APPENDIX A

Progress:

Solution	Activity	Completion	Comments	Total Percent Finished
Phase 6 short term (FEG)	Meet individually with jurisdictions to discuss data	X	Completed: Dec 2022	90
	Discuss initial findings with CBP advisory group	X	Completed: Feb 28th 2023	
	Hold first full group meeting of FEG	X	Completed: March 1st 2023	
	Complete data review of preprocessing methods and ag inputs	X	Completed: April 1st 2023	
	MB informal briefing	X	Happens monthly	
	USDA presentation to AgWG and WQGIT	X	Completed: AgWG- April 2023; WQGIT- May 2023	
	Analyze compatability of new data sources	X	Completed: June 5th 2023	
	Summarize investigation results and brief PSC		Schdeuled for 9/2023	
Phase 7 long term (AMT)	Participate in Phase 6 solutions	X	Completed: 6/1/2023	
	Create living workplan document outlining order of tasks	X	Completed: March 13th 2023	
	Make decisions for Phase 7 model	~~~	In progress through 2025	

Figure 1. A visual representation of the timelines for the proposed Fertilizer Action Plan activities with dates of completion.

Fertilizer Expert Group Workplan/Timeline:

1) The informal team has completed introductory meetings with jurisdictional representatives and fertilizer experts. Each meeting to date has been with an individual jurisdiction to establish a baseline for each jurisdiction's data reporting and management.
2) The Chesapeake Bay Partnership advisory team has begun to examine state reported data and AAPFCO reported fertilizer sales tonnage data sets. This examination will determine if more recent state reported data could be utilized in the current Phase 6 model. – ***completion date: February 28th, 2023***
3) Convene the first full group meeting to discuss potential sources of fertilizer data. This will entail discussion about the current fertilizer data set and other potential data sets for implementation into CAST. - ***completion date: March 1st, 2023,*** *the objectives of this meeting are as follows:*
    - Assist in determining what data is available for use to supplement the current AAPFCO fertilizer data in the short term (Phase 6).
    - Determine the best method to collect potential data sources for examination by the Agricultural Modeling Team (AMT) for Phase 7 model development.

4) Review data preprocessing methods and agricultural inputs. ***– completion date April 1st, 2023,*** *this objective will entail*:
    a. The review of the data preprocessing methods
    b. Any changes made to the original data by CBPO, or the data provider should be clearly documented in a Quality Assurance Project Plan (QAPP).
5) USDA presentation –***completion date April 30, 2023***,
    a. USDA will be invited to provide at least one presentation to Ag Workgroup and Water Quality GIT to describe Agrichemical Application survey.
6) Analyze the compatibility of new data sources with CAST including potential USDA-NASS data. Itemize and characterize known sources for recommendation to additional workgroups. ***–completion date June 5th, 2023.***
    a. This review will also include identification and compilation of data, gaps in data, and costs to fill those gaps.
7) Provide briefing to MB: Provide recommendations to move forward in both Phase 6 (short term) and Phase 7 (long term) versions of CAST. ***–completion date April Management Board Meeting***
    a. Enumerate possible data sources
    b. Describe funding/policy changes necessary to acquire or supplement new data.
    c. Collaborate with AMT and STAC.
    d. Create briefing for April MB meeting.
8) Provide briefing to the PSC: Provide a summary of research results and recommendations including a timeline for data review and implementation to the Principals Staff Committee. ***– Expected completion date September 2023***
9) AMT examination of alternative fertilizer data for Phase 7 CAST development – ***Expected completion date December 2025***

APPENDIX B:

Findings from Fertilizer investigations:

- The Chesapeake Bay Program currently utilizes AAPFCO fertilizer sales tonnage data as well as state recommended application rates and USDA-NASS soil amendment expenditure data to determine fertilizer applications.
    - After discussions with AAPFCO personnel updates have been made to the CBP AAPFCO data processing. These updates include:
        - Reattribution of previously unknown fertilizer use codes to the non-farm category.
        - Reformatting data so that the letter E represents a zero value instead of a stop point in the text file.
        - The formatting of negative values as returned fertilizer which was not utilized.
    - These discussions led to a reassessment of outliers for the fertilizer data as well as resmoothing once these outliers were assessed.

        - The results of this finding were that the current method overestimated TN and P205 due to data processing errors.
            - This is not the case when using updated processing methods for the AAPFCO fertilizer sales tonnage data set.
- State reported fertilizer sales tonnage data from DE, PA, VA, and MD have strong historic agreement with AAPFCO data from the same period.
    - Fertilizer tonnage sales data were collected directly from DE, PA, VA, and MD for a period which overlapped the available AAPFCO data record. These data sets showed agreement through the historic record.
- State reported fertilizer sales tonnage data have far less latency than current AAPFCO data.
    - Data collected directly from states were available through 2020. These data have a two year latency. This latency is caused by late reporting from fertilizer companies. The latency period is far shorter then for AAPFCO which currently sits at seven years.
- Current USDA-NASS surveys are not practical for determining fertilizer applications at a county scale across the watershed.
    - Agrochemical application surveys are available from USDA NASS. These data are available at the state scale and only cover the largest producing states in the country, and thereby do not provide a consistent source of data for all Bay states.
        - Additionally the crops covered by these surveys rotate so that there is not consistent coverage over time for the crops which do have data collected. (e.g. Fertilizer applications may be recorded for fruits every two years. This leaves a biennial gap in data.)
    - These data can provide valuable reference information assisting in future model calibrations.
- It is possible to create new NASS surveys that are region specific although the benefit of doing this might be outweighed by the costs.
    - USDA NASS has the ability to create new surveys. The caveat to this is that they require substantial fiscal commitments in addition to staff to conduct the surveys and compile results. These costs can be prohibitively expensive.
    - By creating new surveys with no completion requirements, response rates can be extremely low creating misleading data and trends.
    - By creating new surveys USDA NASS expects existing survey response rates to drop due to survey burnout. This can reduce the effectiveness of the surveys currently in progress by the agency.
- Multiple organizations, including Plant Nutrition Canada and The Fertilizer Institute, utilize AAPFCO data to determine fertilizer applications.
    - After examining alternative data sets to AAPFCO fertilizer sales tonnage it was observed that many institutions use this data set.
    - No other data set was found that could provide county level coverage of fertilizer across the entirety of the Chesapeake Bay Watershed.

APPENDIX C:

Table C1. Fertilizer Expert Group Membership.

Role	POC	Role	POC	Role	POC
MD Jurisdictional Representative	Alisha Mulkey	PA Fertilizer Expert	David Dressler	The Fertilizer Institute (Industry)	Leanna Leverich Nigon
PA Jurisdictional Representative	Frank Schneider	NY Fertilizer Expert	Jan Morawski	International Plant Nutrition Institute (Industry)	Tom Bruulsema
NY Jurisdictional Representative	Cassie Davis	VA Fertilizer Expert	David Gianino	USDA -NRCS	Lisa Duriancik
NY Jurisdictional Representative	Greg Albrecht	DE Fertilizer Expert	Justin Lontz	USDA - NRCS	Candiss Williams
VA Jurisdictional Representative	Seth Mullins	WVA Fertilizer Expert	Chad Linton	USDA - NRCS	Leon Tillman
DE Jurisdictional Representative	Clint Gill	DC Fertilizer Expert	Cecilia Lane	USDA - NASS	Tony Dorn
WVA Jurisdictional Representative	Dave Montali	DOD Fertilizer Expert	Jessica Rodriguez	USDA -ARS	Tamie Veith
DC Jurisdictional Representative	Jonathan Champion	NPS Fertilizer Expert	Rene Senos	USDA - ARS	Curtis Dell
DOD Jurisdictional Representative	Kevin DuBois	CBC Representative	Marel King	VA Jurisdictional Representative	Kevin McLean
MD Fertilizer Expert	Philip Davidson	USGS	Alex Soroka	USDA-ERS	Roberto Mosheim
VA Jurisdictional Representative	James -Martin	VA Fertilizer Expert	Wayne Pendleton		

In addition to the jurisdictional representatives the Chesapeake Bay Program (CBP) has compiled a support staff (Table 2) to assist jurisdictional representatives and experts. These experts will provide technical expertise on CAST in addition to technical analytical support to ensure that the current fertilizer data needs of CAST will be met. CBPO staff will also provide the Agricultural Modeling Team coordinator to coordinate this group.

Table C2. Current Chesapeake Bay Program Advisory Team members.

Role	POC
Coordinator	Tom Butler
Agriculture	Mark Dubin

CAST	Olivia Devereux, Jessica Rigelman
Watershed Technical Workgroup	Ruth Cassilly, Jeff Sweeney
Modeling Workgroup	Gary Shenk
Urban Stormwater Workgroup	David Wood

APPENDIX D:

Recommendation Pros and Cons:

3.a) Calculate the percent change in annual fertilizer sales for the sum of states with data between the last year of available data for the state without data (AAPFCO or state data) and the year to be estimated.

Pro:	Con:
Incorporates newer information then AAPFCO alone	Does not have a single data set to cover each state (some states are extrapolated)
Reduced data latency	Does not work well if states fertilizer sales trends are independent.
Works well if all states are assumed to have similar fertilizer sales behavior	

3.b) Continue to use the last year of available AAFCO or state data.

Pro:	Con:
Faster model update time with less effort to update annual data due to reduced data collection and analysis.	No regularly updated state data is inconsistent with other state data that is updated, and can lead to potential inequalities of inorganic nutrient distribution amongst all states using a watershed fertilizer stock approach.
	Watershed fertilizer stock benefits of reduced fertilizer use are not manifested for all states equally. (E.g. constant value in older states can be higher then more up to date data. When creating the fertilizer stock for the watershed this would distribute the higher historic fertilizer to states who have seen reduced fertilizer sales)
	Can be easily gamed by reporting only in advantageous years

3.c) Use a state-specific trend using the last 5 years of available AAPFCO and/or state data for the state without updated data. This trend will be compiled after the calculation and removal of outliers in the AAPFCO data.

Pro:	Con:

Works well if all states fertilizer sales trends operate independent of each other.	Sales trends may be based entirely off available AAPFCO data which are older than state reported data (2016)
Trends are set with more recent fertilizer sales data	Trends developed from historic sales data (AAPFCO) may not be reflective of current and future trends.

<u>Recommendation Caveats and Rules:</u>

3.1 If less than three of six states provide data directly then AAPFCO fertilizer sales tonnage data will be used for any given year.

3.2 If at least three of six states provide data directly for any given year, then state data will be used with nonreporting states data taken from AAPFCO if it is available or if not, being estimated by: Calculating the percent change in fertilizer sales for the sum of states with data between the last year of available data for the state without data and the year to be estimated.

- Fert(NodataState,Year2) = Fert(NodataState,Year1) * Sum(Fert(StatesWithData,Year2)/Sum(Fert(StatesWithData,Year1)

[*Note* options b and c were evaluated as alternatives. After group discussion both options were deemed undesirable; of the two option b was preferred to option c*]

b) Continue to use the last year of data.
   i. Fert(NodataState,Year2 = Fert(NodataState,Year1)

c) Use a state-specific trends using the last 5 years of available data. This trend will be compiled after the calculation and removal of outliers in the AAPFCO data.
   i. Fert(NodataState,Year2) = Fert(NodataState,Year1)*slope*(year2-year1)

3.3 In cases where states do not submit data directly but do submit to AAPFCO the AAPFCO data will be utilized rather than a projection.

3.4 When conditions for recommendation 3 are met subsequent data will not replace fertilizer data from previous years.

APPENDIX E:

Phase 6 Data Processing Methods:

Current processing steps for Ag watershed fertilizer pounds

Section 1: Annual Mass

1. Read in the AAPFCO data
2. Compute pounds of N and P from the data (all data - no sub setting)
    1. Multiply tons by P2O5 fraction and TN fraction
    2. Treat numbers with "e" as zero
    3. Note raw data has implied decimals
    4. Convert tons to pounds (*2,000)
    5. Convert P205 to PO4-P (*0.4365)
3. Get the total pounds for each nutrient for each state and year
    1. FIPS codes are present for all data. Some county codes are "999" but all data have a state code, which is the first two digits of the 5-digit FIPS.
4. Keeping the data at the whole state geographic scale, use totals from step 3 to compute medians, standard deviations, and limits (median + 2*standard deviation, median - 2*standard deviation). The median is the number in the middle. The standard deviation formula is the square root (sum of the square of the difference between each value and the median. This is the sum of each of the differences. Then divide by the number of records which is the number of states * number of years.) All of that is under the sq. root. The denominator is N, not N-1.
5. If the total is an outlier (either above or below the limits in step 4) or missing, then replace that value with the average of the totals in the year before and after the outlier (so if 2000 is an outlier, replace the 2000 total with the average of 1999 and 2001).
6. The only exception to step 5 is if two years in a row are outliers and/or missing. In that case, replace the first outlier with the previous year and the next outlier with the average of two years prior and the next year (so if 1991 and 1992 are outliers, then replace 1991 with 1990 and 1992 with the average of 1990 and 1993), all at the state geographic scale.
7. Use these new data with all the outliers replaced to get totals for each year (summing over all the six states for each nutrient).
8. You now have a file with one record per year for each of the two nutrients all for years.

Section 2: Annual farm percentage

1. Using the original data from section 1, step 2 above, compute total farm and non-farm pounds of N and P for each year. Farm records are where the 'use' variable is either 0 or 1. Non-farm is comprised of use codes other than 0 and 1. Non-farm also includes where use is "NA".
2. Compute the percent of farm pounds (= farm pounds / (farm pounds + non-farm pounds))
3. Compute the 3-year rolling average for the farm percents: each year is the average of the current year and the previous two years (so the value for 1990 is the average of 1988, 1989, and 1990 and the values for the first two years (1985 and 1986) are missing).
4. For years before 1993, replace the moving average with the 1993 moving average, which will show no trend prior to 1993.

5. You now have a file with one record per year for each of the two nutrients and the six states.

Section 3: Determining the ratio of fertilizer in watershed counties to entire state area:

1. Get the fertilizer expenditure data for each ag census year by county for the 6 states. Data is available beginning with the 1997 ag census.
2. Linearly interpolate between ag census years
3. Sum the expenditures for the counties in or partially in the watershed and for all counties in the 6 states.
4. Divide the watershed counties expenditures by the 6 state expenditures to get the fraction for the Chesapeake Bay watershed counties.
5. Use the 1997 fraction for 1985-1996

Section 4: Final estimates of fertilizer for 1985 to the current AAPFCO year

1. Combine the total pounds per year (results of section 1) with the farm percentages per year (results of section 2) by multiplying the annual farm percentage by the 6-state sum for each year and nutrient to get the adjusted farm pounds.
2. Compute the total farm pounds for the sum of all watershed counties as the adjusted farm pounds times from the step above multiplied by the expenditure fraction for the watershed counties (results of section 3)
3. The pounds of N and P calculated for 1985 are used for 1984

Incorporating state data for years after AAPFCO data are available (*NOTE all states named in calculations are for example purposes. Any of the states in the watershed have the potential to report or not report data on any given year):

Section 1:

1. For states with reported data, incorporate each states' data from the last year of available AAPFCO data to two years prior to the present into this process through step 6.
    a. For DE, MD, PA, and VA start using state data in 2017 even if AAPFCO become available.
2. For states without reported data:
    a. Method 1: Calculate the percent change between the previous and current year of cumulative state reported data and apply the percent change in fertilizer to non-reporting states based on the last available years of AAPFCO data.
        i. NY and WV 2017 = % change of DE, MD, PA, and VA from 2016 to 2017 applied to NY and WV 2016.
        ii. NY and WV 2018 = % change of DE, MD, PA, and VA from 2017 to 2018 applied to NY and WV 2017 calculated in step above
        iii. NY and WV 2019 = % change of DE, MD, PA, and VA from 2018 to 2019 applied to NY and WV 2018 calculated in step above
        iv. NY and WV 2020 = % change of DE, MD, PA, and VA from 2019 to 2020 applied to NY and WV 2019 calculated in step above

b. Method 2: Continue to use the last available AAPFCO reported year for states without reported data.

   i. NY and WV 2017 - 2020 = NY and WV 2016

c. Method 3: Use a state-specific trends using the last 5 years of available AAPFCO data for states without reported data.

   i. NY and WV 2017-2022 = (slope * year) + intercept

- Now there is data for each state and year. Continue with Section 1, steps 7 and 8.

NOTE* Methods 2 and 3 refer to the calculations to be filled using Options B and C which were deemed undesirable for implementation by the group. This information is provided for informational purposes.

Section 2:

- There is no farm and non-farm categories for all states 2017-2020. Use the data from the states with data. E.g., the percent of farm pounds (= farm pounds in DE,MD,PA,VA / (farm pounds + non-farm pounds DE,MD,PA,VA)). Then calculate the rolling 3-year average.

Section 3:

- Use the last year of expenditure data for ag census for the years where there is more current fertilizer data. Use the 2017 expenditure data for 2017-2020.

A comparison of Census of Agriculture expenditures over time is shown below in Table E 1 and Figure E 1.

Expenditure Year	Watershed Total	Six State Total	Watershed Ratio
1997	2.9E+08	4.36E+08	0.664045
2002	3.06E+08	4.46E+08	0.685598
2007	4.88E+08	7.2E+08	0.677452
2012	7.34E+08	1.07E+09	0.685478
2017	6.48E+08	9.33E+08	0.69423

Table E1. Watershed, state total expenditures, and ratio of expenditures in the watershed, based on soil amendments from USDA NASS data.

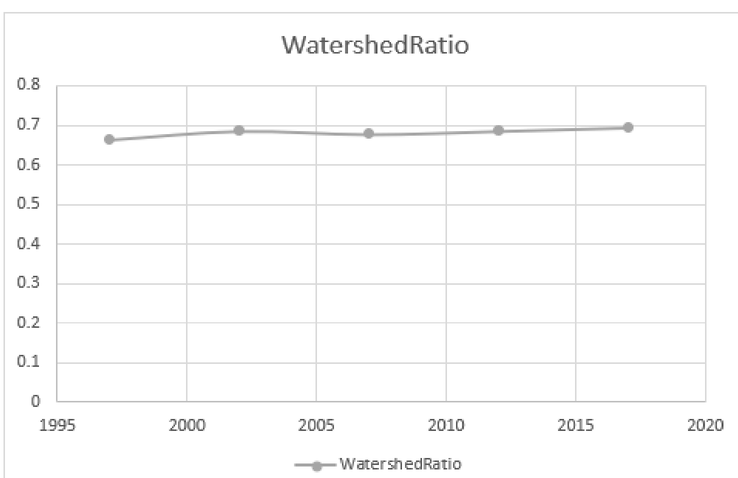

Figure E1. Ratio of expenditures in the Chesapeake Bay watershed over time.

Section 4:

- No changes

Section 5: Applying the change product

1. Calculate the change pounds for each nutrient by year from 1995.
   a. 1995 = 0
   b. 1994 = 1994-1995, 1993 = 1993-1994, etc.
   c. 1996 = 1996-1995, 1997 = 1997-1996, etc.
2. Calculate the new pounds by applying the change from 1995 calculated above to the original 1995 pounds.
   a. 1995 new = 1995 original
   b. 1994 new = 1995 original + (1994 new -1995 new), 1993 new = 1994 new + (1993 new -1994 new), etc.
   c. 1996 new = 1995 original + (1996 new -1995 new), 1997 new = 1996 new + (1997 new -1996 new), etc.
3. Now you have the final watershed fertilizer pounds used in CAST.