effects: an emerging science. *Wiley Interdisciplinary Reviews: Water*, *5*(1), e1254.

Hubbart, J. A., Kellner, E., & Zeiger, S. J. (2019). A case-study application of the experimental watershed study design to advance adaptive management of contemporary watersheds. *Water*, *11*(11), 2355.

Poff, N. L., Bledsoe, B. P., & Cuhaciyan, C. O. (2006). Hydrologic variation with land use across the contiguous United States: geomorphic and ecological consequences for stream ecosystems. Geomorphology, 79(3), 264-285.

Attachment 1: Synthesis of Water Quality Monitoring and Interpretation Activities Reviewed by the Federal Water Quality Monitoring Team

1. **Water Quality Monitoring**: The Water Quality Monitoring Team reviewed water quality monitoring efforts in the Chesapeake Bay watershed such as the Chesapeake Bay Non-Tidal Monitoring Network, USGS Chesapeake Bay Studies, and the Chesapeake Monitoring Cooperative for citizen monitoring. The following is a summary of those programs.

- **Chesapeake Bay Non-Tidal Monitoring Network**: Changes in nitrogen, phosphorus, and suspended-sediment loads have been calculated by the U.S. Geological Survey (USGS) using monitoring data from the observing stations. Constituent loads are calculated with at least 5 years of monitoring data, and trends are reported after at least 10 years of data collection. The NTN comprises 123 monitoring stations throughout the Chesapeake Bay watershed where nutrients and sediment are collected monthly and during storms. The network is a cooperative effort by USGS, the U.S. Environmental Protection Agency (USEPA), and agencies in the states of the Chesapeake watershed and the District of Columbia. https://va.water.usgs.gov/storymap/NTN/

  Links: Overview of Chesapeake Nontidal Monitoring and Mapper
  https://va.water.usgs.gov/storymap/NTN/
  USGS Nutrient and Sediment Trends in Chesapeake Bay Watershed
  https://www.usgs.gov/centers/cba/science/usgs-updates-trends-nutrients-and-sediment-chesapeake-bay-watershed?qt-science_center_objects=0#qt-science_center_objects

- **USGS Chesapeake Bay Studies**: The USGS is involved in numerous water quality studies across the spectrums of spatial, temporal, and landscape scales. The major program is the USGS Chesapeake Bay Studies. The U.S. Geological Survey (USGS) has the critical role of providing scientific information to improve the understanding, and inform restoration of the Chesapeake ecosystem, the Nation's largest estuary. The USGS works with Federal, State, and academic science partners to provide research, monitoring, forecasting, and interacts with stakeholders to apply findings to enhance restoration and conservation for the Chesapeake and other National ecosystems. The USGS Chesapeake Science Plan has four themes:
  1) Theme 1: Provide an integrated understanding of the factors affecting stream health, fish habitat, and aquatic conditions.
  2) Theme 2: Assess the risks to coastal habitats, DOI lands, and migratory waterbirds.
  3) Theme 3: Characterize past, present, and future changes in landscape characteristics to assess the health, vulnerability, and resiliency of vital lands, habitats, and watersheds.
  4) Theme 4: Integrate science and inform stakeholders.

  Below is a list highlighting a few studies apropos to the Water Quality Monitoring Team and the Chesapeake Bay region.

- Water Science Center Projects – Many Water Science Centers have cooperative projects designed to observe and model water quality. One such is the Pennsylvania Water Science Center's Chiques Creek project. The project is a cooperative effort between NRCS and the USGS that implements in-stream monitoring to evaluate water-quality changes, for instance changes in suspended sediment and nutrient loads, resulting from stream restoration efforts being completed to reduce flood damage under a NRCS Watershed Flood Prevention and Operations Program (PL-566) project.
- Cover Crops – This project is being done in cooperation with Federal and State agencies and uses time series satellite imagery to observe cover crop implementation.
- Stream gaging network – gaging stations supported by local, state, and federal funds. All stream gages typically capture flow (or at least water surface elevation) with many also outfitted with real time water quality instruments.
- Groundwater networks – groundwater networks are supported by local, state, and federal funds. The water levels in most wells are measured on a regular basis with some capturing continuous water levels and water quality instruments.

- **Chesapeake Monitoring Cooperative:** The Chesapeake Monitoring Cooperative coordinates citizen monitoring efforts around the Chesapeake Bay watershed, consolidates data, and makes data from these groups available. This cooperative is funded by EPA and run by Chesapeake Bay partners including Alliance for the Chesapeake Bay, Izaak Walton League, ALLARM and UMCES. Data collected by CMC citizen groups is organized into 3 data quality tiers so all data are of known quality and can be used for different purposes.

  EPA is currently working with the cooperative to identify opportunities for the citizen monitoring groups to fill in data gaps in water quality monitoring. The Cooperative is currently focused on expanding stream benthic macroinvertebrate monitoring to assess stream health in more areas of the watershed. This involves identifying priority geographic areas, developing regionally consistent protocols, and training groups.

  The Cooperative is currently working with the National Fish and Wildlife Foundation (NFWF) to develop strategies and protocols for pre- and post-monitoring to assess the water quality changes due to NFWF projects in the Chesapeake Bay watershed.

  Opportunities identified for using this information to support the Team's objectives are:
  - Upload citizen monitoring water quality data to the WQ Portal.
  - Find opportunities to use citizen monitoring to fill data gaps in priority ag watersheds where we are trying to make a direct connection between ag practice implementation and improvements to water quality.
  - Find opportunities where citizen monitoring can conduct pre- and post-monitoring of ag conservation practice implementation in priority agricultural watersheds (NFWF projects for example).
  - USGS CBPO monitoring team could develop status reports from citizen monitoring.

Link: https://www.chesapeakemonitoringcoop.org/

2. **Tools for Compiling WQ Monitoring Data**: The Team reviewed two web-based databases that compile water quality monitoring data and other relevant information in a user-friendly platform for partners to easily access.

- **How's My Waterway:** How's My Waterway is a web-based tool that was designed to provide the general public with information about the condition of their local waters based on water quality monitoring and assessment data that states, federal, tribal, local agencies and others have provided to EPA. Water quality information is displayed on three scales in How's My Waterway; community, state and national. How's My Waterway is an easy to use mapping application that provides information on state 303(d) lists and TMDLs. Data from How's My Waterway can be incorporated via web services to other applications. Information available in How's My Waterway:

  Community:
  - Water quality in your local watershed.
  - Information on swimming, eating fish and aquatic life.
  - Restoration and protection efforts.
  - Permitted discharger information.
  - Identified Issues (impairments and discharge violations).
  - Local drinking water information.
  - Water monitoring information.

  State:
  - Information about a state's water program.
  - Summaries of specific water assessments.
  - A state-wide survey of water quality where available.
  - State drinking water metrics.

  National:
  - The quality of water resources nationwide and their main challenges.
  - National drinking water information and metrics.

  Link: https://www.epa.gov/waterdata/hows-my-waterway

- **Chesapeake Bay Watershed Data Dashboard:** An online tool that provides accessible and understandable data and scientific information to help guide water quality and watershed restoration planning efforts. It is meant to assist those who plan restoration projects at the regional or local level by providing a holistic view of the watershed in a visually appealing, easily understandable manner.

  Chesapeake Bay Program partners requested a way to access technical information to use in the development and implementation of Watershed Implementation Plans. They

wanted a single location in which to access data and information, as planners must currently pull datasets from multiple sources.

The Data Dashboard serves as a public-facing easy-to-use tool through which monitoring data can be made available and integrated with other data and information.

Staff at the EPA Chesapeake Bay Program Office carried out user research and workshops with partners at federal, state and local levels to understand:

- What sort of information partners found to be important during their planning efforts.
- What information the scientific community deemed essential to consider during the planning process.
- The order in which planners looked for certain types of information during their process.
- The way in which planners organized information during their process.

The dashboard provides consolidated visual data to help users:

- Understand local water quality and the conditions of living resources—plants, animals, habitats and ecosystems—and how they've changed over time.
- Understand sources of pollution and drivers of local water quality.
- Identify effective and affordable management practices.
- Identify opportunities for implementing management practices on the landscape.
- Plan for future change, such as urban growth and climate change.

The information on the dashboard can be used to

- Target restoration efforts by location, sector or practice.
- Develop scenarios to run on the Chesapeake Assessment Scenario Tool (CAST).
- Develop outreach materials and communicating watershed information.
- Build local stories to engage with stakeholders.

Link: https://gis.chesapeakebay.net/wip/dashboard

3. **Analyses and Interpretation of Water Quality Monitoring Data:** The Team reviewed data analysis and interpretation initiatives underway that aim to evaluate the effect of agricultural conservation practice implementation on water quality in priority agricultural watersheds. They reviewed initiatives such as the National Water Quality Initiative, the Showcase Watersheds initiative, and additional USGS projects.

- **NWQI – National Water Quality Initiative**

National Water Quality Initiative is a partnership among NRCS, state water quality agencies and the U.S. Environmental Protection Agency to identify and address impaired water bodies through voluntary conservation. NRCS provides targeted funding for financial and technical assistance in small watersheds most in need and where farmers can use conservation practices to make a difference.

Conservation systems include practices that promote soil health, reduce erosion and lessen nutrient runoff, such as filter strips, cover crops, reduced tillage and manure management. These practices not only benefit natural resources but enhance agricultural productivity and profitability by improving soil health and optimizing the use of agricultural inputs.

State water quality agencies and other partners contribute additional resources for watershed planning, implementation and outreach. They also provide resources for monitoring efforts that help track water quality improvements over time.

- **Showcase Watershed Initiative:** This project, funded by USGS Chesapeake Bay Studies, is using USDA NRCS conservation practice implementation data coupled with environmental data sources to explain factors and changes in stream health, fish habitats, and aquatic conditions. The project is identifying spatiotemporal water-quality response patterns in the four showcase watersheds (Smith Creek, VA; Upper Chester, MD; Conewago Creek, PA; and Difficult Run, VA). Both discrete and real-time water quality monitoring data collected between 2011 – 2019 are used. In addition, the Weighted Regression Time, Discharge, and Season (WRTDS) is being calculated to assess a flow normalized load. This load is being compared with the patterns of BMP implementation over time, which allows evaluation of the where practices have maximum effectiveness. Early results from identifying spatiotemporal water-quality response patterns in the four showcase watersheds indicate that conservation practices are impacting water quality response as well as climatic changes.

- **USGS 1619-Protected Conservation Practice (BMP) Data and Analysis**
    - The USGS and NRCS renewed a Memorandum of Understanding (MOU) on December 10, 2020 to continue the existing cooperation between USGS and NRCS for the evaluation of conservation practices and systems for improving water quality throughout the Chesapeake Bay watershed. The renewed MOU is for five years. The first MOU was established in 2010 and renewed in 2015.
    - State Support - The USGS acquires NRCS data, runs QA/QC routines, and aggregates to protect producer privacy. The data are then provided to the states to inform practice implementation tracking and other state agricultural sector programmatic evaluation and support. The work includes a feedback loop to USDA's Farm Production and Conservation Business Center to improve original USDA data.
    - Pennsylvania Practice Keeper – Funded by the US EPA, begun in FY20, the Chesapeake Bay Program (CBP), through a federal-state partnership, is striving to improve the reporting of practices designed and implemented to reduce nutrients and sediment from agricultural activities in the Chesapeake Bay watershed. The data that track practices are typically maintained in different databases at different levels of federal, state, and local government. Combining datasets on agricultural conservation practices from the U.S. Department of Agriculture (USDA) and state databases could result in double-counting of practices. To avoid duplicate reporting, the Commonwealth of Pennsylvania currently excludes a subset of data from the USDA databases when developing its set of implemented conservation

practices to report to the Chesapeake Bay Program Office (CBPO) each year. The USDA and the Commonwealth of Pennsylvania are concerned that not all state and federal practices are being reported to CBPO. This project is analyzing a portion of Pennsylvania data to assess the degree of difference, duplication or omission across datasets.

- Conservation Practice Data as Explanatory Variables in PES Projects – USGS Chesapeake Bay Science projects are using conservation practice data as explanatory variables in analysis. Once example is the Showcase Watersheds work. Another study is using the conservation practice data to help determine the consequences of land management actions on the primary drivers of contaminant mixtures in five agricultural watersheds in the Chesapeake Bay, where fish health issues have been documented for two decades. The study found that land-use and other landscape variables were adequate predictors of concentrations and these concentrations were lower in watersheds with a greater intensity of BMPs in their upstream catchments.
- Conservation Practice Targeting maps – One of the projects that NRCS may find most interesting is a FY21 USGS production of conservation practice targeting maps for the Bay watershed. The USGS will create maps to help prioritize BMP implementations through integration of monitoring, modeling, and BMP data. This will allow assessment of conservation practice impacts of in areas where other models and monitoring data have indicated high nutrient and sediment loading. The work will also identify locations that have low loads and a high concentration of BMPs, which may indicate the practices were effective. This information can help identify cost savings opportunities.

- **Sharing Results of Analysis and Interpretation:** The following offer good venues for federal partners to share the results of their water quality monitoring data analysis and interpretation:
  - NRCS Local Work Groups – USGS and others can share latest on local water quality data findings at NRCS local workgroups. The local work groups are composed of a diverse group of people with agricultural and natural resource interests. Members may be agricultural producers representing the variety of crops and livestock raised within the local area; owners of nonindustrial private forest land; representatives of agricultural and environmental organizations; and representatives of governmental agencies carrying out agricultural and natural resource conservation programs and activities for the area.
  - State Technical Advisory Committee meetings - The State Technical Committee provides recommendations for establishing technical guidelines and program criteria and priorities necessary to carry out conservation provisions of the Farm Bill. The State Technical Committee may advise the NRCS state conservationist on many issues. Examples include:
    - State program management policies and procedures
    - State program management policies and procedures Technical programmatic recommendations
    - Statewide public information and outreach campaigns

- Identifying significant statewide natural resource concerns
- Guidelines for developing ranking criteria for evaluating applications
- Guidance on eligible conservation practices
- Technical guidance on conservation practices, including new, innovative practices
- Cost-share rates and incentive payment limits and methods of payment
- Identifying, monitoring, and analyzing performance indicators
- Evaluating and reporting program impacts on natural resources and the environment
- Coordinating with other federal, state, tribal, and local public and private activities

4. **Agricultural Conservation Practice Effectiveness Studies**: The Team evaluated initiatives designed to assess the effectiveness of agricultural conservation practices in reducing nutrient and sediment loadings.

- **CEAP – Conservation Effects Assessment Project**: USDA's NRCS and ARS (Agricultural Research Service) use CEAP (Conservation Effects Assessment Project) to assess and quantify the environmental benefits from using conservation practices in cultivated cropland. The goal of the CEAP-Cropland Component is to report conservation effects in terms that represent recognizable outcomes, such as cleaner water and soil quality enhancements that will result in more sustainable and profitable production over time. The CEAP model can be used to assist states in the ranking process for programs as well as targeting resource concerns.
  - Integrates Natural Resources Inventory, geospatial data, conservation practice implementation data and monitoring to obtain resource assessments
  - Creates partnerships with federal, state, local agencies/universities
  - Carried out at landscape level (field/watershed)
  - Evaluates cumulative effects and benefits of conservation practices on natural resources and the environment

  A useful tool is the CEAP-SVI (Conservation Effects Assessment Project Soil Vulnerability Index). This web-based tool assists field staff with conservation planning by highlighting the portion of the field where issues related to surface run-off and leaching could possibly occur or are evident.

- **USGS BMP SPARROW** – The goal of this project is to use high-quality spatially explicit BMP implementation data in an existing modeling framework to: 1) quantify effects of BMPs on nutrient loads from agricultural sources to local surface waters and delivered to the estuary and 2) develop empirical estimates of the effectiveness of specific agricultural BMP categories. Models can improve assessment of progress and establish realistic targets for reductions. Work to date shows a signal in water quality observations of the effect of BMPs on nitrogen delivery to streams.

- **USGS Cover Crop Health** – This project explains patterns in agricultural conservation practices and cropping lifecycles. Using cutting-edge analysis of satellite data and models, USGS provides producers and other stakeholders a connection between field level management decisions and regional water quality.

- **Chesapeake Bay Program BMP Panels** – The Chesapeake Bay Program's Agriculture Workgroup continues to convene Best Management Practice (BMP) Panels to evaluate latest research to develop and update BMP nutrient and sediment reduction efficiencies for specific agricultural conservation practices to use in modeling the estimated nutrient and sediment reduction from agricultural conservation practice implementation in the Chesapeake Bay watershed.

- **Discovery Farms** – There may be opportunities to use "Discovery Farms" for further evaluations of the water quality outcomes of agricultural conservation practices, as is being done in the Great Lakes basin. For the last few years, a group of West Virginia University faculty and NRCS-WV staff have been working toward just such a goal in the eastern panhandle of West Virginia. WVU currently has an experimental farm in the Bay Watershed, where the Institute of Water Security and Science has established an experimental hydrologic monitoring program that is specifically designed to answer questions regarding the water quality effects of agricultural conservation practices at field to sub-watershed scales.
    - Plant Materials Center (PMC) - The mission of the Plant Materials Program is to develop plants and plant technology to solve conservation needs. Technical information is passed to NRCS field staff to better assist landowners on working farms and ranches. A key focus area for the PMC is the protection and enhancement of water quality.

- **Monitoring Dynamic Soil Properties –** The goal of this project is to expand soil health by increasing outreach and education to our producers. This will be done by evaluating changes in dynamic soil properties resulting from incorporating multi-species cover crop mixes into crop rotations. This will be a 3-5 year project and will focus on both single species cover crop (wheat, rye, or winter pea) and multi-species cover crop mix (wheat/rye, crimson clover, and forage radish). The data will be gleaned through a planned lab analyses to provide more quantitative analyses. The information will be captured through a soil health assessment card.

5. Lessons Learned from other Regions of the U.S. - Great Lakes Restoration Initiative

- **Edge-of-Field Monitoring** - Voluntary edge-of-field water quality monitoring enables agricultural producers and scientists to quantify the impacts of conservation work on water quality. Through edge-of-field monitoring, NRCS works with producers and conservation partners to measure the amount of nutrients and sediment in water runoff from a field and compare the improvements under different conservation systems. Over 6 edge-of-field projects are in Wisconsin, Ohio, Michigan, New York and Indiana. USGS funds these projects at the state level and the USDA NRCS provides technical assistance.

- **Demonstration Farms -** Through this collaboration and funding, NRCS installs leading edge conservation practices that reduce phosphorus runoff and publicly highlight the most effective conservation systems in an area. The farms showcase conservation systems and serve to spread the word about new technologies, research and experience gained. Great Lakes Restoration Initiative (GLRI) Conservation Technical Assistance (CTA) funds are used for this effort.

- **Linking Soil Health Assessment to Edge-of-Field Water Quality in the Great Lakes Basin** – A team effort between the University of Wisconsin−Green Bay, Purdue University, and the USGS to connect soil health parameters with water quality leaving agricultural fields. GLRI CTA funds are used for this effort.

- **Great Lakes Commission (GLC) REAP Project (Research Effectiveness of Agricultural Programs) -** This project examines the socio-economic impact of investments from GLRI-funded programs and projects aimed at increased adoption of conservation practices that improve water quality in the following GLRI Priority Watersheds: Lower Fox River, WI; Saginaw River, MI; Maumee River, OH/IN/MI; and Genesee River, NY. The REAP project supports the GLRI Action Plan II goal of reducing nutrient loads from agricultural watersheds by providing detailed information on agriculture incentive program successes and opportunities for improved water quality benefits.

- **Great Lakes Blue Accounting – ErieStat Pilot -** The future of the Great Lakes region hinges on effectively leveraging and sustaining our primary asset – the world's largest freshwater system. Hundreds of different entities – across eight states and two provinces – currently invest billions of dollars in restoring and maintaining the Great Lakes, but we do not have a way to measure the effectiveness of these efforts to protect ecosystems, safeguard human health and bolster the economy. This Pilot enables a way to start measuring effectiveness.

  Link: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/?cid=nrcsdev11_023903