Agricultural BMP Implementation Verification Supporting Information

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Prepared for

Agriculture Work Group

Chesapeake Bay Program

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1.0 INTRODUCTION

1.1 PURPOSE

The Chesapeake Bay Program's Agriculture Workgroup (AgWG) is exploring options to verify the implementation and operation of agricultural Best Management Practices (BMPs) in the Chesapeake Bay Watershed (CBW). The objectives of this effort are to identify approaches or protocols for verifying agricultural BMP implementation, to assess the varying levels of data confidence associated with different protocols, and to reflect the varying confidence levels by potentially adjusting credit values for BMP implementation in the Chesapeake Bay Watershed Model (CBWM). Verification of both cost-shared (c/s) and non-cost-shared practices is desired. Major options identified by the AgWG fall into five categories:

- On-farm assessment by trained personnel;
- Farmer self-assessment, with or without spot check by agency personnel;
- Review of existing agency or on-farm records;
- Statistical sampling; and
- Remote sensing.

1.2 METHODS

Two approaches were taken to assemble supporting information for BMP verification. First, a search of scientific literature and published reports was conducted to document past and ongoing BMP verification protocols relevant to the Chesapeake Bay Watershed. Second, brief telephone interviews and email exchanges were conducted with 19 individuals both within and outside of the CBW who had been identified by the AgWG as having significant experience and/or expertise in BMP verification. The purpose of these interviews was to identify specific verification programs and key principles that should be applied to future verification efforts. The names and affiliations of the interviewees are listed at the end of this report.

2.0 OVERVIEW OF VERIFICATION

2.1 WHAT IS VERIFICATION?

The Chesapeake Bay Program (CBP) Partnership has defined verification as the process through which agency partners ensure practices, treatments, and technologies resulting in reductions of nitrogen, phosphorus, and/or sediment pollutant loads are implemented and operating correctly. The process for certifying tradable nutrient credits is a separate, distinct process not addressed either by these principles or through the partnership's BMP verification framework. In the context of this report, verification refers to the accurate tracking, documenting, and accounting of the use of agricultural BMPs at a watershed or larger scale. The term "verification" does not refer to measuring specific BMP performance or pollution-reduction efficiency, but rather to the confirmation of the presence of functional BMPs (i.e., those BMPs operating to provide a water quality benefit) across the landscape. Thus, verification is essentially a detailed inventory of all BMPs implemented within an area of interest.

2.1.1 *Purposes*

Verification efforts may serve a number of purposes, including providing accountability for government-funded programs, documenting compliance with regulations or progress toward a management goal (e.g., a total maximum daily load or TMDL), or assessing the effectiveness of a watershed management program (e.g., through modeling). Tracking of on-site conservation practice implementation is an important first step for assessing watershed management effectiveness. The lack of BMP tracking makes it difficult to assess how much is being done to reduce pollution from agricultural sources and what the resulting reductions are likely to be.

In some parts of the U.S., verification of agricultural BMPs is conducted in support of trading programs, wherein pollution reductions estimated to be achieved through BMP implementation can be traded to other pollutant emitters; the Maryland Nutrient Trading Program and the Ohio River Basin Trading Project (EPRI 2012) are two examples of such programs. Some states have programs to document implementation of BMPs in support of agricultural certainty programs that give farmers a "safe harbor" from regulatory action as long as they follow certain procedures which may include implementation of BMPs Examples include the Florida Department of Agriculture and Consumer Services (FDACS) BMP manuals, the Louisiana Master Farmer Program, Michigan's Agricultural Environmental Assistance Program (MAEAP), and the Virginia Department of Conservation and Recreation (VDCR) Resource Management Plans (Craig and Noto 2012). Some regions or states conduct BMP verification as part of regulatory programs, e.g., the Florida Implementation Assurance Program for the Lake Okeechobee and other priority watersheds (FDACS 2008).

2.1.2 *Methods*

BMP verification can be conducted using several different approaches, including direct on-the-ground inventory, self-reporting by landowners, examination of agency records, statistical sampling, or remote sensing. These approaches are discussed extensively in this report. A discussion of how different approaches may be most appropriate for different types of BMPs can be found in section 4.0. For example, the presence of structural BMPs may be verified visually (on the ground or by remote sensing), while existence of a nutrient management BMP cannot be verified visually, but instead requires detailed information on management activities by the farmer. While specific procedures vary among different general approaches, some basic guidelines intended to ensure high quality work can be found in *Government Auditing Standards* (GAO 2007), which includes methods for designing performance appraisals that may also be useful in designing verification programs.

An important step in implementing a verification effort is gaining knowledge of the BMPs implemented in the area of interest. In the CBW, the specific list of agricultural BMPs of interest for verification is defined by the practices that are included in the CBWM through NEIEN (National Environmental Information Exchange Network) (Sweeny 2012). Practices associated with agriculture are listed in Table 1.

Table 1. Agricultural practices reported through NEIEN.

Nutrient Management	**Other Agricultural Practices (cont.)**
Nutrient Management	Manure Transport
Decision Agriculture	Water Control Structures
Enhanced Nutrient Management	Non-Urban Stream Restoration
Conservation Tillage	Poultry and Swine Phytase
Continuous No-Till	Dairy Precision Feeding
Other Conservation Tillage	Ammonia Emissions Reductions
Cover Crops	**Other Practices***
Cover Crops and Commodity Cover Crops	Brush Management
• Early, standard, late-planting	Contour Buffer strips
• Species	Contour Orchard and Other Fruit Area
• Seeding method	Fishpond Management
Pasture Grazing Practices	Firebreak
Alternative Watering Facilities	Hedgerow Planting
Stream Access Control with Fencing	Irrigation System, Microirrigation
Prescribed Grazing	Irrigation System, Sprinkler
Precision Intensive Rotational Grazing	Irrigation System, Tailwater Recovery
Horse Pasture Management	Irrigation Water Conveyance, Pipeline, High-Pressure, Underground, Plastic
Other Agricultural Practices	Irrigation Water Management
Forest Buffers	Strip cropping
Wetland Restoration	Strip-Cropping, Field
Land Retirement	Strip-Cropping, Wind
Grass Buffers	Terrace
Tree Planting	Transition to Organic Production
Carbon Sequestration/Alternative Crops	Tree/Shrub Pruning
Conservation Plans/SCWQP	Underground Outlet
Animal Waste Management Systems	Upland Wildlife Habitat Management
Barnyard Runoff Control	Contour Farming
Mortality Composters	*These practices are grouped/credited as a “Conservation Plan” according to the Scenario Builder requirements appendix.

Detailed information about BMPs employed in the CBW – including definitions and estimates of pollutant reduction effectiveness – has been published by Simpson and Weammert (2009).

Verification of BMP implementation is comprised of documenting two principal components:

- Presence of the BMP (does the practice exist at the location reported?) and
- Quality of the BMP (does the installation follow acceptable design standards to ensure water quality benefits?).

2.1.3 Data Confidence

Regardless of the specific approach taken for verification, confidence in the results is an issue of prime importance. In this report, confidence refers primarily to statistical assessment of the accuracy (or uncertainty) of the BMP verification **result**; for example, reporting the number of acres of cover crops determined by a survey as accurate to within ± 10 percent is a quantitative expression of confidence in the estimate. In a related use of the term, confidence can also refer to knowledge of the level of achievement of a required or desired level of implementation in a specific program or area of interest; for example, reporting that 80 percent of planned BMPs have been verified is a measure of confidence that the desired level of treatment has been applied. As the term is used here, confidence does not refer to BMP efficiency. Understanding of uncertainty in BMP implementation data is an essential component of documenting statistical confidence in model results or other applications using verified BMP implementation data. In the CBW, for example, accurate tracking and accounting of the use of BMPs is of paramount importance, because the CBP relies on these data to estimate current and future nutrient and sediment loads to the Bay (NAS 2011). Documentation of statistical confidence is not an easy task, however, and few quantitative assessments of confidence in BMP verification efforts inside or outside of the CBW have been reported (see section 4).

Whether the BMP implementation data are used for tracking progress against program implementation goals or generating input for modeling runs, the ultimate goal of verification efforts is to give stakeholders confidence that the right actions are being taken on the land according to schedule to achieve water quality goals for the CBW. Verification is essential to understanding what has been accomplished on the ground regardless of the extent to which water quality goals have been met. At best, with appropriate verification it can be claimed that BMP implementation efforts have contributed to observed improvements in water quality, while, at worst, verified implementation in the absence of water quality improvement forms a solid basis for determining the next steps in an adaptive management process to ultimately meet water quality goals.

Regarding individual practices, the confidence with which one can assess and report implementation varies both with the specific practice and the tracking method used. One could assess the confidence level associated with reporting implementation (presence and adherence to design standards) of each practice (e.g., nutrient management, cover crops) using each tracking method (e.g., farmer self-reporting, remote sensing), but the literature is essentially devoid of such experience. Even if confidence levels were available for all combinations of practices and tracking or verification methods, it would be a daunting if not impossible task to combine that information to derive a suitable measure of overall confidence in state reporting of BMP implementation. One reason for this is the very nature of watersheds and pollutant pathways; some practices are more important than others by virtue of their locations and their potential for reducing pollutant loads.

For example, performing on-site assessments at all animal operations to confirm implementation of animal waste management systems may be less important than auditing 20 percent of NMPs if the relative pollutant load from cropland is far greater than that from animal operations.

Because of the many complexities associated with assigning data confidence levels to tracking individual BMPs via various approaches, let alone combining that information in some way to derive overall measures of confidence, it is appropriate to consider ways in which one can determine levels of confidence at the program or state level. For example, how confident can we be that implementation levels reported by the state or accurate? Or, how confident can we be that the state program is achieving its implementation goals on schedule? There may be multiple confidence levels that could be appropriate for each state depending on the range of combinations of practices, programs supporting practice implementation, and tracking or verification methods the state employs.

In order to assign confidence levels at the program or state levels it is necessary to examine the methods used by each program or state to track and verify BMP implementation. Such an assessment, however, would undoubtedly create some discomfort if presented on a state basis. It would be more palatable, perhaps, if the methods used by all Bay states were pooled and assessed independent of which state used them. Bay states could then select (or alter existing) methods for their own programs based on the confidence levels they hoped to achieve.

When assessing alternative verification methods, it is important to keep in mind the various factors that impact uncertainty even from a qualitative perspective (e.g., "low" or "high"). The types of questions that should be considered when assessing verification methods include:

- How was the BMP identified (e.g., by survey or remote sensing)?
- At what spatial scale was the BMP identified (e.g., farm or watershed)?
- What specifications defined the BMP design (e.g., NRCS or other)?
- Who installed the BMP?
- How was the BMP implemented?
- How was the BMP funded?
- When in the year was the BMP implemented?
- Who approved the final product?
- How frequently is the BMP inspected or maintained?

2.2 Verification in the CBW

Since 2010, the National Environmental Information Exchange Network (NEIEN) has been the mechanism used to report non-point source (NPS) BMP implementation for progress reporting from the Bay states and jurisdictions to the Chesapeake Bay Program Office (CBPO). The NPSBMP exchange and its database framework were developed through a cooperative effort of the trading partners initiated in 2005. Prior to 2010, progress reporting was conducted by email and ftp distribution of spreadsheet files and reports with manual processes to compile, standardize, and process the information.

The NPSBMP exchange has multiple facets and levels of validation that may or may not be relevant to verification efforts. In addition to facilitating the exchange of practice implementation details, the framework contains modules to report detailed information and metadata for the primary point of contact and agency, data source contact and agencies, funding and financial components, geographic location, land use, and binary objects. There are 181 different distinct data elements defined in the data exchange template (DET), which also defines the attributes (numeric, character, length, number of decimals permitted, whether elements are required, conditionally required, or optional) which are enforced by the NPSBMP node plugin software. If a submission does not conform to the reporting requirements, it is rejected by the system with error messages for submitters that can be used to troubleshoot the issues and re-submit the data. No data is saved in the NPSBMP database until all errors in a submission are addressed.

Each jurisdiction maintains their own tracking system or mechanism for tracking BMP implementation and provides data to CBPO through the exchange network using the agreed upon data formatting structures and definitions. Each record submitted to CBPO is required to contain a "state unique identifier" which can be used for traceability and tracking data flow through various systems.

The NPSBMP exchange allows for an individual record of practice data to be reported at 5 different geographic scales, from statewide (least specific) to latitude and longitude coordinates (most specific). In between these two in order of specificity, are HUC8 (8-digit hydrologic unit code), County, HUC10, and HUC12. Rules stipulate that the most precise level specified in the data will be used, but some jurisdictions simply report county or statewide summaries.

Although the data exchange has a distinct list of practice codes (see Table 1) that are validated according to the DET, it is designed to be flexible and accept a variety of different state-specific "free text" measures for each practice (such as Buffer Area, Length Fenced, Width Fenced, or Area Protected). The system also accepts a variety of potentially "synonymous" measures (such as Buffer Area and Area Protected in the previous example). Jurisdictions are requested to document and define all of the free text measures reported through NEIEN so that they can be handled correctly by CBPO's Scenario Builder and the Watershed Model. Input data are checked for both NEIEN and Scenario Builder compliance, and it is possible that reported data can be NEIEN-compliant, but not compliant with Scenario Builder requirements; such data cannot be used for progress reporting.

In 2010, the newly developed Chesapeake Bay Tracking and Accounting System (BayTAS) was enhanced to support NEIEN data submissions. The BayTAS system provides jurisdictions with a series of validation reports that include summaries (& details) of the practice data reported. These reports identify and flag data that do not comply with Scenario Builder requirements so that jurisdictions may address issues if needed. The reports are designed so that jurisdictions can confirm every record submitted and whether it passed or failed validations and is passed to scenario builder for progress reporting. CBPO staff and jurisdiction data submitters use these feedback reports to highlight potential outliers and confirm implementation rates in an iterative (submit-check-fix, resubmit-check-fix) manner, until all data quality issues identified are addressed or accepted by both parties.

CBPO has identified that an effort should be undertaken to address issues known to be in the historic BMP implementation record (prior to 2010) prior to the 2017 calibration effort. Because these files were transferred via email and handled manually, there is little traceability or documentation to support the record or address the issues.

A 2011 report by the National Academy of Sciences (NAS 2011) was highly critical of BMP verification efforts in the CBW. The report stated that tracking and accounting of BMPs is incomplete and inconsistent across the CBW because many Bay jurisdictions are struggling with limited resources, complex and rapidly changing data collection and reporting protocols, data privacy constraints, and quality assurance and control needs. Furthermore, given that some BMPs are not tracked in all Bay jurisdictions, the NAS report stated that current accounting cannot be viewed as accurate. The committee concluded that independent auditing of the tracking and accounting at state and local levels would be necessary to ensure the reliability and accuracy of the data reported.

3.0 Current BMP Verification Programs and Activities in the Chesapeake Bay Watershed

3.1 Delaware

[no information has been provided by the state]

3.2 Maryland

Maryland programs that address issues of agricultural BMP verification include several components and each includes a rigorous set of quality assurance/quality control (QA/QC) procedures:

3.2.1 The Maryland Agricultural Water Quality Cost Share Program (MACS)

The Maryland Agricultural Water Quality Cost Share Program (MACS) has a procedures manual used by all 24 soil conservation districts that sets forth all of the policies and procedures of installing the BMPs for MACS. It also includes information on spot checks. The USDA's Natural Resources Conservation Service (NRCS) also has a series of manuals (Field Office Technical Guides – FOTG) that describe the standards and specifications for all federally cost-shared BMPs. The MACS Program manual relies on the NRCS technical standards and specifications in the FOTG for the placement and installation of all BMPs.

The MACS annual Quality Assurance Review (QAR) process consists of an overall review of the state's 24 Soil Conservation District (SCD) operations to determine if programs are administered according to applicable technical guidelines. The review team consists of a representative from the Maryland Department of Agriculture (MDA), Office of Resource Conservation (usually the Operations Office Area Coordinator and/or someone from the MACS Staff), an NRCS engineer, and local SCD staff. A list of MACS practices installed within the last year is supplied to the review team using a standardized protocol. The review team inspects the project files in the SCD Office and conducts field verification of the practices and their operation installed in the field. The results of the review are communicated to the SCD's staff and all other parties involved. Any deficiencies are noted and training and/or follow up is offered to or required of the field staff or the operator to bring the practice into compliance. Follow-up reports or revaluations are conducted later.

The MACS spot-check review process is also conducted once a year. All completed practices within their maintenance life are eligible for review. A random, computer generated sample of 10% of all practices is generated by the MACS Office at MDA Headquarters for field review by the SCDs. This field inspection (which is in addition to the monitoring and inspection that takes place during BMP construction) determines whether the BMPs were constructed according to plan specifications and whether the BMPs are being maintained. Where the teams find unsatisfactory conditions, a letter of notification is sent to the farmer identifying the issue to be addressed and establishing a time frame to correct the problem. The BMP is re-inspected again, normally within a year, to ensure compliance and performance. Possible reasons for unsatisfactory conditions could include a lack of maintenance or a change of ownership. If there has been a change in ownership, MDA institutes a transfer of maintenance requirements to the new owner through the Property Transfer process. If the new owner does not agree to maintain the BMP, MDA seeks repayment from the original owner of principle and in some cases, interest. Maintenance issue are required to be addressed using the same technical standards applied during design and construction.

When a project is reviewed and determined satisfactory, it is removed from the inspection-eligible list for two years. Once the maintenance life (typically ten or fifteen years, depending on the practice) is completed, the practice is removed from the eligible list. A practice is not reviewed if it is within 6 months of expiring. The review team consists of staff from SCD offices.

3.2.2 Farm Stewardship Certification Program

The Farm Stewardship Certification Program (FSCP), run by a third party sanctioned by MDA, is an incentive program to document practice implementation at the farm scale by inventorying farms and inspecting all practices and nutrient management records. Trained assessors determine compliance with regulatory requirements, determining whether BMPs are functioning, identifying any water quality concerns, and judging whether the farmer can be certified as a good farm steward. Those who are meeting TMDL requirements are declared farm stewards.

3.2.3 Inventory of Non-Cost Shared Practices

All types of practices (federal, state, self-implemented) are assessed under the Inventory of Non-Cost Shared Practices (INCSP). An established protocol is used to assess farmer-installed BMPs, including taking photos, recording information in a file, and ascertaining whether practices meet standards and specifications. Funding is made possible through a conservation and innovation grant. Data accuracy is considered high, partly because assessment specialists are trained and certified to collect, record, and verify information.

3.2.4 Nutrient Trading

A nutrient trading on-farm assessment tool is used for assessing TMDL compliance and the potential for creating additional nutrient reductions to trade. This is similar to what is done for both the FSCP and the INCSP. Field-by-field assessments by trained staff (similar to training for the FSCP) are performed to ascertain whether the farm has met its TMDL obligations. Staff also explore and discuss with the farmer opportunities for creating offsets for trading. Management records are pulled from the farm record during site visits to verify implementation of nutrient management and other practices – this information is used in assessing the farm's performance. Nutrient trading QA/QC is similar to that for the FSCP and INCSP. On-farm assessments are performed by two separate teams to confirm offsets for trading and to provide certification. A 10% spot check of those farms entering the trading market is performed, and Maryland Department of Environment (MDE) will also do random spot checks (credits are written into an NPDES permit). The buyer of offsets is required to hire an independent 3rd party to check all farms in trades over the lifetime of trades to confirm their accuracy. MDA's effort (training, staffing) is paid for through a conservation/innovation grant. Because trading involves an NPDES permit, accuracy and confidence have to be very high. If a farm is out of compliance with the permit, there are Clean Water Act fines.

3.2.5 Verification of State Cost-Share

The SWCDs work with farms on practice installation. MDA and NRCS use standard plans for inspection and verification of practices installed, and federal and state c/s funded BMPs are inspected jointly. On the front end, once a practice is installed the SWCD certifies implementation and compliance with standards and specifications. MDA and NRCS pull a random list from each SWCD and inspect farms with practices newly installed that year. When on farms, however, they inspect and document all practices installed at any time, including previous years to ensure that they are in compliance with standards and specifications. An inspection report is generated, and correction notices (60-day and 30-day) are given if necessary. If the farmer does not fix the identified problems, they are no longer eligible for c/s. State headquarters staff perform the verification of state c/s as part of their normal duties – there is no special grant. Data confidence is high because technical experts verify everything via on-site inspections.

3.2.6 Manure Transport Program

MDA has developed inspection and verification of program compliance procedures for the Manure Transport Program. These procedures cover activities at the application and claim stages, and guidelines have been developed for on-site farm status reviews. On-site reviews take place during or immediately after implementation and focus on determining whether (a) the receiving operation utilization of transported manure is consistent with the nutrient management plan, (b) crops or crop residue in a field are consistent with the nutrient management plan, (c) "Delivery Site Guidelines" or "Stockpiling Guidelines" have been followed or are being followed, and (d) any residual manure will cause any water quality concerns. The review procedures include (a) selection of up to 10% of any of the active and completed agreements, (b) inspections conducted resulting from a complaint from an adjacent property owner or others, and (c) inspections in conjunction with a nutrient management implementation review. If the applicant fails to comply with program guidelines, follow-up action may include requiring corrective actions, possible exclusion from future participation, liability for funds paid, and referral to the Nutrient Management Implementation team for compliance enforcement.

3.2.7 Cover Crop Program

Because this is the biggest program in Maryland ($18M/yr), verification is much more intense. On the front end, the eligibility of all farmers signing up for the program is reviewed. Participants must certify when the cover crop is planted, the type of cover crop, and areas in the field where it is planted. Staff are sent out to field verify the acreage, type, date, location, stand (80% or greater stand is required), and seed quality to determine planting information. Because they may be eligible for planting incentives based on early planting dates, farmers are required to certify in the fall ("fall certify") any fields planted in accordance with up to three deadlines. SCDs conduct field checks on at least 20% of acres of small grains on each farm for which there is fall certification. If participants fall certify for more than one planting date, the participant may have multiple field checks. If any issues arise with the participant's 20% field check, the SCD then expands the field check to include all of the participant's certified acres. An additional random check of 10% of contracts is conducted in the spring to verify killdown. Copies of all records are kept and used in the payment process, and MDA is currently piloting an effort to convert hard-copy maps to geographic information system (GIS) files.

Going forward MDA is investigating remote sensing of cover crops not involved in c/s programs using satellite imagery and field-scale verification. The current cover crop program covers only about ¾ of what is implemented; remote sensing is used to capture the rest (includes farmer-implemented cover crops). Preliminary pilot studies have shown that remote sensing can be used to provide reliable information to communicate with farmers about their cover crop's performance, including presence/absence of a cover crop, and N and P benefits that might be derived from the cover crop. This additional information will provide a more complete picture of cover crops in the state.

3.2.8 Nutrient Management Program

The Water Quality Improvement Act of 1998 requires farmers with gross annual income of $2,500 or more or livestock operations with 8,000 pounds or more of live animal weight to manage their farms using nutrient management plans (NMPs) that protect waterways from excess crop fertilizers and animal waste.

Reviews of NMPs are conducted to determine whether the plans were written accurately and implemented properly. Farmers are required to have and implement NMPs for their operations and are also required to submit nutrient management Annual Implementation Reports (AIRs) by March 1st of each year to document nutrients applied by crop type during the previous year.

MDA's Nutrient Management Program maintains a separate database for regulatory compliance. Nutrient management implementation in the agricultural sector is tracked to comply with multiple regulatory requirements:

- Farmers submit an initial NMP to MDA written by a certified nutrient management planner.
- Farmers must submit an AIR to MDA by March 1 for the previous calendar year. The AIR notes any changes to the operation, crops grown, fertilizer use, acreage managed, animal production, etc.
- Farmers are responsible for keeping prescribed records of nutrient inputs and outputs.

NMPs are reviewed and certified by 3 regional MDA staff to ensure plans are prepared in accordance with appropriate requirements. This review is an evaluation of the work of the professional individuals certified and licensed by MDA to develop plans for Maryland farmers and is designed to ensure the quality of plans prepared. MDA has been conducting reviews of plans since 2003. Plans can be prepared by the farmer (with technical assistance from a University of Maryland Extension expert) or consultants, but plans can only be prepared by those that have been certified (farmer or consultant). Consultants who do not prepare the plans properly risk losing their licenses.

Field inspections of plans started in 2005 and MDA officials strive to complete about 400 inspections per year. The review process includes a targeted selection of farms to be reviewed. The strategy for identifying farms to inspect is weighted toward those operations considered to have the greatest risk for water quality impacts-primarily operations managing manure. For example, of the 427 implementation reviews planned statewide for 2010, 282 (66%) were focused on operations involving manure. In the regions of the state with the highest concentrations of animals, (Western Maryland, and the Eastern Shore), 79% of the reviews were targeted toward operations involving manure. Three fields are reviewed at each farm selected, with farmer-reported crops and fertilizer applications compared with the NMP. The farmer is required to maintain records documenting the rate, timing, and method of nutrient applications, as well as crop yields. Farmer requirements are included in the Maryland Nutrient Management Program Plan Implementation Review Process for Operators, which is available to all farmers and prepared by the MDA Office of Resource Conservation. A four-part Nutrient Management Program Plan Implementation Evaluation report is prepared to document the review and serves as the compliance enforcement notification when certain deficiencies are noted in the review. Any problems identified during the review require notation on the evaluation form and a follow-up review. The timing of the follow-up review depends on the deficiency noted. Failure to correct the deficiency within the allotted time warrants further enforcement action, including fines. The most common problem cited during recent implementation reviews is the failure to have a current NMP.

As a more efficient use of staff resources, and to leverage performance, MDA staff conducts cross compliance checks between nutrient management compliance and applications for financial assistance programs. Farmers who are out of nutrient management compliance or have not submitted required nutrient management documentation are not eligible to participate in state incentive programs. Farmers who receive financial assistance for agricultural waste management BMPs must have their NMP reviewed and approved by nutrient management staff prior to receiving payment. Farmers who receive financial assistance for nutrient management planning services are required to have their plan reviewed and approved prior to receiving payment. MDA annually reviews at least three NMPs prepared by each state certified nutrient management service provider to ensure they meet standards. Follow-up actions can include suspension of plan writing certification. Farmers or service providers who apply nutrients to agricultural land are required to become state certified and attend training to maintain their certification. Farmers who fail to have a plan or file yearly AIRs are subject to enforcement with fines of up to $250 from MDA and $10,000 from MDE.

Tables 2-5 provide recent information on inspection activities for nutrient management:

Program Performance & Verification:
Nutrient Management Plan Submission

FY	NMP ac submittals outstanding	Enforcement Actions
2006	223,000	1,099
2007	201,000	1,635
2008	100,000	1,733
2009	4,300	55
2010	700	20

Table 2. Nutrient Management Plan Enforcement Actions.

Program Performance & Verification: Nutrient Management Annual Reports

FY	AIR required	% Submitted in FY	Enforcement Actions
2006	5969	75%	154
2007	6080	86%	254
2008	5800	98%	302
2009	5514	97%	553
2010	5554	96%	473

Table 3. Nutrient Management Annual Report Enforcement Actions.

Program Performance & Verification: Nutrient Management Field Inspections

FY	NMP Site Inspections	NMP Compliance	Enforcement Actions
2006	167	78%	0
2007	500	89%	0
2008	450	65%	90
2009	400	69%	191
2010	391	73%	173

Table 4. Nutrient Management Plan Field Inspection Enforcement Actions.

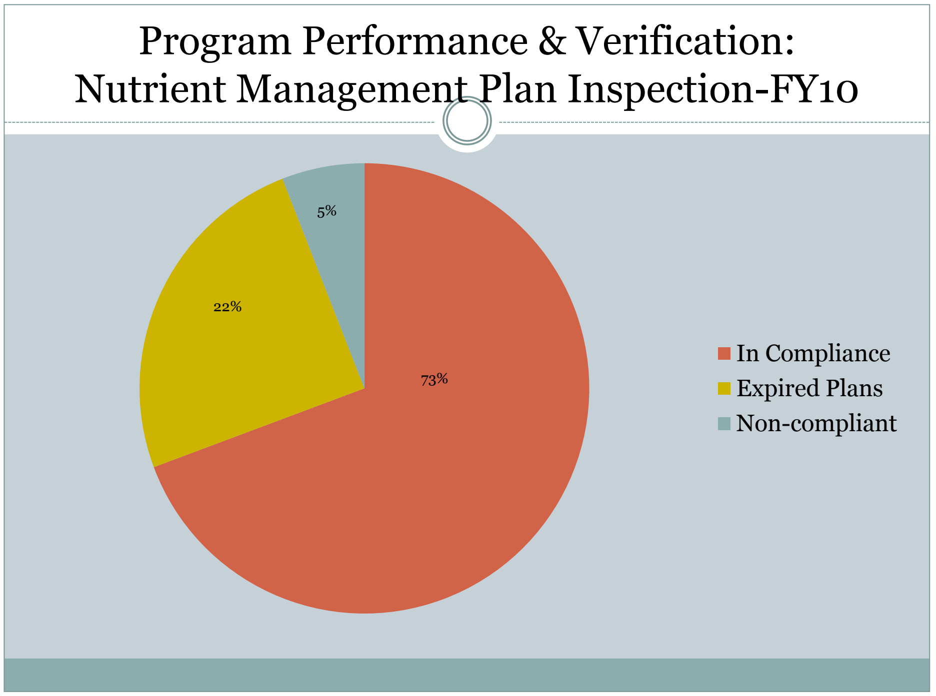

Table 5. FY 10 Nutrient Management Plan Inspections.

3.2.9 Conservation Tracker

About four years ago Maryland developed Conservation Tracker ("Tracker") to address a concern that the existing federal tracking/accounting systems being used were not complete (i.e., missed state and farmer-installed practices). Tracker is a comprehensive system employed at the SWCD level for tracking all farm conservation programs and all practices on the farm. The state uses Tracker to report annual implementation progress to the CBP, but the system also has manure transport data, CREP data, cover crop data, and other data.

MDA has a QA/QC protocol involving state c/s program records to confirm that data in Tracker are accurate. Conservation data obtained using Tracker will be reviewed and verified for conformation to program requirements and validated using data quality objectives established by the MDA Office of Resource Conservation Operations. Only data that are supported by appropriate quality control criteria and meet the data quality objectives will be considered acceptable for reporting. Data validation occurs at the time of entry into Tracker through the extensive use of field validations, including table lookups, formulas, and data-type restrictions. Once processed in the database, MDA generates various quality control charts and reports on a quarterly basis to identify potential data quality issues. Evaluation and verification of any data issue is resolved locally by SCD staff. The same process is followed for federal data to ensure that Tracker data are correct. Additionally, field validation of BMP implementation is managed through annual Quality Assurance Reviews (QARs). Field checks of 10% of all BMPs implemented within the active maintenance life span are conducted and documented to ensure they continue to function in accordance with design standards and specifications. Cross checks/validation are conducted with MACS Agreements and Nutrient Trading Program assessment reports for accuracy.

3.3 NEW YORK

[no information has been provided by the state]

3.4 PENNSYLVANIA

Application of a comprehensive BMP verification protocol in Pennsylvania is currently considered cost-prohibitive. Pennsylvania relies on USDA-NRCS records for verification of implementation of federally cost-shared practices. There is no single protocol for non-cost shared practices; rather there are protocols for individual BMP types – e.g. the QA/QC procedures in the recent tillage survey by the RC&D.

Monitoring and inspection of nutrient management and other BMPs are conducted for verification in Chesapeake Bay Special Projects (PA DEP 2007). Monitoring compliance of the implementation and maintenance of individual special projects and nutrient management programs of those farms under non-expired Landowner/Operator-Conservation District Agreements (CBP-SP3) is an important factor in judging the effectiveness of Pennsylvania's CBP. All farms under a non-expired CBP-SP3 in the Bay Special Projects Funding Program (SPFP) are subject to compliance inspections once every four years.

Monitoring of special projects is a responsibility of the conservation district (CD) that should be ongoing throughout the lifespan of the special project/BMP. The initial implementation of a project is documented through the CBP-SP5, Cost Verification Form, during the completion stages of the project. Upon completion and throughout the lifespan of the CBP-SP3, the landowner could be subject to a formal Field Interview & Compliance Field Inspection Report (CBP-SP9). Compliance inspections are designed to randomly sample at least one landowner, but no more than three, from each special project sponsored by the CD.

Annual field reviews and compliance field inspections are scheduled and coordinated by CDs. These inspections include an appropriate representative from the Pennsylvania Department of Environmental Protection (DEP) and should include a representative from NRCS when necessary due to BMP design and/or job approval authority.

If problems are noted during inspections, corrective actions must be taken by the landowner/operator within 30 to 60 days. The date for a follow-up inspection will be noted on the CBP-SP9 form and verified by the Chesapeake Bay Field Representative (CBFR). If landowners are not fulfilling applicable program requirements, CDs can be required to return state funds to the Commonwealth.

3.5 VIRGINIA

Virginia conducts spot checks to determine practice viability and lifespan. For structural practices, spot checks should be conducted after the close of the program year but early enough to allow modification and vegetation to be re-established (if needed). Annual practices such as WQ-4 (legume cover crop) and SL-8 (protective cover for specialty cropland) are not subject to spot-checking, but technical certification inspections can be carried out during the program year as appropriate. Spot checks are intended only to verify that a practice exists on the farm, and are not intended to be technical inspections. Technical accuracy was determined at the time of certification by technical personnel. If technical problems exist however, the CD and the appropriate technical agency are notified.

Random spot checks are conducted annually by the District Conservation Specialist/Technician under the guidance of the Conservation District Coordinator (CDC) to determine that the individual practice is still viable. Technical agencies involved (NRCS and Virginia Department of Forestry) are notified that spot checks are to occur but they are not required to be present. A random 5% sample of each type of practice is completed. In addition, a 5% sample of the total number of selected practices from previous years is conducted to monitor long-term compliance. The CDC will conduct administrative reviews periodically.

Upon the completion of the spot checks, CD personnel must inform the appropriate technical agency that corrective action is needed and can begin, and must also inform the District Board at its next regularly scheduled meeting. Copies of all spot-check forms are sent to the CDC and copies are maintained in the CD files. Spot-check reports on practices receiving c/s from other sources are copied to the appropriate agency.

CDCs consolidate all spot-check information into a table indicating how many inspections were conducted, how many practices were in compliance, and how many practices require additional CD follow-up. A copy of this report is forwarded to the Agricultural Incentives Program Manager. The report is used by the CDC to ensure that those practices that need additional CD attention are taken care of and all issues are resolved or a pro rata return of c/s and tax credits are returned to the CD.

In conjunction with spot-checking, each assigned CDC may examine cooperator files to ensure accordance with plans, policies, and procedures. The assigned CDC may choose to examine only those cooperator files that have been selected for spot-checking or they may choose an overall sampling of no more than 10% of all cooperator files currently under the practice lifespan.

3.6 West Virginia

West Virginia is in the process of developing a tracking and reporting system for both cost-shared (current and expired) and non-cost-shared BMPs in order to credit farmers who have installed practices with or without federal or state c/s dollars and use the data collected in the CBWM. The development of this process is described in Appendix G to the *WV Phase II Final Chesapeake Bay Watershed Implementation Plan,* dated 3/30/2012 (West Virginia WIP Development Team 2012). Development of the tracking program has been done in collaboration with the National Association of Conservation Districts (NACD), USDA, U.S. Environmental Protection Agency (USEPA), West Virginia Conservation Agency (WVCA), West Virginia Department of Environmental Protection (WVDEP), and other state departments of agriculture.

The West Virginia Department of Agriculture (WVDA) has hired a Tracking and Reporting Specialist to focus on tracking and reporting of BMPs. In particular, this person has developed, field-tested, and refined protocols for capturing the details of previously unreported or non-cost-share BMPs that contribute to water quality primarily through a farm-by-farm voluntary approach. The key points of the tracking and reporting protocol are:

1. Working with 4 pilot farms to develop a tracking sheet and Reference Book (includes the Bay Program BMP name, definition, reduction efficiency, the corresponding NRCS practice standard, and an example picture).
2. Testing of the tracking sheet and Reference Book on the pilot farms to make adjustments.
3. Reliability and validity testing of the information collected on the pilot farms by a third party. The University of Maryland Agricultural Technical Coordinator provided assistance at this stage.
4. Adjusting the protocol such as modifying pre-planning tasks, how to ask questions to get all the data needed, and how to determine the level of function of each BMP.
5. Training of WVDA staff to collect data in a consistent manner from farm to farm and staff member to staff member.
6. Working with Tetra Tech to develop a database to store the data and submit to the CBWM.
7. Outreach to farmers to let them know that the program is up and running so they can volunteer their information.
8. Collecting data. All data collected are submitted to the Tracking and Reporting Specialist to enter into the database.
9. Re-checks of farms will be performed every 10 years and will be done through a mailer survey that will list the BMPs found on the farm and ask the farmer if the practice is still in existence, has been modified, or if new BMPs have been added to the farm.
10. Data will be aggregated on the county level by the database and be sent to the WVDEP BMP reporting database to be submitted to the NEIEN.

Field testing of the first-cut tracking spreadsheet resulted in the development of a new Farm Assessment Sheet (FAS) used for gathering the necessary information in the field needed to properly credit the BMP. The BMPs being collected include all those approved by the CBP and interim BMPs. The Field Assessment Sheet includes basic contact information, a list of the BMPs being tracked and/or credited by the CBP, and cells to enter the practice name, tract and field number, number of units or systems, level of function, the year it was installed, the latitude and longitude, notes, and who verified the practice. The FAS also includes a decision tools list to help the field staff consider the necessary standards a practice must meet to determine its level of function.

NACD assisted in formulating the definitions of BMP function that the WVDA is using on the farms to assess BMPs:

- **Meets NRCS Standard and Specifications-** practices that comply with all the requirements in the State Technical Guide and Engineering Field Manual.
- **Functional Equivalent-** practices that provide nutrient and sediment reductions equal to practices that fully meet NRCS Standards and Specifications but do not meet the rigorous NRCS criteria. Deviation from a NRCS conservation practice technical standard in construction materials may still provide the same annual water quality benefits but may have a shorter physical lifespan. An example would be a grassed buffer strip along a stream that is correct width, species compositions, etc., to meet NRCS Standards and Specifications but the fence keeping livestock out of the area does not meet the standard.
- **Almost Functional Equivalent-** practices that do not meet NRCS Standards and Specifications yet provide some degree of nutrient and sediment reduction. This may include practices that do not meet the NRCS conservation practice standard due to design factors. An example would be a grassed buffer strip along a stream that is less than correct width, or does not have the correct species composition, etc. to meet NRCS Standards and Specifications.
- **Expired Cost-Shared Practices-** are those beyond the contractual lifespan. The practice was originally cost-shared, installed and met NRCS Standards and Specifications. The farmer is voluntarily continuing maintenance of the practice as it continues to provide sediment and nutrient reduction benefits. It now becomes a functional equivalent reported by the state.

Although USEPA does not currently credit practices that meet the "almost functional" standard, the WVDA will continue to collect information on these BMPs in order to present them to the CBP's AgWG for scientific review in the event that they can be approved and credited in the CBWM.

Further field testing has led to updates of the BMP Reference Book, improved consistency of BMP naming between the CBP and West Virginia, and resolution of privacy concerns of farmers by limiting geo-locating to use of a central global positioning system (GPS) coordinate for a farm or field.

As a result of the new tests on the pilot farm, slight adjustments have been made to the tracking and reporting protocol. The WVDA will still use the five Nutrient Management Specialists to collect non-cost-share BMP data. However, when they are in the field mainly for collecting nutrient management information, they will only focus on collecting information on the BMPs that have the highest reduction efficiency, have the greatest effect on scenarios, and are some of the more common/easily identifiable practices on West Virginia farms. The BMPs that the Nutrient Management Specialist will focus on are: animal waste management systems, riparian forest buffers, grass buffers, cover crops, stream protection with fencing, and conservation tillage. The Tracking and Reporting Specialist, however, will gather information on all BMPs present when on the farm.

After training of staff is complete, the WVDA will begin the farm-by-farm voluntary tracking and reporting program. Farmers will be made aware of the program through education and outreach and will call the Tracking and Reporting Specialist to begin participation in the program. A WVDA staff member will make an on-site visit and collect all necessary data and submit it to the Tracking and Reporting Specialist who will then enter the data into the database. The Tracking and Reporting Specialist has been working to promote why the WVDA is conducting this program and what it means to landowners through displays at county fairs, meeting with the Conservation District Board members, and attending the Farmer Feedback Nights sponsored by the West Virginia University (WVU) Extension. Once the program is off the ground, the Tracking and Reporting Specialist will use news articles in local newspapers, Conservation District newsletters, and extension newsletters to spread the word about this program. The WVDA sees the success of this program being linked to efficient execution of the protocol when staff are on the farm so that the farmer will recommend participation to other farmers

Concurrently, the Tracking and Reporting Specialist is working with Tetra Tech to develop a database that will store the information collected. It will be the responsibility of the Tracking and Reporting Specialist to enter all the data collected into the database. Tetra Tech is designing the database to reflect the Field Assessment Sheet. The database will aggregate the data on a county level basis when the report is needed to report to the WVDEP database that serves as the node to the NEIEN. Generating county level data reports for decision makers will also be a feature of the database. The database will also be able to generate farm by farm reports solely for the purpose of re-checking a farm after ten years to verify practices are still in place and to account for any new BMPs a landowner may have installed or the CBP may have approved.

The other side of the tracking and reporting program includes reporting those practices that have lived their contractual lifespan with NRCS or FSA and are therefore no longer reported by the agency, leading to their deletion from the CBWM system. However, the WVDA will try to re-check and verify that such practices are still in place and functioning. This will require cooperation with NRCS and FSA to be able to identify these practices. NRCS and U.S. Geological Survey (USGS) are already cooperating to extract the data so that the practices can be verified. The WVDA looks forward to the result of that cooperation in order to continue to use the expired BMPs in the CBWM.

The WVDA Tracking and Reporting Specialist has also been working with NRCS, FSA, WVCA and WVDEP to develop a Cost-share Tracking Sheet (CSTS) that reporting agencies can use when they report their BMPs for purposes of the CBWM. The CSTS lists the NRCS practice standard and code with the corresponding Chesapeake Bay BMP name so that the agency can report their BMPs properly and include information such as the Chesapeake Bay units, sizes, and land use. The purpose of creating the CSTS is to streamline the process of taking the data given to WVDEP staff to input into the West Virginia node of NEIEN. The CSTS also aims to capture actual field data, such as buffer sizes and stream fencing, to substitute for the assumptions being made in the CBWM. In the future, the CSTS will be reported on the county level by each county field office and will cover the appropriate reporting period.

Because this type of program has never been attempted before by the WVDA, an adaptive management approach will be used to make adjustments to the protocol or database in order to accurately and efficiently collect and submit data. This technique will also be useful as BMPs are revised by the AgWG. The WVDA will be evaluating the program effectiveness and cost/benefit at the end of each year to determine areas of the program that need to be adjusted and determine if the farm-by-farm method is effective. The WVDA is committed to making the process, especially the voluntary process on the farm, as efficient as possible as it recognizes that this program is a major undertaking for its staff and West Virginia's farmers. The initial cost estimate for this program is $950,000 which includes employee travel and wages, database development, and inputting and maintaining the data for each farm. Funding is made possible through the Chesapeake Bay Regulatory and Accountability Program.

In the event that the farm-by-farm approach is not effective, the alternative plan to collect non-cost-share BMPs is to use the farmer self-certification method with a 10-20% spot check of farms as outlined by NACD. At this time, the WVDA will work with USEPA and appropriate NACD staff to develop a protocol for implementing the farmer self-certification method; local stakeholders at the Farmer Feedback Nights preferred this method over the farm-by-farm method. WVDA needs to be assured, however, that information collected via self-certification is accurate and follows the standards outlined by NACD that were developed in conjunction with USEPA. The WVDA believes the farm-by-farm method will achieve the most accurate results and that by re-checking farms in ten years through a survey of BMPs found on the farm previously, the WVDA will be able to meet the desires of the farmers to have a self-certification program.

4.0 Literature Findings

4.1 Agricultural Work Group Proposed Protocols

Results of the literature review are summarized below, generally organized by the main protocols initially proposed by the AgWG.

4.1.1 On-farm assessment by trained personnel

Bracmort et al. (2004 and 2006) conducted a retrospective examination of BMPs implemented in the Black Creek Watershed (IN). A representative sample of grassed waterways, grade stabilization structures, field borders, and parallel terraces installed about 20 years earlier during the Black Creek Project were inspected and assigned a condition score using evaluation tools developed for that purpose. Evaluation of the current condition of the BMPs found that one-third of the practices no longer existed and that the two-thirds that still existed were in fair condition and partially functional. Efficacy of BMPs in reducing nonpoint source (NPS) pollution (evaluated using the SWAT (Soil and Water Assessment Tool) model) varied with their condition. Under good conditions, BMPs alleviated average annual sediment and phosphorus yields at the outlet by 32% and 24%, respectively. As BMPs deteriorate, their ability to reduce sediment and total P diminishes.

Modeling results for BMPs in varying conditions revealed that the average annual sediment yield was reduced by only 10%, which is nearly 3 times less than the reduction corresponding to BMPs in good condition. Estimated average annual phosphorus yield at the watershed outlet was reduced by 17% for BMPs in their current condition, providing nearly 70% of the phosphorus reduction estimated for BMPs in good condition.

4.1.2 Farmer self-assessment, with or without spot-check by agency personnel

The Minnesota Department of Agriculture (MDA) conducts statewide monitoring and evaluation of pesticide BMP use (2007). The MDA conducts biennial surveys of pesticide use practices reported by farmers and conducts field audits within select watersheds.

Florida conducts a number of BMP verification programs based on farmer self-assessment. Under Rule 40E-63 permitting, landowners are required to submit BMP plans based on a point system for various BMPs - 25 BMP equivalents or points were set as the minimum target BMP level (South Florida Water Management (SFWMD) 1999). After the BMP permit plans are approved, Rule 40E-63 requires follow-up post-permit verification of the approved BMP plans on two levels: (1) BMP implementation reports and (2) BMP field verification. Annual BMP implementation reports are required to be submitted to the District; they are to summarize not only the initial implementation of BMPs but also ongoing BMP maintenance and documentation. SFWMD Everglades Regulation Section staff conduct BMP site verifications on an eighteen-month rotational basis to allow examination of BMPs implemented in both wet and dry seasons. Field verification procedures begin with generating a database-driven BMP checklist specific to the permit drainage basin. The checklist consists of all BMPs selected by the permittee to be implemented. The checklist is mailed to the permittee prior to the verification to assist the landowner in preparing his documentation for the inspection. The verifications involve a combination of visual field observations and a review of office records. During the office review the SFWMD staff focuses on records that document soil test results, fertilizer recommendations and applications, BMP training of farm personnel, pump logs, and any other material that supports BMP implementation. While in the field, SFWMD staff note any visual evidence that the selected BMPs have been implemented. This evidence may range from spoil on canal banks indicating canal cleaning was performed, fertilizer banding or land leveling equipment operating, and maintenance of vegetation on ditch banks to reduce sedimentation, to any other observable evidence that supports BMP implementation. The verifications are a “spot check” of the landowner’s implemented BMPs. This spot check is a snapshot in time of how and when BMPs were implemented for that particular field and land use. The SFWMD knows which types of BMPs have been chosen by the landowner for each particular land use and location so a verification can be conducted.

In several other regions of the state, the Florida Department of Agriculture and Consumer Services (FDACS) Office of Agricultural Water Policy (OAWP) runs an Implementation Assurance Program (FDACS 2008). Producers participate by submitting a Notice of Intent (NOI) to implement a checklist of practices applicable to acres being enrolled. The OAWP developed a Best Management Practices Tracking System (BMPTS) to record the submittal of NOIs and assist in tracking BMP implementation. The OAWP issues detailed reports on results of the program. For example, in the Lake Okeechobee Watershed Implementation Assurance Process, each operation is visited upon completion of c/s structural BMPs, to ensure these BMPs have been properly installed, prior to receiving state c/s funds. Overall, Implementation Assurance site inspections are conducted in order of when conservation plans are completed and implemented, generally within 6 months of plan implementation. Staff fill out a review/checklist form and assign an overall rating of “Satisfactory,” “Needs Improvement,” or “Unsatisfactory,” based on the observed condition of BMPs relative to the conservation plan. For operations that receive a “Satisfactory” rating, no follow-up visit is necessary. However, OAWP staff will conduct “routine” site visits approximately annually, depending on the inspection workload. At this time, maintenance of structural BMPs will be reviewed and rated. For a rating of “Unsatisfactory” or “Needs Improvement,” there will be a scheduled follow-up inspection, usually within 120 days to check on progress. Additional follow-up site visits will be scheduled as circumstances warrant. BMPs commonly reviewed during site inspections include both structural (e.g., culverts, culvert risers, fences, water troughs, well capping) and management (e.g., nutrient management, maintenance of structural practices, record keeping) BMPs.

OAWP reports include extensive presentation of findings, survey/review forms, and flow charts of the verification process. No assessment of accuracy or confidence is provided.

4.1.3 Review of Existing Agency or On-Farm Records

Because NRCS is the primary agency involved in BMP planning and implementation, NRCS records are often used as a source of verification information. According to the NRCS electronic Field Office Technical Guide (eFOTG), conservation practice standards and statements of work indicate elements of practice implementation/installation that field staff need to report into NRCS records. Following are four examples of deliverables contained in statements of work. It should be noted that state-specific deliverables may be added as appropriate.

Nutrient Management (590) Statement of Work National Template

Deliverables

1. Records of implementation.
    a. Extent of practice units applied, acres.
2. Guidance for record keeping (implementation records maintained by the producer or agent).
    a. Records of crops produced, planting and harvest dates, yields, residue management.
    b. Records of recurring soil tests, and other tests (e.g. manure, plant tissue, water) used to implement the plan.
    c. Records of recommended nutrient application rates.
    d. Records of nutrient applications including quantities, analyses, and sources of nutrients applied; dates and methods of application.
    e. Records of recurring review of the plan including the dates or review, individual performing the review, and recommendations that resulted from the review.

3. Certification that the application meets NRCS standards and specifications and is in compliance with permits.
4. Progress reporting.

Riparian Forest Buffer (391) Statement of Work National Template

Deliverables

1. Records of application.
    a. Extent of practice units applied.
    b. Width and extent of buffer zones.
    c. Actual plant materials used and protective measures.
2. Certification that the application meets NRCS standards and specifications and is in compliance with permits.
3. Progress reporting.

Cover Crop (340) Statement of Work National Template

Deliverables

1. Records of application.
    a. Extent of practice units applied.
    b. Actual materials used.
2. Certification that the application meets NRCS standards and specifications and is in compliance with permits.
3. Progress reporting.

Water and Sediment Control Basin (638) Statement of Work National Template

Deliverables

1. As-built documentation.
    a. Extent of practice units applied.
    b. Drawings.
    c. Final quantities.
2. Certification that the installation meets NRCS standards and specifications and is in compliance with permits.
3. Progress reporting.

The USDA- Agricultural Research Service (ARS) Little River Experimental Watershed (LREW) in Georgia has been the site of several BMP verification efforts. Sullivan and Batten (2007) used historical paper files and maps (circa 1980-2006) to develop a digital geographic database of conservation practices supported by the NRCS. Watershed boundary, USDA tract boundaries, and field boundaries were digitized from USGS quadrangles. An associated database file was created containing county names, tract and field numbers, the NRCS program under which the practice was granted, the NRCS practice number and description, the NRCS estimated acreage covered by the practice, the completion date, and whether the practice was of cost or no cost to NRCS. Results showed that nearly 16% of the land area in the LREW had participated in one or more NRCS recommended conservation programs within the last 30 years. Forty-seven different conservation practices were observed within the LREW, ranging from fish pond management to grassed waterways. The most predominant conservation practices observed were: nutrient management (13.1% of all practices), pest management (12.9%), grassed waterways (9.6%), contour farming (9.5%), seasonal residue management (8.9%), and terraces (8.8%). Some 46% of BMPs were implemented voluntarily with technical assistance provided by NRCS field staff. Cost-share programs predominantly funded the establishment of grassed waterways, terraces, nutrient management, and pest management. Voluntarily implemented practices consisted primarily of contour farming, residue management, and nutrient management.

Settimi et al. (2010) subsequently used the LREW BMP database in a USDA Conservation Effects Assessment Project (CEAP) study to evaluate the effectiveness of federally funded conservation programs. Using a subwatershed database having complete field coverage of four LREW subwatersheds (with and without NRCS assistance), GIS databases were queried to evaluate the adoption and placement of erosion control practices that were visible in a 2005 digital orthoquad. Forty-seven percent of all fields in the subwatershed database had implemented visible erosion control–specific conservation practices. Implementation was linearly related to slope class (r^2 = 0.64, $p < 0.10$). Fields identified as having participated in federally funded conservation programs coincided with high resource concern areas 35% of the time.

Reid-Rhoades et al. (2008) and Wilson et al. (2008) endeavored to determine the effectiveness of conservation practices for reducing sediment yield in Topashaw Canal watershed (TCW) in north-central Mississippi. A census of conservation practices installed within the TCW by various governmental agencies (NRCS, USDA Farm Service Agency, and US Army Corps of Engineers) was compiled by collecting land management history for tracts that were currently or had participated in conservation incentive programs such as EQIP (Environmental Quality Incentives Program), CRP (Conservation Reserve Program), and special regional erosion control projects. Descriptive data were entered into spreadsheets with the funded conservation program identified by tract number and sensitive information (e.g., landowner identifiers) removed. Spatial coordinates associated with each practice were recorded to prepare data sets for watershed modeling with AGNPS (AGricultural Non-Point Source Pollution Model) and SWAT. This was done using 1996 aerial photographs from the Farm Service Agency (FSA) offices with the tract numbers for each funded conservation practice identified. Satellite imagery for December of 2006 provided current aerial photography of land use. These images were verified by making GPS measurements at about 30 known points within the TCW that were easily identified in the images. The practice data were interpolated into spatial information through the creation of digitized polygons using scanned aerial photos that associate land use management schemes with tract numbers. Land use practices that were not included in government incentive programs were compiled from agency data and satellite imagery.

Jackson-Smith et al. (2010) used intensive field surveys and interviews with program participants to assess the accuracy of using official records as a measure of short- and long-term BMP use in a northern Utah watershed. The researchers worked in the local USDA offices to review the official contract files for each of the 90 landowners or farmers who participated in the Little Bear River Watershed Project (LBRWP) from 1992 to 2006. They gathered and entered into a database (1) official NRCS practice codes and additional detailed information about each specific conservation practice that participants were contracted to implement during the life of the LBRWP, (2) the FSA farm tract and field numbers describing where each practice was located, (3) general information about each operation, and (4) contact information for each program participant. The researchers focused on whether or not the BMP still existed or was actively being used and maintained, regardless of current contract status, although contract dates were noted. In addition, aerial photographs of each participant's land were photocopied, and based on the information from the files, markings were placed on the photocopied images to signify where each of the contracted BMPs was located on the physical landscape. Face-to-face interviews were conducted with 55 of the original 90 participants. Following each interview, the original database of LBRWP BMPs was updated to note instances where the participant reported information that conflicted with that obtained from the NRCS files. Subsequently, researchers determined the implementation status for each BMP included in a participant's original files using several techniques. Initially, they shared a list of BMPs on file and the aerial photographs with respondents and systematically reviewed each practice to discover whether or not the practice was successfully implemented, whether they encountered any problems during the implementation of the practice, and whether or not they were still using the practice. While a seemingly simple exercise, coding the implementation status for BMPs was sometimes complex. During interviews, several instances were encountered where a respondent indicated no recollection of a particular BMP being part of their contract and numerous others where they insisted that the description of the practice (usually drawn from the NRCS practice code definitions) was not a completely accurate characterization of what happened. The net result of post-interview coding was to create a new set of tabular and spatial databases that represent an updated (and presumably more accurate) catalogue of conservation behaviors in the Little Bear River watershed.

Overall, Jackson-Smith et al. (2010) determined that project participants could not verify implementation for 88 (16%) of the contracted BMPs. Most of these were instances where all available evidence pointed to a failure to successfully implement the practice, though a handful of cases involved misclassified BMPs where a different type of practice was actually carried out. In almost every case of non-implemented BMPs, respondents simply did not recognize the practice as being part of their original project. Another group of respondents described what they had done in connection to a contracted management BMP, but it was apparent to the research team that their actions did not meet even a minimal definition of the changes in behavior implied by adoption of this type of BMP. Overall, it was determined that over 20% of implemented BMPs appeared to be no longer maintained or in use. BMPs related to crop production enterprises and irrigation systems had the lowest rate of continued use and maintenance (74% to 75%), followed by pasture and grazing planting and management BMPs (81%). By contrast, nearly every instance of fencing and riparian protection structures in the files were found to have been implemented on the study farms. Generally speaking, structural BMPs and practices for which c/s was available were more likely to be implemented, perhaps because they involved greater investment of public and private funds. However, the implementation gap between cost-shared and non-cost-shared practices was not as significant as anticipated. Although c/s is often believed to be an essential incentive to encourage use of BMPs, in this study, the majority of practices implemented were unfunded, although the rate of implementation of unfunded practices was significantly lower than the rate of c/s practices.

The study findings suggested that official watershed program contracts and related records can be a very useful resource for describing patterns of conservation behaviors at the watershed scale but that they may not provide a complete and accurate description of BMP adoption and related behaviors instigated by a conservation program. Management practices are particularly susceptible to non-implementation and maintenance.

4.1.4 SURVEYS AND STATISTICAL SAMPLING

Tetra Tech, Inc. developed for USEPA (USEPA 1997) a guidance document intended to assist state, regional, and local environmental professionals in tracking the implementation of BMPs used to control agricultural NPS pollution. Information is provided on methods for selecting sites for evaluation, sample size estimation, sampling, and results evaluation and presentation. The focus of the guidance is on the statistical approaches needed to properly collect and analyze data that are accurate and defensible. Probabilistic sampling designs are discussed – including simple random sampling, stratified random sampling, cluster sampling, and systematic sampling – to meet specific objectives for tracking and evaluating the implementation of BMPs. Measurement and sampling errors are also examined. Sources of information are listed, including the USDA NRI (National Resources Inventory), the USDA Census of Agriculture, the National Agricultural Statistics Service (NASS), local USDA program information, FSA data, and state Cooperative Extension.

The guidance documents methods for estimating sample sizes required to compute point estimates such as proportions and means, as well as detecting changes with a given significance level for a variety of sampling designs. Methods for evaluating data through statistical hypothesis testing are presented. A chapter addresses the process of determining whether agricultural BMPs are being implemented and whether they are being implemented according to approved standards or specifications. Guidance is provided on what should be measured to assess BMP implementation, as well as methods for collecting the information, including physical farm or field evaluations, mail-and/or telephone-based surveys, personal interviews, and aerial reconnaissance and photography. Designing survey instruments to avoid error and rating BMP implementation are also discussed. Self-evaluations, while often not a reliable source of BMP implementation data, are proposed as a way to augment data collected through expert evaluations or in place of expert evaluations where the latter cannot be conducted. Aerial reconnaissance and photography are also discussed as data collection tools, although newer and better technology is now available.

NASS provides timely, accurate, and useful statistics in service to U.S. agriculture using both censuses and surveys. A survey employs a sample selected from a target population and uses statistical techniques to make inferences about that population. Most NASS programs use a survey to obtain representative data. A census is a complete enumeration of the entire population. The Census of Agriculture is the largest and best known census administered by NASS. The most important survey data sources are farm or ranch operators who voluntarily supply information about their operations. NASS reports provide broad coverage of agriculture, including about 120 crops and livestock items, and supplies statistics on a variety of additional subjects important to agriculture, e.g., cropping practices and land use, fertilizer, number and size of farms, farm labor and wages, prices received and paid by farmers, and weekly weather and crop reports. Data are collected through mail, telephone, face-to-face interviews, and on line.

While NASS does not ordinarily collect comprehensive data on BMPs, for the upcoming 2012 Census of Agriculture, farmers and ranchers will be asked to report number of acres on their operations that were drained by tile, artificially drained by ditches, and under a conservation easement. NASS will also ask for the number of cropland acres under no-till, conservation tillage, conventional tillage, and planted to cover crop (excluding CRP). NASS will conduct special projects for other agencies or states under contract, as long as NASS standards and protocols are followed. Statistical measures of accuracy and confidence are computed for all surveys and data are included with each report. Details on NASS programs and procedures are available at: http://www.nass.usda.gov/Education_and_Outreach/Understanding_Statistics/index.asp.

Lambert et al. (2007) presented information on the CEAP-Agricultural Resource Management Survey (CEAP-ARMS) of 2004. This survey represents an annual source of data on the finances and practices of a nationally representative sample of U.S. farms that also includes information on the characteristics of the farm operators and their households. The CEAP-ARMS questionnaire links ARMS farm household, resource, and economic data directly to CEAP production practice and program participation data, and corresponding field-specific NRI data. The paper is an exercise of integrating different data sources of varying precision to draw conclusions about influences of socio-economic factors on adoption of conservation practices and environmental benefits.

Cunningham (2003) and Benham et al. (2005) developed sixteen survey-like assessment tools to address the need for a low-cost, rapid method of quantifying the quality of agricultural BMPs. BMP quality was defined as the adherence to design, site selection, implementation, and maintenance criteria as specified by state and federal conservation practice standards. Quality assessments are made based upon visual observations of BMPs rather than traditional assessment methods such as water quality monitoring. Tools were developed and tested as part of a proof of concept study. A different assessment tool was designed for each of 16 distinct BMP types (e.g., waste storage, grassed filter strips, cover crops, stream fencing) based on c/s guidelines, NRCS standards, and other practice criteria. Each tool included a mix of nine types of question/answer sets: interview open-ended, interview multiple-choice, interview binary (yes/no), interview multiple-choice photograph selection, assessor chosen open-ended, assessor chosen binary, assessor chosen multiple-choice, binary post-data collection, and multiple-choice post-data collection. A scale of one to five was used as the scoring system for each assessment question. One hundred and fifty-five cost-shared and 150 non-cost-shared BMPs were assessed on 128 farms in the James River Basin of

Virginia. Results indicated no significant statistical difference between the overall quality of cost-share and non-cost-share practices within any indicator BMP category. Overall, the quality of the cost-share and non-cost-share practices assessed was roughly equal. No consistent identifiable trend of c/s status and BMP quality was readily evident from the data.

Storm et al. (2006) reported on a detailed 2005 survey given to Oklahoma State University Cooperative Extension Service agents and specialists to gain an understanding of agricultural practices and land covers that occurred from 1996 to 2001 in the Fort Cobb (OK) basin. This survey went into great detail about the different types of crops in the basin along with different tillage practices, common double crops, fertilization rates, cattle stocking rates, and harvest dates. Results from the survey indicated that over thirty different agricultural land covers/practices occurred in the basin. During the summer of 2005, an additional field survey of all cultivated fields in the basin was conducted, including several pieces of pertinent information to develop a new land cover map. The information collected included current crop, previous double crop, tillage practice, presence of irrigation, cattle grazing, and vegetation height. Each cultivated field was mapped using National Agricultural Imagery Program (NAIP) aerial photos and ArcMap software. Survey staff drove the entire basin with a laptop connected to a GPS unit with real time tracking. When they encountered a cultivated field, they delineated field boundaries and other information using NAIP photos displayed within ArcMap. To improve accuracy, the GPS unit would plot an icon or marker to represent their location on the aerial photos. The survey was compiled to create a highly detailed crop data layer. The advantage to this approach compared to the previous model was the ability to distinguish crop types.

Veith et al. (2008) compared SWAT modeling of a small northeast watershed under two different resolutions of input data. Management practices of individual fields over an 11-year period (1994-2004) were obtained from annual farmer surveys. The surveys included tillage, fertilizer, plant, and harvest dates and methods for each crop. Results suggested that while detailed input data can enable the model to provide valuable water quality information, research efficiency during exploratory and initial problem-solving efforts might be maximized by using more easily obtained, although more general, data.

In Canada, MacKay et al. (undated) reported that BMP adoption information is collected by a variety of organizations including government, producer groups, and conservation authorities, and is often driven by a specific agri-environmental program. This information is often not synthesized in a way that can provide information on overall BMP adoption across the country, and therefore is challenging for policy makers to make use of it. A BMP Adoption Index has been developed to synthesize this variable information. The BMP Adoption Index calculates a BMP adoption score for farmers based on their responses to the Farm Environmental Management Survey (FEMS). This survey was conducted by Statistics Canada using a representative stratified sample of 20,000 crop and livestock farmers across Canada after the 2006 growing season. The questionnaire asked crop farmers about manure and fertilizer spreading, pesticide application practices, tillage practices, and crop residue management, and asked livestock producers about livestock housing, manure storage and treatment, and grazing management practices. Both crop and livestock farmers were asked about land and water management, hazardous waste management, and environmental farm planning. The survey collected data on all practices being implemented, not just BMPs, in order to gain an understanding of the range of practices being implemented on farms across Canada. In total, 184 practices were included in the calculation from the crop questionnaire and 214 practices were included from the livestock questionnaire. Ninety-six of these practices were common to both questionnaires. The BMP Adoption Index is calculated by combining the management practices being implemented by each survey respondent in 2006 with a ranking that reflects the efficacy of the management practice in improving the environmental performance of a farm. The ranking scale ranges from 1 to 5 where 1 indicates a poor practice that is expected to cause environmental degradation, 3 indicates a neutral practice and 5 indicates the most beneficial practice that is expected to reduce or eliminate risk and provide benefits to the environment. Note that the use of the Index aggregates all BMPs.

The Conservation Technology Information Center (CTIC) conducts an annual tillage/crop residue survey in the Midwest using a detailed roadside transect survey procedure (CTIC 2008). The cropland roadside transect survey method is designed to gather information on tillage and crop residue management systems. Experience has been that counties with a grid road system, those with fields readily visible from the road, where crops are planted in a relatively short period of time, and where conservation tillage is being adopted are the most likely candidates for conducting a transect. Note that the deliberate selection of areas where conservation tillage is being adopted may represent a significant bias to the survey. The purpose of the survey is threefold: (1) to provide information that can be used by individual soil and water conservation districts and others in establishing priorities for educational or other programs, (2) to evaluate progress achieved in reaching county or statewide goals, and (3) to provide accurate data on the adoption of conservation tillage systems by crop for the CTIC National Crop Residue Management Survey. This makes the transect survey an ideal tool for assessment as well as measuring progress for locally led conservation. When conducted properly, this cropland transect survey procedure provides a high degree of confidence in the data summaries. Users can have 90% or more confidence in the accuracy of the results. This level of reliability translates into data summaries that can help guide the local or state decision-making process. Several states have used transect data to allocate cost-share funds, develop new resource management goals, and to provide information to the general public about the positive impact of progress on land use trends. CTIC describes the specific steps involved in conducting the survey, addressing issues such as establishing a driving route, selecting the survey date and team, collecting the survey data, and calculating the crop acreage and percentage of coverage for each tillage system.

Shukla et al. (2006 a and b, 2010) reported on Florida surveys conducted in cooperation with the Gulf Citrus Growers Association (GCGA) and FDACS to document and assess adoption of BMPs by Florida citrus producers. The survey questionnaire included five major water quality BMP categories: water volume, sediment control, aquatic plant control, pesticide use, and nutrients. The survey captured grove-specific BMP adoption data by asking general questions descriptive of grove management and the importance of BMPs with regard to water quality benefits and grove profits. To determine if a particular practice was in use, growers were asked if they implemented it consistently or not. A third choice of "sometimes" indicated that this practice was not implemented on a regular basis. To understand whether or not a practice was acceptable to the growers, one of the choices was "disagree with the practice." To determine whether a grower would be willing to implement a practice in the future, two additional choices, "plan to use" and "would if cost-shared," were also included. The latter choice determined the potential for implementation of a specific BMP if federal and/or state c/s funds were made available to offset a portion of the implementation cost. Sixty groves covering an area of 115,791 acres were surveyed by personally interviewing the farm manager. The surveyed acreage was distributed between large (>1,000 acres), medium (250-1,000 acres), and small groves (<250 acres). From a water quality standpoint, the percentage of grove land area affected by a specific BMP is more important than the percentage of total grove number. Therefore, almost all of the *large* groves in the region (104,170 acres) were included in the survey. In addition, 75% of *medium*-size groves (9,982 acres) in the Gulf Citrus Production Area were included in the survey. The area occupied by the surveyed *small* groves was 1,639 acres. The grove name and location were kept confidential. The results report the percentage of surveyed area using various BMPs, but includes no assessment of error or statistical confidence.

In April 2010, the USDA NASS conducted a survey of Maryland's commercial agricultural producers regarding BMP implementation and nutrient management planning (Lichtenberg et al. 2010). The University of Maryland commissioned the survey to provide a snapshot into current practice implementation to assist the state when developing its Chesapeake Bay TMDL Watershed Implementation Plan (WIP). Survey questions specifically highlighted prevalence of BMP usage, BMP adoption by farm size and use of c/s by farm size. Results also provided information on NMP compliance, preparation, and content, particularly nutrient targeting and testing. Results indicated that most conservation and nutrient management BMPs are used by relatively small shares of farm operations. A breakdown of adoption rates by farm size indicates BMP use is substantially greater among larger operations than small ones. Use of c/s is relatively low for conservation BMPs and nutrient management practice use, indicating that most BMP adoption is self-funded. However, a strong relationship was not observed between farm size and use of c/s to implement BMPs. Of those who are required to have an NMP, 63% have a plan while the remaining 37% do not; however, compliance varies systematically with farm size. Small operations have the lowest compliance rates. UMD Extension personnel prepare the largest share of plans.

The NRCS reported on a farmer survey conducted to obtain information on the extent of conservation practice use in the Chesapeake Bay region for the period 2003–06 (USDA-NRCS 2011). Information on farming activities and conservation practices was obtained primarily from a farmer survey conducted as part of the overall CEAP assessment. The assessment included not only practices associated with Federal conservation programs but also the conservation efforts of states, independent organizations, and individual landowners and farm operators Conservation practices that were evaluated include structural practices, annual practices, and long-term conserving cover.

Data on structural BMPs were obtained from the NRI-CEAP cropland survey, NRCS field office records, FSA CRP information, and the 2003 NRI.

The survey results define the "baseline conservation condition."

- Structural practices for controlling water erosion are in use on 46% of cropped acres, including 63% of the highly erodible land (HEL).
- About 88% of the acres have a conservation tillage system in use including no-till (48%) or mulch till (40%).
- Producers use residue and tillage management practices, structural practices, or both, on nearly all (96%) cropped acres in the region.
- Appropriate rates of nitrogen application are in use on about 35% of the acres receiving nitrogen (including manure) for all crops in the rotation.
- Appropriate timing of nitrogen application is in use on about 54% of the acres receiving nitrogen (including manure) for all crops in the rotation.
- Good nitrogen management practices (rate, timing, and method) are in use on about 13% of the acres receiving nitrogen (including manure) for all crops during every year of production.
- Good phosphorus management practices (rate, timing, and method) are in use on 17% of the acres receiving phosphorus (including manure) for all crops during every year of production.
- While most acres have evidence of some nitrogen or phosphorus management, there is an opportunity to enhance existing nutrient management practices on most acres, especially those receiving manure.
- Land in long-term conserving cover, as represented by enrollment in the CRP General Signup, consists of about 100,000 acres in the region (2% of cultivated cropland acres), of which 67% is HEL.

4.1.5 Remote sensing

NASS employs three major applications of remote sensing with respect to crop acreage estimates. First is the operational construction of the nation's area sampling frame for agricultural statistics, which has used satellite imagery as a major input since 1978. The area sampling frame is the statistical foundation for providing agricultural estimates with complete coverage of American agriculture. Crop acreage estimation is only one part of this system. The second application, which is now done for seven to ten states per year, has been the use of satellite imagery to improve the statistical precision of crop acreage estimate indicators, especially at the county level in those states. This was the first NASS application of Landsat data and it began in 1972.

The third application, and most popular with GIS data users, is the formation of a public use GIS data file called the Cropland Data Layer. The Cropland Data Layer is the crop specific categorization of the "best available" set of Landsat (30 meter resolution) digital imagery for the crop(s) season of interest. Data users have recently used the Cropland Data Layer to aid in watershed monitoring, soils utilization analysis, agribusiness planning, crop rotation practices analysis, animal habitat monitoring, prairie water pothole monitoring, and in the remote sensing/GIS value added industry. Additional information on NASS use of remote sensing data can be found at:

NASS http://www.nass.usda.gov/Surveys/Remotely_Sensed_Data_Crop_Acreage/index.asp.

Daughtry et al. (2004) set out to determine the spectral reflectance of crop residues and soils and to assess the limits of discrimination that can be expected in mixed scenes. Spectral reflectances of dry and wet crop residues plus three diverse soils were measured over the 400–2400 nm wavelength region. Reflectance values for scenes with varying proportions of crop residues and soils were simulated. Additional spectra of scenes with mixtures of crop residues, green vegetation, and soil were also acquired in corn, soybean, and wheat fields with different tillage treatments. The spectra of dry crop residues displayed a broad absorption feature near 2100 nm, associated with cellulose-lignin, that was absent in spectra of soils. Crop residue cover was linearly related (r^2 = 0.89) to the Cellulose Absorption Index (CAI), which was defined as the relative depth of this absorption feature. Green vegetation cover in the scene attenuated CAI, but was linearly related to the Normalized Difference Vegetation Index (NDVI, r^2 = 0.93). A novel method is proposed to assess soil tillage intensity classes using CAI and NDVI. Regional surveys of soil conservation practices that affect soil carbon dynamics may be feasible using advanced multispectral or hyperspectral imaging systems.

Sullivan et al. (2008) evaluated the usefulness of Landsat TM data as a tool to depict conservation tillage in the Little River Experimental Watershed in Georgia. Satellite imagery was used to calculate four commonly used indices: NDVI, Crop Residue Cover Index, Normalized Difference Tillage Index, and the Simple Tillage Index. Ground truth data consisted of a windshield survey, assigning each site a tillage regime (conventional or conservation tillage) at 138 locations throughout the watershed and surrounding areas. A logistical regression approach was used on two subsets of the data set *(n* = 20 or n = 44) to determine the influence of the number of ground control points on the success of modeling the occurrence of conservation tillage. The most accurate model was re-applied to the satellite image and evaluated using an independent sample of 94 survey sites. Results indicate that the normalized difference tillage and simple tillage indices performed best, with an overall accuracy of 7l% and 78% for models developed using n = 20 and n = 44 sample locations, respectively. Errors were typically in the form of commission, e.g., misclassification based on unusual soil color. Results are encouraging and suggest that currently available satellite imagery can be used for rapid assessment of conservation tillage adoption using minimal a priori information.

Hively et al. (2009a and b) combined cost-share program enrollment data with satellite imagery and on-farm sampling to evaluate cover crop N uptake on 136 fields within the Choptank River watershed, on Maryland's eastern shore. The NDVI was a successful predictor of aboveground biomass for fields with >210 kg/ha (>187 lb/ac) of vegetation (corresponding to 4.2 kg/ha [3.7 lb/ac] of plant N), below which the background reflectance of soils and crop residues obstructed the cover crop signal. Cover crops planted in the two weeks prior to the regional average first frost date (October 15) exhibited average fall aboveground N uptake rates of 18, 13, and 5 kg/ha (16, 12, 4 lb/ac) for rye, barley, and wheat, respectively, corresponding to 1,260, 725, and 311 kg/ha (1,124, 647, 277 lb/ac) of aboveground biomass, with associated c/s implementation costs of $5.49, $7.60, and $19.77 /kg N ($2.50, $3.46, and $8.99 /lb N). Cover crops planted after October 15 exhibited significantly reduced biomass and nutrient uptake, with associated program costs of $15.44 to $20.59/ kg N ($7.02 to $9.36 /lb N). Agronomic factors influencing cover crop performance included species, planting date, planting method, and previous crop. Field sampling locations with >1,000 kg/ha (>890 lb/ac) of springtime cover crop biomass exhibited greatly reduced soil nitrate (<3 mg/kg [<3 ppm]) in comparison to fields with low cover crop biomass (up to 14 mg/kg soil nitrate), indicating a target biomass threshold for maximum water quality impact. Additional sampling years will be necessary to account for cover crop response to climate variability. Combining remote sensing with farm program data can provide important information to scientists and regulators working to improve conservation programs. Results can be used to more effectively use scarce conservation resources and increase water quality protection.

Summarizing the methods of Hively et al. (2009a and b):

Cover Crop Implementation Data. Cover crop implementation data, including digitized field boundaries, cover crop species, planting date, planting method, and previous crop were obtained from the MDA. These data were transcribed from cover crop c/s program enrollment documents that were filled out by participating farmers in the fall of 2005. A total of 136 cover-cropped fields located within the study area were included in the evaluation. A digitized boundary polygon delineating each cover-cropped field was provided by the MDA, based on FSA Common Land Use boundaries and field-specific SCD farm planning documents.

On-Farm Sampling. On-farm sampling was performed on a subset of cover-cropped fields within a week of each satellite image acquisition. The collected data were used to provide calibration of satellite image interpretation (correlation of NDVI to biomass), to estimate cover crop tissue N content for use in calculating nutrient uptake, and to monitor residual soil nitrate.

Remote Sensing Imagery. Multispectral satellite images of the study area (SPOT 5, >90% cloud-free, <20° incidence angle, 10 m [32.8 ft] resolution, four spectral bands, 60 × 60 km [37.3 × 37.3 mi] coverage) were acquired on December 22, 2005, and March 31, 2006. These image acquisition dates were respectively selected to represent total fall and total springtime cover crop nutrient sequestration. Cost-share program data associated with each enrolled field were then used to correlate estimated biomass production and nutrient uptake with agronomic factors (cover crop species, growing degree day, planting method, and previous crop).

Results. A multivariate log-linear model of biomass production, $\ln(\text{Biomass}) = a + b(\text{NDVI}) + c(\text{ImageDate}) + d(\text{Species}) + \varepsilon$, (2) where a is the intercept, b, c, and d are linear coefficients, and ε is residual error, revealed significant effects of NDVI (primary predictor variable, explaining 73% of observed variation), satellite image acquisition date (explaining 3.7% of variability, likely attributable to differences in atmospheric optical conditions at times of satellite overpass), and cover crop species (explaining, in addition to NDVI signal, 4.2% of observed variation, likely attributable to differences in cover crop growth habits and leaf angle in relationship to leaf area index). The remaining 19% of observed variability in measured cover crop biomass was attributed to the unexplained error term. Further research might succeed in reducing model error by attributing components of observed variability to additional predictive factors.

Using remotely sensed satellite imagery, cover crop nutrient uptake efficiencies can be derived at the landscape scale, accounting for the effects of spatial variability and providing insight into agronomic factors affecting cover crop productivity. The results of this study, although they must be corroborated over several growing seasons to account for the effects of climate variability, have strong implications for evaluating and improving the success of cover crop programs and promoting effective water quality protection strategies.

4.2 Hybrid Approaches

Several BMP verification efforts have comprised combinations of two or more of the broad protocols identified by the AgWG.

Tomer et al. (2008) conducted a conservation practice inventory for the South Fork of the Iowa River, 85% in corn and soybean rotations, to describe the extent and placement of key conservation practices in the watershed and evaluate the results in the context of four years of concurrent, detailed water quality data. Cropping rotations were determined using annual classified satellite data made available by NASS (USDA NASS 2007). The satellite data are subject to a supervised classification (i.e., a classification guided by human judgment) aimed to identify commodity-crop acreages (i.e., corn and soybean in Iowa) with minimal error. Five years of classified data (2000 to 2004) were overlaid to map the dominant crop rotations occurring on agricultural lands within the watershed. Agricultural field boundaries, provided by FSA, were used as a majority filter for each year of crop-cover data to provide a single five-year sequence of cover for each field. The observed crop-cover sequences were then grouped to represent dominant rotations in the watershed, including two-year (corn-soybean), three-year (corn-corn-soybean), and longer rotations based on number of consecutive years with corn up to five years (ie., continuous corn). Fields with sequences dominated by grass (pasture) were assigned as permanent cover, and perennial rotations were assigned to fields where the crop sequence included a third crop (in addition to corn and soybean) because the third crop was typically classified as alfalfa or hay in the NASS data.

The distribution of manure applications within the watershed was estimated using a GIS model that divided the N load from each concentrated animal feeding operation (CAFO) facility by the areas of increasingly sized circles (in 40-m [131-ft] radius increments, without overlap) until the area within the circle accommodated the N load at an application rate of 200 kg N ha^{-1} (179 lb ac^{-1}) for corn. The application rates assigned to fields within the circles were varied to account for the observed crop rotation by assigning the full rate to fields where three or more consecutive years of corn and half the rate where 2- or 3-year corn-soybean rotations were observed. This essentially assumes manure application occurs prior to corn and not prior to soybean.

An inventory of conservation practices was conducted during the first half of 2005. The inventory was conducted by NRCS and included four steps. First, a search of records of the agency's progress reporting system with contributions from four local NRCS field offices was conducted. Second, aerial photos were interpreted and digitized to map visible conservation practices such as terraces and grass waterways. Third, a field-by-field, drive-by survey was conducted during May 2005 to provide a snapshot of tillage practices throughout the watershed and confirm the progress reporting system data and air photo interpretations where possible. The survey was conducted by NRCS personnel with knowledge of local tillage systems and experience in estimating residue cover. Data were digitally collected in the field, using tablet-style, touch-screen computers equipped with GPS signal tracking to ensure mapping accuracy. A GIS coverage of the watershed's fields, with field boundaries provided by the FSA common land unit system that documents agricultural lands participating in USDA programs, provided the base map for touch-screen linkage to a data-entry interface. Specialized GIS software was developed to expedite the survey process, which included pull-down menus, accessible by field, with tag-lists of common practices and opportunity to annotate the record, correct existing information, and digitize features missing from the office-prepared map coverage that were observed in the field. Four persons, paired in two trucks, completed the field survey in about three weeks. The final step was to combine the survey data entered by crews and build the final inventory product, a completed GIS project detailing practices by field, which excluded all ownership information. Evaluation of conservation practices in the watershed was conducted by GIS overlay with NRCS Soil Survey Geographic data, particularly HEL and hydric soils, stream proximity, and with crop rotations and anticipated manure application areas, determined as described above. All this information was placed onto a single spreadsheet, which was sorted and filtered to determine areas where resource concerns and conservation practices overlapped.

The survey of conservation practices showed mulch tillage (>30% residue cover) was the dominant class of residue management, covering 58% including one large field (226 ha [558 ac]) under ridge tillage in the Tipton Creek subbasin. Conventional tillage (herein, conventional tillage refers to tillage systems that result in >70% of crop residue being incorporated beneath the soil surface) occupied about 29% of the agricultural land, with no-tillage more limited in extent (7%). About 20% of the cropland is in fields with grassed waterways and/or terraces. There are also water and sediment control structures in 46 fields, protecting 1,185 ha (2,925 ac). Unfortunately, no assessment of error or statistical confidence was reported.

Grady et al. (undated) demonstrated and evaluated three different methods for obtaining geospatial information for BMPs in a mixed use watershed in central Indiana. The researchers obtained geospatial information for BMPs through government records, producer interviews, and remote sensing aerial photo interpretation. Aerial photos were also used to validate the government records and producer interviews. This study shows the variation in results obtained from the three sources of information as well as the benefits and drawbacks of each method. Using only one method for obtaining BMP information can be incomplete, and this study demonstrates how multiple methods can be used for the most accurate picture.

Summarizing the methods of Grady et al. (undated):

> ***Government Records***. Records from three agencies were obtained in 2010. USDA agency records required a Memorandum of Understanding (MOU) to follow the requirements of Farm Bill Section 1619.
>
> ***Producer Interview Data***. Agricultural land owners and operators were interviewed in the winter of 2007/2008. All 54 producers in the watershed were contacted to participate; 32 were interviewed, for a response rate of 59%. Interviews followed a semi-structured interview guide, dealing with a range of topics related to conservation on the producer's land. These topics included reasons for use/non-use of conservation practices, environmental awareness and attitudes, and funding for agricultural practices. In addition to qualitative data collected, producers were asked to provide locations of structural conservation practices and to outline fields with various operational practices on provided maps. These spatial locations were then digitized into a GIS. The interviews collected data on six conservation practices: conservation tillage, cover crops, grassed waterways, filter strips, nutrient management, and pest management.
>
> ***Aerial Photo Interpretation***. Orthophotos of the watershed were available for each year between 2003 and 2010. High resolution imagery from 2005 with a resolution of 1 foot collected as a part of the Indiana Statewide Orthophotography Project served as the basis for analysis and classification of BMPs. These photos were taken before the growing season and therefore show agricultural fields without vegetation and trees without leaves (leaf-off). Photos taken in the summer (leaf-on) with 1 meter resolution from the National Agricultural Imagery Program (NAIP) at the USDA for all other years provided complementary information, such as evidence of the rapid land use changes in this watershed. The 2010 photos helped with identifying BMPs in cases where records indicated past management practices but the land was no longer in agriculture. In addition, seasonality between orthophotos enhanced the ability to interpret these images. The method used for identifying BMPs from aerial photographs used a grid system. A grid layer was created using tools in ArcGIS 9.3 and overlaid on the watershed. Each grid cell was 900 m^2 which was the distance and scale at which the 2010 aerial photos can be viewed on the computer screen without compromising clarity, allowing for examination of each section of the watershed at the same scale.
>
> Structural BMPs were analyzed separately from operational BMPs because they could be confirmed through aerial photos. Three structural practices (subsurface drain, stream bank erosion control, and wetland creation), for which information was obtained from NRCS records, could not be identified through aerial photos and therefore they were not included in the analysis of structural practices.
>
> Government records provided information on more practices than the other two sources. However, this source of information would not be adequate on its own, due to at least four

difficulties associated with the use of government records. First, obtaining information regarding spatial data for management practices from USDA agencies programs required special permission through an MOU, and then cooperation from the various agencies that provided the records. Although individual staff members were helpful, the process (resulting from the restrictive language in the 2008 Farm Bill) was cumbersome and time-consuming. In addition, important watershed stakeholders such as watershed groups may not be approved for this information release. Second, the data provided lacked some information that would have been helpful. Spatial locations provided by one of the agencies (FSA) did not contain attribute data that would provide descriptive information about the practice such as practice type and date of implementation, while the data provided by NRCS was georeferenced to the centroid point of the land unit where it was implemented, rather than including the precise location and shape of the actual practice. Government records also did not contain information about dates of practice installation. This type of temporal information would be useful for monitoring maintenance/upkeep of practices over time and for more accurate comparison with remote imagery (for which dates are always available). Third, the data provided by NRCS were in a format designed for national record-keeping, consisting in some cases of a separate record for each resource concern addressed by a practice rather than an effort to determine practices in a watershed. This facilitates crediting of practices to the resource concern at a national level, but these records had to be manually combined to represent the true number of practices installed in the watershed. Fourth, government records do not reflect the extent to which practices were fully implemented nor whether they are being adequately maintained (Jackson-Smith et al. 2010). Finally, government records were incomplete and likely under-represent the true total of BMPs in the study area

The producer interviews were the unique information source for 29 structural practices and 155 operational practices because operational BMPs such as nutrient management cannot be identified through photos or other remote sensing. If these practices are implemented without government program incentives (and therefore not present in government records), directly asking producers, either through interviews or surveys, is the only way to gather the spatial and temporal locations of these practices. However, these methods are limited by response rates within a watershed.

Photos were the unique source for 24 structural practices in this study, but if aerial photo digitization had been done without knowledge of other BMP records, this technique would have yielded many more BMPs. Current high-resolution photos provide an unprecedented source of information on agricultural practices that has not often been fully utilized. Photos taken annually can be used to estimate dates of practice implementation.

The Ohio River Basin Trading Project, a new joint venture by the Electric Power Research Institute (EPRI), the American Farmland Trust (AFT), and others, is a project that promotes the achievement of water quality goals for nutrients through a trading program that allows permitted emitters to purchase nutrient reductions from another source (EPRI 2012). In this case, farmers who install BMPs can sell their nutrient reductions to permitted emitters such as power plants and wastewater treatment facilities.

For a nonpoint source to generate a credit, it must reduce its loading of N or P below current conditions. Only non-NRCS cost-shared practices are eligible for crediting. Agricultural nonpoint sources will need to provide three years of farm practice history to document their current conditions, including crop rotations, residue management, tillage, nutrient inputs, location and type of existing conservation practices, livestock inventory, and manure handling. A new BMP will generate credits only after it is installed, and only for so long as it is properly operated and maintained, based on quantitative performance protocols. The status of installation, operation, and maintenance will be periodically inspected by an appropriate verifier, such as the state Department of Natural Resources, SWCD, or resource management specialist. Verification records will be maintained and the non-confidential portions of those records may be made available to the public upon request.

During the 2012 – 2014 Pilot Program, the state agency will arrange to periodically monitor, inspect, and verify the implemented BMPs at least annually, based on visual monitoring and inspection, as well as a review of records provided by the landowner and/or SWCD. All states will follow the same verification protocols, and rules. EPRI will ensure consistency and the credit registry will not allow for variation.

A verifier will be assigned to a particular BMP project based on: 1) knowledge of the conservation practices implemented; 2) knowledge of the geography; 3) availability; and 4) absence of significant conflicts of interest. All verifiers will be trained on the plan, credit calculation tools, processes, and protocols. They will have a working knowledge of farm operations and practices to manage nutrients on farms in the Ohio River Basin. Verifiers will complete regular continuing education training as required by EPRI. Verifiers will confirm that (1) the landowner's eligibility information is correct, (2) the BMPs were implemented according to the standards or approved modifications, (3) credits are quantified using appropriate metrics and methodologies, (4) practices are maintained and performing as designed, and (5) appropriate arrangements are in place to ensure practices are maintained. The type of verification/monitoring will vary depending on whether the practice is structural (e.g., livestock exclusion fencing), vegetative (e.g., buffer strip), or management (e.g., nutrient management). Both structural and vegetative practices can be viewed in the field but verifiers will need to check landowner records to confirm that they are being maintained properly. Management practices will mostly be verified by examining landowner records. The verifier must prepare a report of each monitoring, inspection and verification event, along with its opinion as to whether each BMP is, in fact, verified. This report must be submitted to EPRI within 30 days after each event. Producer personal information will be held confidentially. The public can see the HUC 10 where credits are generated, but not the specific farm or field. Regulators can see the farm records.

4.3 ADDITIONAL CONSIDERATIONS

Studies show that BMP function (i.e., efficiency, pollutant reduction) cannot be assumed, even if the presence of a practice is verified by one of the protocols discussed above.

For example, Dosskey et al. (2002) reported that concentrated flow through riparian buffers can be substantial and may greatly limit buffer performance. While sediment removal of up to 99% from runoff has been reported under ideal circumstances (e.g., plot studies), because of non-uniform distribution of field runoff through a buffer, the authors estimated that only 15 – 43% of sediment would actually be removed.

Sharpley et al. (2009) reported that conservation practices vary substantially in effectiveness within and among watersheds. For example, previously reported total P reduction efficiencies for BMPs, such as cover crops can range from 7 to 63%, contour plowing 30 to 75%, livestock exclusion 32 to 76%, and riparian buffers 40 to 93%. Such variability results from inherent heterogeneity of landscape topography, hydrology, climate, and prior land use, which influences soil test P. This large variability clearly demonstrates the site-specificity of BMP reduction efficiencies and highlights the dangers of having to assign an absolute value, as required by nutrient trading programs.

As noted earlier, Bracmort et al. (2006) reported that one-third of BMPs installed in the Black Creek (IN) watershed no longer exist and the remainder were only partially functional, with efficiencies far lower than those originally attributed. Finally, as noted above, Jackson-Smith et al. (2010) found that 16% of BMPs reported as implemented in a UT watershed project were never actually installed and that 20% of implemented BMPs had been abandoned, principally management practices.

These findings emphasize the need for careful verification of both BMP presence and BMP function and the danger of simply assuming that BMPs reported as implemented are providing their full potential effects on water quality.

4.4 SUMMARY OF KEY FINDINGS FROM THE LITERATURE

- Each of the general protocols for BMP verification identified by the AgWG has been applied elsewhere in the U.S., with varying degrees of effectiveness.
- With the exception of some validation data from remote sensing analyses, and a statement of accuracy in the CTIC tillage survey, there have been essentially no assessments of statistical confidence or error reported for any of the approaches to BMP verification described in the literature.
- Verification of structural, annual, and management practices will likely require different protocols and provide different information content and accuracy.
- Hybrid approaches probably have the best potential to provide complete and accurate information on BMP implementation and performance.
- BMP function should not be assumed, even if presence is well-documented.

- To meet the objectives of the CBP, BMP verification will need to go beyond simple documentation of presence/absence; some assessment of condition, performance, or efficiency will be required.

5.0 Summaries of Interviews with Key Informants

While interviewers collected detailed notes during interviews and these notes have been edited and accepted by those interviewed, this summary does not attribute specific comments to specific individuals. Rather, summary points, areas of consensus, and areas of distinct opinion are noted. The summary addresses three areas: specific verification programs identified by the interviewees, reported costs of verification programs, and key principles arising from the body of interview responses.

5.1 Specific verification programs reported

BMP verification programs reported by interviewees are summarized below and identified by the state in which they take place. These programs are a mix of state government, non-governmental organization, and other efforts. Note that program specifics are those given by the interviewees; no attempt was made to fully document the programs from other sources. Further information is available in section 3, from other publications, web sites, etc.

Virginia

GreenSeeker is a high tech system that senses color variations by reading chlorophyll levels in plant tissue used in nutrient management in Virginia. Results consist mainly of records of precision agriculture/nutrient management in a six-county pilot program to assess the quality of the BMP record in support of a TMDL.

Data have been collected from 100 – 125 farms in the Shenandoah Valley using a proprietary protocol (by Watershed Stewardship Inc. (WSI)). In the procedure, WSI staff meet with the farmer, explain the program, and sign a confidentiality agreement stating that they will only use farm information in an aggregate at the sub-watershed or county level; no one has objected to this so far. Farmers sign a release giving electronic access to their NMP, conservation practice, and FSA information (sometimes scanning of paper forms is needed). WSI loads that information into their nutrient load estimator (NLE) software (which describes farms, fields, animals, and crops by acreage using Chesapeake Bay land use categories). They have a list of practices that have been reported and during the whole farm walk-over they verify implementation of everything reported as implemented (cost-shared and non-cost-shared). WSI assesses and verifies implementation and operation and maintenance using both Chesapeake Bay and NRCS standards. They estimate nutrient losses with and without BMPs, formulate a plan, and work with farmers to make progress on the plan as needed. WSI believes their protocol is working well if you need this level of detail, but they are currently reluctant to turn over a proprietary procedure for governmental use because of concerns regarding maintaining resources to support employment of WSI staff.

Maryland

Maryland is reported to have the most regulated BMP reporting program in the Chesapeake Bay region, especially for nutrient management. The state has a procedure for inspection based on technical standards and requirements for compliance with state laws and regulations. Inspectors use pre-printed forms and notify farmers in advance that they are coming. They collect both general farm information (operator information, operation information-type, size) and planning information (detailed information written by a consultant – e.g., current soil test, date, certified planner name and information, information on field-specific nutrient recommendations, nutrient source, application rate and timing, manure generation, and waste management practices). The process also checks for record keeping – e.g., is yield goal based on harvested crop in different years? The final product is a review and evaluation of the operation with regard to nutrient and related management (i.e., animal waste management, fate of excess manure) – this will determine if there are major or minor violations. Warnings are issued for major violations – if not corrected, penalties can result. Minor violations result in recommendations for improvements. A copy of the evaluation is given to the operator and filed in state records. About 8 to 10% of operations are inspected by agency staff annually on a rotating basis. About 70% of inspections are focused on the problem areas; the inspection/verification process applies to all types of operations, whether cost-shared or not.

A pilot program in Howard County, MD (and elsewhere in the CBW) has been conducted, consisting of farm interviews and a review of plans; this process addresses both cost-share and non-cost-share “functional equivalent” practices. The program is linked to the Maryland Nutrient Trading Tool and Tracker with a direct tie-in to NEIEN. The Howard County process involves an interview and farm walk with the farmer/operator and a farm walk to identify BMPs. Practitioners provide data collected on cropland, animal confinement, pasture and hay land, and an updated farm map with BMP location and associated data. The data are verified by a third party (an outside SWCD Employee) and entered into Tracker by the SWCD and into the Maryland Nutrient Trading Tool by third parties.

Information about specific components of Maryland’s programs can be found in section 3.2.

Pennsylvania

Warwick Township in Lancaster County has a comprehensive watershed management program that includes stormwater and agriculture. They have worked with local SWCDs to develop conservation plans on 100% of farms (all types) in the watershed. Water quality data collected through the program are used to identify the benefits of implemented agricultural BMPs and to identify hot spots and work with landowners toward water quality improvement. They do not pro-actively track implementation of conservation plans but if farmers come in for other permits (e.g., subdivisions or lot development) they try to check on progress with their conservation plan. For farms where their municipal wells are located, the Township has hired an agronomic firm to keep all management records on the farm. They get a lot of good information, the farmer benefits with a high-level NMP, and the Township protects well water quality (e.g., lower nitrate), saving money in water treatment. They do not differentiate between cost-shared vs. farmer-driven practices.

North Carolina

Agricultural information is collected beyond normal NASS data collection in designated nutrient sensitive river basins or watersheds that are regulated by the state of North Carolina, i.e., the Neuse and the Tar-Pamlico. A N Loss Estimation Worksheet (NLEW) that is used to meet the regulatory requirement tracks potential N reduction by county based on implementation of nutrient management. The worksheet requires input data from the NMP (e.g., N inputs, N uptake) as well as documentation of conservation practices on fields. Data are collected based on the needs of the tools used in the basins (NLEW, and similar tools for P loss and grazing management). Data collection needs are driven by state regulations but regulations are not reported to be an incentive for farmers to provide more data than they would normally provide. Researchers at NC State University have run four additional detailed basin surveys for N-related BMPs; a detailed description of statistical sampling methods is available. Additional details of the statistical procedures of the NC surveys are available at:

http://www.soil.ncsu.edu/publications/river/Neuse_Report.Final.11.29.2011.pdf

http://www.soil.ncsu.edu/publications/river/Cape_Fear_NCANAT_FinalRpt_11_9_07.pdf

http://www.soil.ncsu.edu/publications/river/TarPam_NCANAT_FinalRpt_Jan30_06.pdf

Minnesota

The Livestock Environmental Quality Assurance II (LEQA) Program is funded by the Minnesota Department of Agriculture. Rather than tracking individual BMPs, the LEQA system uses a "Better Management Systems" index, which is essentially a classification of BMP systems. The process provides some qualitative assessment of BMP system function, called a Water Quality Assurance (WQA), in order to give a reasonable assurance of performance. The LEQA process consists of three steps – an initial assessment, certification, and an annual confirmation. The objectives of the initial assessment are (1) to identify resource conditions for each of the farm management units, (2) to provide an action plan on how to address or maintain the resource condition, and (3) to identify potential sources for technical and financial assistance. Certification assistance is provided by LEQA technicians for the agricultural producers that have an initial assessment and action plan completed. The intent is to give the producers direction and support as they implement a farm management strategy to improve their water quality scores and eventually meet the WQA standards. Up to 20 hours of technical assistance funded by the LEQA program are provided to each producer through the LEQA technician. Using the initial assessment and action plan, the producer and technician decide what resources of concern should be addressed. An annual confirmation process is included in the LEQA program to keep the program fresh in the minds of the producer, provide continuity in the farm and watershed data, and to maintain the value of the WQA for the producer and stakeholders. The annual confirmation addresses any changes in farm acres, cropping systems, animal units and other important factors and confirms or adjusts the WQA scores accordingly. The intention of the LEQA program is to audit 10% of those farms each year that achieve or maintain WQA status. Audits have been conducted by Ag Resource Strategies, LLC, but it is recommended that the local and/or state government conduct future audits to ensure full-circle government-to-government accounting. Additional information about the LEQA program is available at

http://www.mda.state.mn.us/en/protecting/cleanwaterfund/onfarmprojects.aspx.

Washington

A developing program to manage water quantity and quality for irrigated agriculture and fisheries involves potential transfers of water rights in return for water quality improvements among irrigators and tribes in the Klamath River Basin. Requirements for effective trading provide strong incentives for verification of BMPs installed for water quality protection.

National Agricultural Statistics Service (NASS)

NASS provides timely, accurate, and useful statistics in service to U.S. agriculture, although not specifically directed toward verification. They do not ordinarily collect extensive BMP data (although they do routinely collect information on tillage and cover crops); in special programs (e.g., CEAP) they go beyond this. NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. NASS conducts both full censuses and statistical surveys. Information volunteered by farmers and ranchers to trained interviewers (enumerators) is the most important data source for NASS crop and livestock statistics. The four principal types of data collection are mail, telephone, face-to-face, and web-based. Enumerators are carefully trained in survey techniques so that data collected are not biased by the survey process. Statistical measures of survey accuracy are provided for each specific survey effort. NASS does provide their statistical survey services to external agencies and stakeholders (e.g., universities) subject to HQ approval – e.g. CEAP, USDA-Economic Research Service's Agricultural Resource Management Survey (ARMS). Requests for services must meet certain criteria (e.g., cannot do anything proprietary – needs to be made available publicly.)

U.S. Geological Survey

USGS is coordinating conservation data sharing between NRCS, FSA, and USGS, specifically the transfer of federal c/s records for all Chesapeake Bay farmland in October of each year to support the NEIEN submission process. Data are obtained from central records. Practices within their lifespan are "verified" by existing NRCS and FSA protocols, practices outside their lifespan would fall into 'voluntary verification' protocols, as yet undefined. USGS gets privacy protected information from this dataset by submitting a special data request from central records (the whole process will be documented in a report coming out in December). They work with USDA programs and states, integrating federal and state data to eliminate double counting. Data pertain only to approved federal c/s conservation practices. There are about 300,000 practices in the watershed;

each practice on each farm has its own data record. If a practice is still within its lifespan it is assumed to be valid and verified. A current proposal under consideration is to follow up this assumption with a field assessment (or other protocol) to verify that the practice is indeed still in place. If a practice is not within its lifespan, then a field assessment or other protocol will be needed for verification.

USGS is also involved in remote sensing of winter ground cover for sediment and nutrient conservation, working in most of the state of Maryland, and areas of Virginia and Pennsylvania surrounding the "Showcase Watersheds." This could be expanded within a year or so for complete coverage. USGS is able to look at winter ground cover thresholds to identify green vegetation sufficient for successful cover cropping. Currently they are not able to look at crop residue, although that might be possible within five years depending on satellite technology improvements. Nor are they able to look at nutrient application, although geospatial data can be overlapped with crop type/rotation, specific watershed areas, soil types, drainage classes, etc.

USGS began this effort with the Choptank River CEAP 6-7 years ago using SPOT and Landsat imagery. The procedure looks at the reflectance of fields and calculates the ratio of near infrared (IR) to red to estimate vegetation cover in winter fields. This is then linked to performance information for cover crops. They can only look at *green* vegetation with this procedure, *not* residue, so the procedure cannot be used to estimate such practices as conservation tillage or nutrient management. They employ two strategies: (1) use public data (Landsat and NASS National Cropland Data Layer); select a county, look at crop type in summer and identify e.g. cornland; look at winter vegetation and determine the percentage of cornland in vegetation as an indicator of erosion and nutrient loss problem areas (this covers both c/s and voluntary practices unlike methods that use only c/s enrollment information), and (2) in Maryland, identify fields enrolled in cover crop c/s program through collaboration with MDA, analyze on-farm effectiveness of various cover cropping practices, and identify areas with poor performance. Then, by using watershed-wide ground cover mapping by crop type and subtracting the areas enrolled in cover crop c/s, voluntary cover cropped areas can be identified. Verification is done via biomass performance thresholds; they can check their remote sensing data against what Maryland reports on cover crop implementation.

USGS knows where all cover crop acreage is in Maryland. The data for Virginia are not as complete, but they are working toward developing better data on cover crop location in that state. When USGS finds green winter cover they cannot tell specifically if it is a cover crop, but they can tell that it is protected from erosion. The potential exists to also use remote sensing to document stream buffers.

5.2 REPORTED COSTS OF VERIFICATION ACTIVITIES

A few interviewees reported estimated costs associated with BMP verification programs in which they were involved.

The Howard County, MD BMP inventory is reported to cost approximately $1.50/acre, including verification by trained contractors. Intensive animal operations are more costly. Data entry into the Maryland Nutrient Trading Tracker is an additional ~$2/acre.

General frameworks for estimating costs were provided for the Maryland program. If it costs $60,000 per year for an inspector who does an average of 100 inspections per year, the cost is $600 per inspection. This is perhaps for an average farm size of 200 acres, resulting in an average cost of about $3/acre. The estimated cost will be lower if one assumes that the results are more broadly representative of the larger land area. Detailed NMP implementation verification is the most time consuming and expensive practice to inspect. Nutrient management inspections cover nutrient management and animal waste management, but do not address erosion and sediment control which is addressed by the SWCDs.

USGS reported costs of ~$50,000 per year to perform their practice tracking work on all federal conservation practices in the CBW (~300,000 practices), but this should get cheaper over time. The $50,000 is in addition to what NRCS does in the field – it is the cost to USGS to get NRCS data, eliminate double counting, work with the states, perform aggregation, and work with the states to get the data into NEIEN.

Watershed Stewardship Inc. reports a cost of $3,000 - 4,000 per farm because the work so far has all been related to projects for which they agreed to do some detailed analysis and testing. This represents a "research phase" that has a higher cost than would an ongoing routine program. The cost should be lower when done on a production scale (perhaps ~$2,000 for up to 1,000 acres, or ~$2.00/acre). They would add $1.00/acre for farms larger than 1,000 acres. The Tidewater has 8,000-acre farms scattered over 50 miles; in these cases WSI is doing just the first 2,000 acres closest to their address for the project. For farms primarily in row crops the cost would be less because they are simpler to do.

NC State University personnel have run 4 basin/watershed surveys using Section 319 funds – two in the Neuse River Basin, and one each in the Tar-Pamlico and Jordan Basins. Each cost around $250,000 or more to collect detailed agricultural information. Costs were projected to be about $9.00-10.00/acre for surveying fields.

The Minnesota LEQA assessment, planning, and assurance (verification) process cost was ~$1,000/farm for the initial baseline assessment and base plan. A verification walk-through was an additional ~$400 and an annual confirmation was ~$200.

Finally, costs were reported for a verification program for forest carbon credits in Washington. It takes about 2-4 person-months to obtain and process the data (about $30,000-$50,000). Then a third party spends several weeks on the site. Payment is about 15 cents/metric ton of CO_2

equivalent (1 credit = 1 metric ton CO_2 equivalent). Participants need several hundred thousands of credits to cover the assessment costs and make it a worthy investment. Third party verifiers charge $20,000 - $40,000 per verification event, and the cost of measuring 200,000 acres, for example, is only a little greater than for 400,000 acres because they use statistically-based approaches.

5.3 SUMMARY OF KEY POINTS

The following key points were derived from comments and issues raised during the interview process. Often, but not always, these points were shared among more than one of the interviewees. In a few cases, interviewees expressed opposing views; these are presented equitably.

- Any proposed verification program, especially as applied to nutrient trading, should be scientifically defensible, and have a high degree of accountability and transparency.
- Verification programs must go beyond simple presence/absence to address actual practice efficiency.
- The Bay Program should seek the widest possible verification of implemented BMPs, rather than focusing on intensive verification of a few individual practices, e.g., for trading purposes.
- Verification is so poor at present that use of remote sensing to verify even a limited number of practices observable may be a significant improvement.
- There may be some lessons to be learned from other verification programs, e.g., urban stormwater, air pollution emitters, carbon credits from forestry.
- Different types of BMPs – i.e., structural, annual, or management – will require different verification protocols. Remote sensing, for example, may do well at finding structural or land-cover practices, but verification of nutrient management will require strong presence on the ground. Verification – either on the ground or by remote sensing – must be conducted at the right time of year to assess BMPs like cover crops.
- A hybrid approach to BMP verification will generally give better results than a single protocol.
- Some interviewees recommended that different BMP efficiency credits should be given for different (i.e., more or less rigorous) verification protocols.
- While some flexibility in verification programs among states may be desirable, some level of consistency should be ensured so that core values/principles of verification cut across all states.
- Design and implement a verification standard that relies upon third-party, independent trained professionals. This standard should be scientifically defensible, transparent for the public, and have, as an integral component, a very high degree of program accountability.
- Assessments of accuracy or statistical confidence in verification results have been reported only for statistical survey and census data from NASS and from some validation exercises in remote sensing efforts; otherwise, little reliable information exists on the confidence or accuracy of verification results.

- If required, qualitative assessments of verification accuracy should be done by people with statistical and on-the-ground experience, not simply by best professional judgment or by consensus of a committee.
- Assessment of all sources of error in any verification process will provide some measure of transparency and confidence in the process.
- Although several programs collect BMP data at the field or other spatially-explicit scales, confidentiality issues generally prevent the release of such information and require the aggregation of data to the county level.
- Ability to spatially reference practices to the field level may not be useful at present because the model is driven at the county/watershed level.
- Monitoring of response indicators (e.g., soil test P) may be easier and more productive than trying to verify all the individual management actions that go into a complex practice like nutrient management.
- Specific programs involving water quality and agricultural BMPs can provide strong incentives for verification of installed practices. The Chesapeake Bay TMDL, the Maryland Nutrient Trading Program, the Klamath River Basin irrigation/water quality trading program, the Illinois River/Eucha-Spavinaw (AR) watersheds lawsuits, and the Ohio River Basin Trading Program are examples.
- Staff expertise is important in obtaining information directly from farmers. Staff collecting information must be trusted and agriculturally literate; several programs have had success in training the right people to do the job. Some form of certification and ongoing training may be necessary. It may not be appropriate to have the same individuals that designed or installed the practices conduct the verification.
- Verification reporting by the same technicians who install practices is generally inadequate; insufficient attention is usually paid to operation and maintenance issues and the age of practices. NRCS technicians typically assume a practice is working as designed if it is present.
- Farmer self-surveys can be useful, but require some kind of driver/incentive for farmers to provide reliable information; farmers must have a clear understanding of what the BMP is so that reporting is accurate. Spot checks by professionals/agency staff may be critical.
- Work with NRCS and the U.S. Office of Management and Budget (OMB) has shown that a 5 – 10% spot-check level is generally adequate to validate self-reporting.
- Several interviewees recommend having farmers self-report, with a substantial portion of that spot-checked by government employees. A hierarchical system (broad screening followed by more detail) was recommended, where a broad population is assessed in the first level, but not too closely. If things look good, you’re done. If things don’t look good, go back and look in more detail. One interviewee suggests having a penalty for failure to self-report in a cost-share program that is highly certain but not excessively punitive in order to get producers’ attention.

- Farmers may experience survey fatigue. They are surveyed more than anybody and are tired of filling out forms. Some farmers would rather pay a penalty than participate in additional surveys.
- Records review approaches to verification have significant limitations because non-cost-share practices are not included, nor is operation and maintenance or management information. Sparse spot checks will not be sufficient to overcome this limitation.
- Statistical sampling and/or surveys may be efficient and highly useful, but must be done with rigorous statistical methodology by trained practitioners. Different approaches for different populations of producers (e.g., CAFO, vs. non-CAFO, large vs. small, etc.) may be required.
- Even if it is limited to detecting structural or extensive practices, remote sensing should be used to the maximum extent possible as it is the most cost-effective approach.
- Remote sensing is applicable for some structural and land-cover practices, but not for management or complex practice systems. Despite the non-invasive nature of remote sensing, some negative attitudes concerning privacy may be expressed by farmers.
- Remote sensing of some practices (e.g., cover crops) has some advantages. Using enrollment information for cover crops, for example, has limitations in terms of not catching bad years when the cover isn't sufficient. Remote sensing data have the ability to verify successful cover crop implementation easily and at lower cost than for on-site inspections and can be interpreted with respect to potential function of erosion control or reduction in N leaching.
- High-resolution LiDAR (Light Detection And Ranging) and land use analysis can be used to determine if historically installed structural practices still exist on agricultural land or whether they have been replaced by larger/different structures

6.0 SUMMARY OF FINDINGS

6.1 WHERE ARE WE NOW?

These are the most important points derived from both the literature review and the interviews:

- Each of the general protocols for BMP verification initially identified by the AgWG has been applied elsewhere in the U.S., with varying degrees of effectiveness.
- To meet the objectives of the CBP, verification programs must go beyond simple presence/absence to address actual practice quality. Some assessment of condition, performance, or efficiency will be required because simple presence of a BMP does not guarantee its full performance.
- Literature and experience do not support assignment of *Relative Data Confidence* and *Relative Data Credit* values to the various protocols. There have been essentially no assessments of statistical confidence or error reported for any of the approaches to BMP verification described in the literature (exceptions are NASS and CTIC). Such assessments

are essential and should be done by people with statistical and on-the-ground experience, not simply by best professional judgment or by consensus.
- Verification of structural, annual, and management practices will likely require different protocols and provide different information content and accuracy.
- Hybrid approaches probably have the best potential to provide complete and accurate information on BMP implementation and performance.
- Much of the data (e.g., location, nutrient application rates) derived from on-farm assessments can only be shared and used in modeling if allowed by the farmer.
- On-farm assessments are expensive ($1-10/acre or more) and burdensome to farmers.
- Interviewers and assessors must have a level of expertise and be trained for consistency across the many Chesapeake Bay jurisdictions.
- Farmers need to be instructed on how to perform self-assessments consistently across the many Chesapeake Bay jurisdictions.
- Remote sensing approaches are good for presence or absence of structural and visible practices but require ground-truthing and calibrated methods for development of applications specific to agricultural practices (e.g., cover crops) and are essentially useless for management practices such as nutrient management. Remote sensing also creates suspicion in some minds and jurisdictions.
- Approaches that involve on-the-ground assessments can be used for both structural and management practices, but are likely to be too expensive for most jurisdictions to apply to an entire area of concern. In addition, presence or absence of a practice such as nutrient management can be inferred from presence of specific equipment and records, but only through analysis of those records (e.g., crop yields, nutrient application rates) and perhaps soil testing (P) can an assessment of BMP functionality be made.
- Farm inventory and self-assessment information is often constrained by a narrow program focus (e.g., cost-shared practices only, NPDES only), inconsistent interpretation of inventory questions, or confidentiality concerns.
- Records reviews are limited to programs supported by and practices implemented with cost-share or technical support.
- Statistically-based sampling approaches can be conducted with less expense than examining an entire basin and results can be extended to a wider region; however, such sampling requires a high level of scientific rigor and the required expertise may not be available in many jurisdictions or coordinated across jurisdictions. NASS efforts are exceptions because their surveys are conducted with a high level of technical expertise.

6.2 WHERE DO WE NEED TO GO?

A BMP verification program for the CBW should have these core characteristics:

- Address both cost-shared and non-cost-shared practices implemented by landowners under all programs, including federal, regional, state, local, and voluntary efforts.
- Document both presence and functional quality of BMPs.

- Allow necessary flexibility among CBW states, but provide a base level of consistency across the CBW to ensure a fundamental quality of data.
- Any proposed verification program, especially as applied to nutrient trading, should be scientifically defensible, and have a high degree of accountability and transparency.
- Include estimates of confidence and uncertainty with respect to both the verification results and the achievement of treatment goals and/or requirements.

6.3 CHALLENGES AND OPPORTUNITIES

Verification, like any QA/QC activity, increases costs, but should also increase the value of the information collected. Bay states have a variety of verification activities in place to address BMP implementation programs, with small and large differences in intensity, level of detail, approaches, and history.

With regard to agriculture, every state must contend with privacy and confidentiality issues, particularly when seeking information at more specific than the county or HUC 12 level. This has ramifications for geolocating BMPs for tracking and modeling purposes.

Budgets and staffing for verification efforts vary across the Bay states. Consistency in verification efforts across the CBW is highly desirable, yet differences in available resources will make it a challenge to achieve consistency at a suitably high level of confidence. In addition, states may be reluctant to change methods for a variety of reasons even if the goal of consistency across states is appealing to them.

Linkage of verification efforts to the CBWM presents challenges with regard to scale issues. Appropriate scales for verifying BMP implementation may not be the same or be compatible with the county scale used by the Bay model. For example, verification of BMP implementation for riparian zone protection may be best carried out at the watershed or landscape scale, whereas NMP implementation is best verified at the farm scale. In short, the best approach to verification for different BMPs under different programs may incorporate spatial and temporal scales that do not conform to those required by the CBWM.

Significant opportunities exist for Bay states if they choose to seek consistency in their verification efforts, including the possibility of leveraging agreements with USDA and agricultural interests to obtain better information on BMP implementation, cost efficiencies in applying methods such as remote sensing and on-site reviews, and enhanced capability to report to stakeholders both accomplishments and the need for additional support to achieve water quality goals in the CBW.

7.0 RECOMMENDATIONS

The CBP Partnership has defined verification as the process through which agency partners ensure practices, treatments, and technologies resulting in reductions of nitrogen, phosphorus, and/or sediment pollutant loads are implemented and operating correctly. The process for certifying tradable nutrient credits is a separate, distinct process not addressed either by these principles or through the partnership's BMP verification framework.

[***NOTE:*** We plan to address application of existing Bay state verification programs after we obtain information from all Bay states.]

Working to verify that practices are properly designed, installed, and maintained over time is a critical and integral component of transparent, cost efficient, and effective implementation pollutant reduction programs. Verification helps ensure the public of achievement of the expected nitrogen, phosphorus, and sediment pollutant load reductions over time. The CBP Partnership is committed to building from existing practice tracking and reporting systems and working toward achieving the following principles (CBP 2012).

- Principle 1: Practice Reporting
- Principle 2: Scientific Rigor
- Principle 3: Public Confidence
- Principle 4: Adaptive Management

The emphasis on verification should be to confirm whether practices are *implemented and operating correctly* as intended, as stated above. A balance of *scientific rigor* with *cost-effectiveness* and a sense of *priority* are also essential to a successful verification effort. *Transparency* is needed in both the process of verification and tracking and reporting of the underlying data. The principles also state that verification protocols will recognize existing funding and allow for *reasonable levels of flexibility* in the allocation or targeting of those funds.

As discussed earlier (see Section 3.0) CBW states have clearly taken different approaches to BMP verification, both in process and level of intensity. It is not the purpose of this report to evaluate state verification programs. However, it must be noted that some level of consistency across the CBW should be sought in order to verify that practices are properly designed, installed, and maintained for the benefit of the Bay. At the same time, the need for flexibility in how states approach their own verification needs must be recognized, including accounting for the investments states have already made in budgets, program development, personnel resources.

7.1 SEPARATE THE VERIFICATION EFFORT FROM THE MODELING EFFORT

The coupling of BMP implementation verification to Bay modeling creates an expectation of data confidence and precision that cannot be met. By separating verification from modeling it becomes more feasible to satisfy verification objectives and principles within current resource and political constraints. In addition, observations drawn from verification information can still be used to inform modeling decisions in a qualitative way rather than, for example, through application of numeric relative data credits. If verification results show a pattern of over-crediting nutrient management implementation in a specific geographic area, model runs for that area could be adjusted accordingly.

7.2 Consider Multi-Sector Verification

Some verification methods that are recommended for agriculture can also be used for urban and other sources. Remote sensing, for example, could be applied broadly to all land use categories and cost-efficiency could be improved through coordinated planning, execution, data analysis, and reporting. Remote sensing is particularly disliked by some individuals – broad application to all source categories could reduce resistance. If geographic targeting of verification is employed there would be opportunities to coordinate on-the-ground assessments across sectors. Again, this could reduce resistance to the activity, and would also improve the overall verification effort by virtue of developing a more comprehensive picture of implementation activities in the area.

7.3 Identify Indicators for Verification

The current approach to verification addresses all practices in all areas, a strategy that is perhaps necessitated by the linkage to modeling efforts. Much as dissolved oxygen concentration is used as an indicator of aquatic life support conditions, indicators of BMP implementation and operation status could be considered for the verification effort. For example, nutrient management as specified in NRCS Practice Code 590 includes erosion and sediment control practices in addition to direct management of nutrients. Therefore, successful implementation of the 590 practice could be considered an indicator of successful implementation of erosion and sediment control measures as well. An indicator for effective nutrient management could be trends in soil-test P values. Other indicators to consider are composite indicators such as BMS (Better/Best Management Systems) which is an index of multiple practices (e.g., a soil condition index) used in Minnesota. While these relationships may not be established sufficiently at this time to support their use as indicators, it may be worthwhile to consider and test the application of such indicators to increase the cost-efficiency of data gathering for verification purposes.

7.4 Target Verification to Problem Areas

By its very nature, verification efforts are usually targeted to areas of concern. A formal procedure for identifying priority areas and practices for verification efforts could be developed to reduce the cost of verification, enhance the impact of verification efforts on improved water quality, and increase the value of information gained through verification. State WIPs and Bay modeling are both sources of information that can be used to identify geographic areas in which verification is more important from a water quality perspective. Similarly, state agriculture programs will most likely have information that can be used to identify areas in which farmer adoption of practices is lagging, places where verification could be more important. Finally, some practices are more important to achieving Bay water quality goals than are other practices, and these could be given more attention in verification efforts; the importance of practices may vary by geographic area.

It should be noted that by targeting verification there will be no unbiased estimator of basin-wide implementation. Those areas or practices not targeted will either be unrepresented or underrepresented in the verification process. Representative sampling would be needed to develop an unbiased estimate of basin-scale implementation. Alternatively, a stratified random sampling approach could be used in which additional information is collected for certain strata (i.e., the targeted areas) while still providing a baseline level of information for all strata.

7.5 Use Hybrid Approaches in a Sampling Approach

No single approach in the draft protocols can be used to verify implementation of all practices in all jurisdictions. Many of the reasons for this have been discussed earlier.

There are several options for the type of verification activity to be performed at each sampled farm. These include walkabout assessments (on-farm surveys), farmer self-assessments, record reviews, remote sensing analyses, and NASS-type surveys. In a hybrid approach each verification tool would be applied where it is most cost-effective. A consistent hybrid approach across all Bay jurisdictions is essential to address the requirements of scientific rigor and transparency. Such consistency requires that the hybrid approach be developed with rigor and constraints and not be left as a menu-based free-for-all.

Transparency could also be enhanced by establishing diverse teams of analysts and evaluators for each verification tool used. For example, NASS could be contracted to design a statistically-based sampling approach with input from both the environmental and agricultural communities. Farm walkabouts could be conducted by teams that represent agribusiness, state agricultural and environmental agencies, and academia.

7.6 Consider Statistically-Based Sampling

Even though one jurisdiction (MD) has committed to tracking essentially every farm to confirm implementation of BMPs, a Bay-wide full census of BMPs is unlikely. Statistically-based sampling offers a way to identify a subset of farms from which meaningful verification data can be obtained – using a hybrid approach with multiple tools including walkabouts for structural/annual practices and surveys for management practices – then extended to infer information from the entire population. Steps involved will include:

1. Define sampling objectives – (inclusion of multiple objectives to meet other state needs – e.g., incorporating NPDES inspections, may be desirable.)
    a. e.g., to determine BMP implementation and operation levels in targeted areas or for targeted practices (targeted or biased sample), or
    b. e.g., to determine BMP implementation and operation levels basin-wide (unbiased sample).
2. Define populations/sub-populations to sample:
    a. Crop agriculture (structural/annual practices)
    b. Animal agriculture (structural/annual practices)
3. Determine population of each sub-population

   c. By state
   d. By WIP watershed
   e. By county (for Bay model)
4. Determine sample size of each for XX% confidence (assuming 100% accuracy in field assessment) (scientific validity) – NASS knows how to do this.
   f. By each population/sub-population in #2
   g. Cost is ~$1-3/acre for on-farm assessments; $X for farmer self-assessments, etc.
5. Select the farms to be included in the verification round for that year.
   h. It is recommended that sample size be artificially inflated by 50 to 100 percent (pick a %) because a substantial share of farms selected for sampling will be found to be unavailable for various reasons (e.g., uncooperative, no longer a farm, etc.).
   i. From the pool of farms to sample that are able to be sampled, randomly select the number needed for statistical purposes.
   j. It is recommended that the process of farm selection be redone every year (or at some regular interval) to change the actual farms sampled (i.e., don't return to the same farms every year). This will ensure a pure, random sampling approach.
6. The type of verification activity performed at each sampled farm can vary. Options include walkabout assessments (on-farm surveys), farmer self-assessments, record reviews, remote sensing analyses, and NASS-type surveys.
7. Aggregate up from samples to estimates of implementation levels at state, WIP watershed, and county levels

The variables tracked in the verification protocol should be chosen such that they are solid indicators of BMP implementation and appropriate operation. They could also be indicators as described in section 7.3. Selecting variables or indicators that are also meaningful to the Bay modeling effort would be beneficial but not required; it is recommended that these variables/indicators are selected in consultation with those involved in the CBWM.

A clear challenge to this approach would be gaining acceptance and ensuring sustained participation by each of the Bay states. The approach could be sold on a number of fronts, including cost savings, sound science, transparency, and consistency.

7.7 Select Appropriate Protocols

The verification activities chosen for step 6 in section 7.6 should be matched with the variables to be tracked and observed. For example, on-farm assessments are needed for many annual and most management practices, whereas remote sensing could be used for cover crops and tillage. Records reviews only capture program records so are inadequate for capturing "all things" implemented on a farm. If records reviews are used, the specific variables or practices to be tracked/assessed should be compared with the information contained in records to see if supplemental information will be needed.

7.8 Use Available Resources

NASS has the most experience surveying agricultural lands and operations and could be approached with a proposal to cover some of the tracking to be performed under a hybrid approach. For example, they could develop the statistical design, train those who will be collecting the data, manage the data, and analyze and summarize the data for use by others.

Groups such as Watershed Stewardship Inc. have expertise in on-farm surveys, and ARS has expertise in using remote sensing to identify land under cover crops. If a windshield survey is desired for conservation tillage estimates, CTIC should be consulted for the design phase and possibly training.

Specialized programs such as nutrient trading programs or TMDL implementation efforts may require and/or sponsor special verification efforts. The methods and results of such efforts may provide valuable guidance for wider application.

LITERATURE CITED

Benham, B.L., J.H. Robbins, K.M. Brannan, S. Mostaghimi, T.A. Dillaha, J.W. Pease, and E.P. Smith. 2005. Development of survey-like assessment tools to assess agricultural best management practice performance potential. *J. Soil Water Cons*. 60(5):251-259.

Bracmort, K., B. Engel, and J. Frankenberger. 2004. Evaluation of structural best management practices 20 years after installation: Black Creek watershed, Indiana. *J. Soil Water Cons.* 59(5): 191-196.

Bracmort, K. S., M. Arabi, J. R. Frankenberger, B. A. Engel, J. G. Arnold. 2006. Modeling long-term water quality impact of structural BMPs. *Trans. ASABE* 49(2): 367–374.

CBP. 2012. Attachment A. CBP Verification Committee's revised draft BMP verification principles revised: April 30, 2012 http://www.chesapeakebay.net/channel_files/18318/attachment_a-revised_draft_bmp_verification_principles.pdf (Accessed 10/26/2012).

CTIC. 2008. Cropland Roadside Transect Survey. Procedures for using the cropland roadside transect survey for obtaining tillage/crop residue data. Conservation Technology Information Center, West Lafayette, IN www.crmsurvey.org (Accessed 10/26/2012).

Craig, R.K. and T. S. Noto. 2012. State nonpoint source control programs for agriculture: a look at agricultural certainty. Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010

Cunningham, J.H.. 2003. An assessment of the quality of agricultural best management practices in the James River Basin of Virginia. M.S. thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University, Blacksburg, VA.

Daughtry, C.S.T., E.R. Hunt, and J.E. McMurtrey III. 2004. Assessing crop residue cover using shortwave infrared reflectance. *Remote Sens. Environ.* 90:126-134, doi:10.1016/j.rse.2003.10.023.

Dosskey, M.G., M.J. Helmers, D.E. Eisenhauer, T.G. Franti, and K.D. Hoagland. 2002. Assessment of concentrated flow through riparian buffers. *J. Soil Water Cons.* 57(6):**336-343.**

Electric Power Research Institute (EPRI). 2012. Ohio River Basin trading project. http://my.epri.com/portal/server.pt?open=512&objID=423&mode=2&in_hi_userid=2&cached=true (Accessed 10/26/2012).

Florida Department of Agriculture and Consumer Services. 2008. 1st Annual report on the implementation of agricultural BMPs. Office of Agricultural Water Policy. Tallahassee, FL.

Government Accountability Office (GAO). 2007. Government auditing standards. GAO-07-162G. Comptroller General of the United States. U.S. Government Accoutability Office, Washington, D.C.

Grady, C., A.P. Reimer, J. Frankenberger, and L.S. Prokopy. (in review). Locating existing best management practices within a watershed: the value of multiple methods. *J. Am. Water Resour. Assoc.*

Hively, W.D., G.W. McCarty, and J. Keppler. 2009a. Federal-state partnership yields success in remote sensing analysis of conservation practice effectiveness: results from the Choptank River Conservation Effects Assessment Project. (Technology Transfer Feature) *J. Soil Water Cons.* 64(5):154A. http://www.jswconline.org/content/64/5/154A.full.pdf

Hively, W.D., M. Lang, G.W. McCarty, J. Keppler, A. Sadeghi, and L.L. McConnell. 2009b. Using satellite remote sensing to estimate winter cover crop nutrient uptake efficiency. *J. Soil Water Cons*. 64(5):303-313.

Jackson-Smith, D.B., M. Halling, E. de la Hoz, J.P. McEvoy, and J.S. Horsburgh. 2010. Measuring conservation program best management practice implementation and maintenance at the watershed scale. *J. Soil Water Cons.* 65(6):413-423.

Lambert, D., G.D. Schaible, R. Johansson, and U. Vasavada. 2007. The value of integrated CEAP-ARMS survey data in conservation program analysis. *J. Soil Water Cons*. 62(1):1-9.

Lichtenberg, E., D. Parker, and S. Lane. Best management practice use and nutrient management in Maryland, A 2010 Snapshot, University of Maryland, 22 pp.

MacKay, R., E.M. Bennett, and A. Lefebvre. Undated. Using a beneficial management practice (BMP) adoption index in agri-environmental policy in Canada [no additional citation info available]

Minnesota Department of Agriculture. 2007. MDA evaluation plan for voluntary pesticide best management practices, pesticide management plan for water resource protection

National Academy of Sciences. 2011. Achieving nutrient and sediment reduction goals in the Chesapeake Bay: an evaluation of program strategies and implementation. National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu. Report in Brief: http://dels.nas.edu/Report/Achieving-Nutrient-Sediment-Reduction-Goals/13131 (Accessed 10/26/2012).

Pennsylvania Department of Environmental Protection (DEP). 2007. Administrative manual for the special projects funding program of the Chesapeake Bay Program. Technical Guidance Number 361-5500-001. Pennsylvania Department of Environmental Protection, Bureau of Watershed Management.

Reid-Rhoades, P., L. Oldham, and G.V. Wilson. 2008. Technical report on Conservation Effects Assessment Project for Yalobusha Watershed. NSL Technical Report 51. Mississippi State, MS: Extension Service, Mississippi State University.

Settimi, J.R., D.G. Sullivan, and T.C. Strickland. 2010. The evaluation of conservation practice placement in the Little River experimental watershed using geographic information systems. *J. Soil Water Cons.* 63(3):160-167.

Sharpley, A.N., P.J.A. Kleinman, P. Jordan, L. Bergstrom, and A.L. Allen. 2009. Evaluating the success of phosphorus management from field to watershed**.** *J. Environ. Qual.* 38:1981–1988.

Shukla, S., R. E. Rouse, S. S. Shukla, E. A. Hanlon, K. Portier, and T. A. Obreza. 2006a. Citrus BMP implementation in Florida's Gulf Citrus production area: water, sediment, and aquatic weeds. Circular 1497. IFAS Extension, University of Florida, Gainesville.

Shukla, S., R. E. Rouse, S. S. Shukla, E. A. Hanlon, K. Portier, and T. A. Obreza. 2006b. Citrus BMP implementation in Florida's Gulf Citrus production area: nutrients. Circular AE474. IFAS Extension, University of Florida, Gainesville.

Shukla, S., R.E. Rouse, S.S. Shukla, E.A. Hanlon, K. Portier, and T.A. Obreza. 2010. Citrus BMP implementation in Florida's Gulf Citrus production area: pesticides. University of Florida, IFAS Extension, Publication AE473.

Simpson, T. and S. Weammert. 2009. Developing best management practice definitions and effectiveness estimates for nitrogen, phosphorus, and sediment in the Chesapeake Bay watershed. Final Report. University of Maryland Mid-Atlantic Water Program. www.chesapeakebay.net/marylandBMP.aspx (Accessed 10/26/2012).

South Florida Water Management District (SFWMD). 1999. Everglades interim report. South Florida Water Management District, West Palm Beach, FL, http://www.sfrestore.org/crogee/ra15/ra15.html (Accessed 10/26/2012).

Storm, D.E., P.R. Busteed, and M.J. White. 2006. Fort Cobb Basin - Modeling and land cover classification DRAFT. Submitted to Oklahoma Department of Environmental Quality http://www.deq.state.ok.us/WQDnew/tmdl/fort_cobb/osu_fort_cobb_modeling_jan_2006.pdf (Accessed 10/26/2012).

Sullivan, D.G., and H.L. Batten. 2007. Little River experimental watershed, Tifton, Georgia, United States: A historical geographic database of conservation practice implementation. *Water Resour. Res.* 48:W09471, doi:10.1029/2006WR005836.

Sullivan, D.G., T.C. Strickland, and M.H. Masters. 2008. Satellite mapping of conservation tillage adoption in the Little River experimental watershed, Georgia. *J. Soil Water Cons*. 63(3):112-119.

Sweeney, J. 2012. Chesapeake Bay program BMP tracking and reporting system. Environmental Protection Agency, Chesapeake Bay Program Office CBP WQGIT BMP Verification Committee Meeting July 19, 2012.

Tomer, M.D., T.B. Moorman, D.E. James, G. Hadish, and C.G. Rossi. 2008. Assessment of the Iowa River's South Fork watershed: part 2. Conservation practices. *J. Soil Water Cons*. 63(6):371-379, doi:10.2489/jswc.63.6.371.

USDA NASS (National Agricultural Statistics Service). 2007. Cropland data layer. Washington, DC: USDA National Agricultural Statistics Service. http://www.nass.usda.gov/research/Cropland/SARS1a.htm. (Accessed 10/26/2012).

USDA-NRCS. 2011. Assessment of the effects of conservation practices on cultivated cropland in the Chesapeake Bay Region. Conservation Effects Assessment Project (CEAP) http://sustainableagriculture.net/blog/chesapeake-bay-ceap (Accessed 10/26/2012).

USEPA. 1997. Techniques for tracking, evaluating, and reporting the implementation of nonpoint source control measures I. Agriculture. EPA 841-B-97-010. Office of Water, Washington, DC.

Veith, T.L., A.N. Sharpley, and J.G. Arnold. 2008. Modeling a small, northeastern watershed with detailed, field-level data. *Trans. ASABE* 51(2):471-483.

West Virginia WIP Development Team. 2012. West Virginia's Chesapeake Bay TMDL final phase II watershed implementation plan. In cooperation with the WV Department of Environmental Protection, WV Conservation Agency, and WV Department of Agriculture, Submitted to the Chesapeake Bay Program, March 30, 2012. http://www.wvca.us/bay/files/bay_documents/253_WV_WIP_Final-Phase_II_03292012.pdf (Accessed 10/26/2012).

Wilson, G.V., F.D. Shields, Jr., R.L. Bingner, P. Reid-Rhoades, D.A. DiCarlo, and S.M. Dabney. 2008. Conservation practices and gully erosion contributions in the Topashaw Canal watershed. *J. Soil Water Cons*. 63(6):420-429, doi:10.2489/jswc.63.6.420.

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