# 5 Section 5: Land Use

## 5.1 Introduction

Figure 5-1 shows the calculation of nitrogen or phosphorus loads delivered to tidal waters for a land use in a land-river segment, defined in Section 11. The top line represents the edge-of-stream loading rate considering local inputs but not management practices or watershed characteristics. The multiplication of the loading rate by the land use acres in a land-river segment results in the total load in the land-river segment.

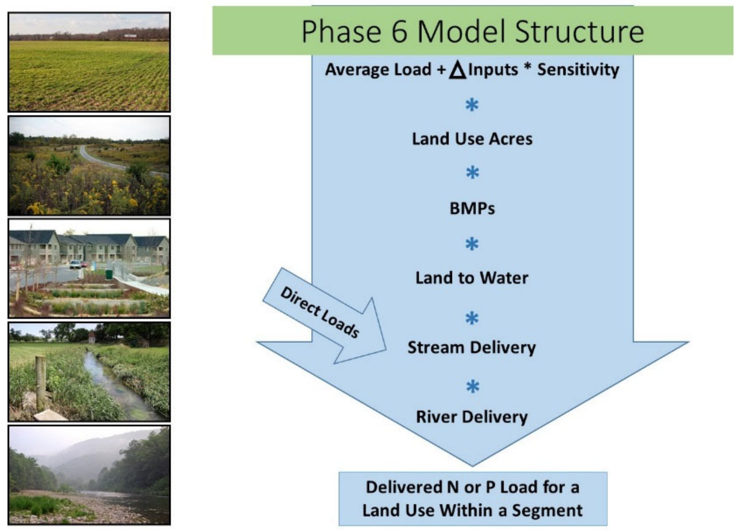


*Figure 5-1: Phase 6 Model Structure*

To calibrate the Phase 6 Watershed Model, annual land use data are required for each unique combination of 2058 land-river segments, five regulated stormwater designations, and ten federal agency categories. There are 4566 of these composite segments in the Phase 6 domain with a median area of 5.7 km$^2$ (2.2 mi$^2$), one order of magnitude smaller than the land-river segments (median area of 47.3 km$^2$ (18.3 mi$^2$)). In addition to their use in model calibration, annual land use data are needed for the implementation period, 2014 – 2025, to support the development of Phase III WIPs, two-year milestones, and annual progress runs.

The best available land use data that exist for the Phase 6 domain are 1-meter resolution land use for the year 2013. These data serve as the baseline from which land uses were backcast to 1985 and forecast to 2025. The backcast and forecast methodologies are different because the former is based on interpolations between observations while the latter is based on modeled extrapolations of those observations into the future. The time series of land use is combined with the U.S. Census of agriculture at the land-river segment scale to provide a consistent annual land use data set at the composite segment scale over the period 1985 through 2025.

## 5.2 Phase 6 Land Use Classification

The Phase 6 model requires consistent annual data on all sources of nutrients and sediment. Most of these sources are land uses. Pollutant sources that are not land uses include wastewater and septic discharges, direct atmospheric deposition, and stream bank and shoreline erosion (see Section 8). There are 29 unique land uses estimated at the composite segment scale in the Phase 6 model. Twelve of these are explicitly mapped at 1m and/or 10m resolution. The other 17 are estimated at the county level using information from the USDA Census of Agriculture or county construction and timber harvest permits. County-level data are spatially disaggregated to composite segments using the 10m-resolution mapped land use data. The 29 land uses include 17 agricultural classes, 6 developed classes, 4 natural classes, and 2 other classes and are estimated annual over the period 1985 – 2025. Details about how the area of each land use is generated and how various datasets are integrated and reconciled are included within this section.

*Table 5-1: Phase 6 land uses*

| Agriculture | Developed | Natural | Other |
|---|---|---|---|
| AOSpace* | Roads | True Forest | Mixed open |
| Full Season Soybeans* | Impervious Non-Roads | Non-tidal Floodplain Wetland | Harvested forest** |
| Other Agronomic Crops* | Tree Canopy over Impervious | Headwater or Isolated Wetland | |
| Small Grains and Grains* | Turf Grass | Water | |
| Specialty Crop Low* | Tree Canopy over Turf Grass | | |
| Double Cropped Land* | Construction** | | |
| Specialty Crop High* | | | |
| Silage with Manure* | | | |
| Grain without Manure* | | | |
| Grain with Manure* | | | |
| Silage without Manure* | | | |
| Pasture* | | | |
| Other Hay* | | | |
| Legume Hay* | | | |
| Riparian Pasture Deposition* | | | |
| Permitted Feeding Space* | | | |
| Non-Permitted Feeding Space* | | | |
| * Derived from the USDA Census of Agriculture | | | |
| ** Derived from county-level permit data (except in Virginia for 2013 where these classes were mapped) | | | |

## 5.3 2013 Phase 6 Land Uses

### 5.3.1 High-Resolution Land Cover

"Land cover" represents observable characteristics of the land surface. For example, land may appear covered by impervious surfaces, herbaceous vegetation, or tree canopy. High-resolution (1m x 1m pixels) land cover data provided the basis for estimating the extent of Phase 6 land uses at the composite segment scale. These data were produced for the entire Phase 6 domain (206 counties within, intersecting, and adjacent to the Chesapeake Bay watershed). The data were derived from 2013 or 2014 leaf-on aerial imagery from the USDA's National Agricultural Imagery Program, available leaf-off imagery produced by state and county agencies (variable vintages), and the latest LiDAR imagery available for approximately 75 percent of the watershed counties as of May 2016. Three contractors developed these data with the overall effort divided by states. The Chesapeake Conservancy classified land cover in New York, West Virginia, and Maryland. The University of Vermont's Spatial Analysis Laboratory, under contract to the Chesapeake Conservancy, classified land cover in Pennsylvania and Delaware. Worldview Solutions Incorporated produced the land cover for Virginia. Due to some differences in method and target classes, the Chesapeake Conservancy and University of Vermont also classed tree canopy over impervious surfaces for those Virginia counties with available LiDAR data. Detailed information on how these data were produced and their classification schema are available from:

http://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/land-cover-data-project/

https://www.vita.virginia.gov/media/vitavirginiagov/integrated-services/pdf/LandCover_TechnicalPlanOfOperations_v7_20160506.pdf

Because the classification schema used in Virginia differed from the schema used in other states, a generalized cross-walk was developed to relate these land cover products to the Phase 6 land cover classes used to inform the Phase 6 land use (Figure 5-2).

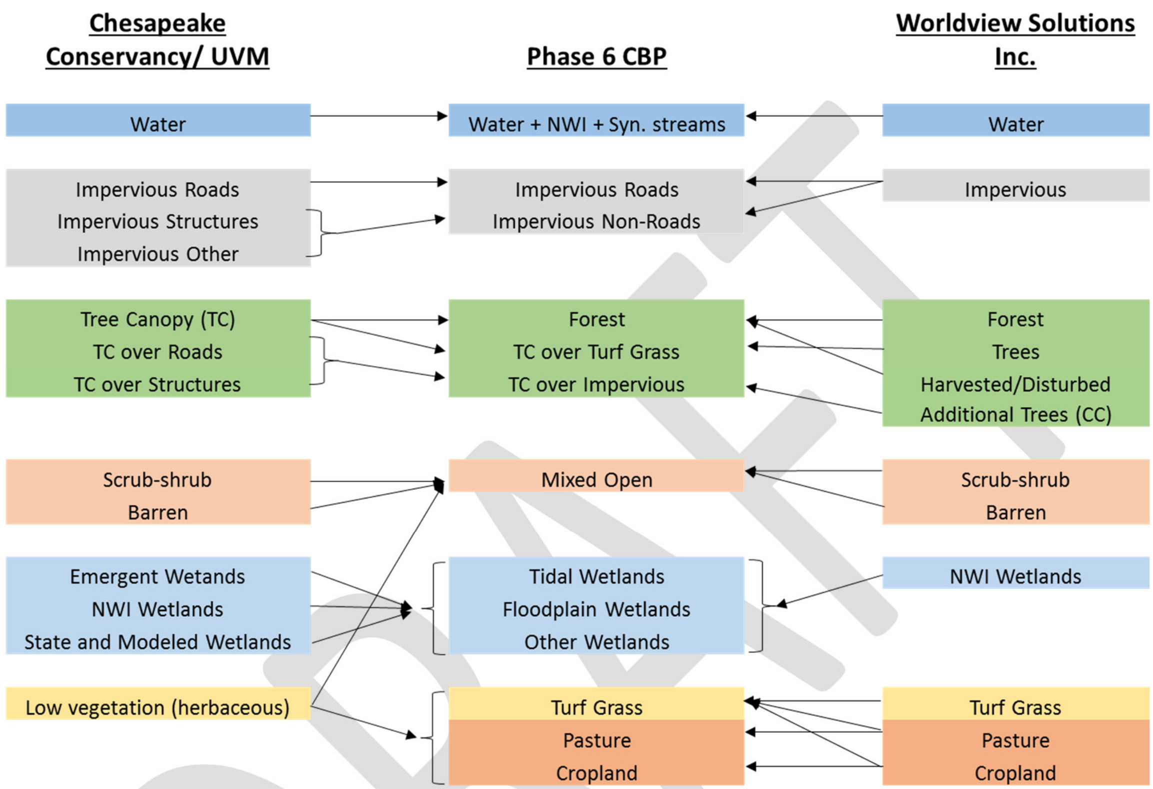


*Figure 5-2 Land cover classification schema*

### 5.3.2 High-Resolution Land Use

In contrast to land cover, “land use” represents how humans use the land, e.g., residential, commercial, agriculture, or mining and so on. Nutrient and sediment sources are related to land cover, land use, and land management. The CBP’s land use classification schema was developed to represent a hybrid of both surface characteristics and use (land management is represented through reported Best Management Practices). For example, land use data may indicate that a half-acre parcel is “residential” while high-resolution land cover data indicate the portions of the residential parcel that are covered by impervious surfaces, herbaceous cover or tree canopy. Using these data in combination, one can discern that the impervious surfaces within the parcel are likely composed of buildings, driveways, and sidewalks instead of roads, the herbaceous vegetation is mostly turf grass instead of cropland, and the trees likely have an understory of turf grass instead of an unmanaged forest understory. In preparation for this effort, the LUWG collected county-level parcel and land use data where available from local and state sources over the 2013 – 2015 timeframe. As of spring 2016, approximately 60 percent of the counties in the P6 domain provided parcel data and 45 percent provided some form of land use data.

The first step in translating the high-resolution land cover to the Phase 6 mapped land uses was to decide on a classification schema. The CBP Land Use Workgroup (LUWG) led this effort, working closely with the Forestry Workgroup, Urban Stormwater Workgroup, Agriculture Workgroup, Watershed Technical Workgroup, Wastewater Workgroup, Federal Facilities Workgroup, Wetlands Workgroup, and Water Quality Goal Implementation Team to develop a set of classes that both represent unique sources of nutrients and/or sediments and could be mapped with available information. The LUWG also worked with these groups to develop the class definitions and decision rules required to map each class. Note that the WQGIT approved the proposal to not include an explicit extractive land use in the Phase 6 Watershed Model. Areas known to be extractive are simulated as “mixed open” and excluded from areas classed as agriculture or turf grass.

### 5.3.3 Mapped Land Use Classes

Sixteen land use classes were mapped at 1m-resolution throughout five states (DE, MD, NY, PA, WV) and the District of Columbia. Seventeen land use classes were mapped at 1m-resolution in Virginia because they used ancillary data on the locations of cropland and pasture that only exist for Virginia.

| 1m Land Use (DC, DE, MD, NY, PA, WV) | 1m Land Use (VA) |
|---|---|
| Impervious Roads | Impervious Roads |
| Impervious Non-Roads | Impervious Non-Roads |
| Tree Canopy over Impervious | Tree Canopy over Impervious |
| Turf Grass | Turf Grass |
| Tree Canopy over Turf Grass | Tree Canopy over Turf Grass |
| True Forest | True Forest |
| Non-tidal Floodplain Wetland | Non-tidal Floodplain Wetland |
| Headwater or Isolated Wetland | Headwater or Isolated Wetland |
| Water | Water |
| Mixed open | Mixed open |
| Fractional Turf (small) | Fractional Turf (small) |
| Fractional Turf (medium) | Fractional Turf (medium) |
| Fractional Turf (large) | Fractional Turf (large) |
| Fractional Impervous | Fractional Impervous |
| Agriculture | Cropland |
| | Pasture |

These data are available for viewing and download from:

The following thirteen land use classes have been mapped at 10m s document describes the 1m classification scheme applied to the 1m land use data mapped for the Chesapeake Bay watershed and intersecting counties using 2013 (DE, NY, PA, and MD) and 2014 (WV and VA) aerial imagery. These data have also been aggregated to 10m resolution with a condensed classification scheme. The 10m land use data include a more complete representation of streams and differentiate between cropland and pasture throughout the watershed- these distinctions are largely absent in the 1m data. The aggregated

10m data currently inform the Chesapeake Bay Program's Phase 6 watershed model, the Bay Total Maximum Daily Load (TMDL), and Phase III Watershed Implementation Plans. The 10m land use data consist of thirteen separate 10m-resolution raster datasets which can be viewed and downloaded from: http://chesapeake.usgs.gov/phase6/map/.

Impervious Roads (IR) = Paved and unpaved roads, bridges, and some driveways.

Impervious Non-Roads = Buildings, driveways, sidewalks, parking lots, runways, some private roads, most railyards, and barren lands within industrial, transitional (early stages of construction), and warehousing land uses. The class includes 30 percent of herbaceous and barren lands within industrial, transitional (early stages of construction), and warehousing land uses. The class excludes rail rights-of-way because the spatial accuracy of the rail data is insufficient to align with the 1m-resolution land cover data informing the land use classification. Note that portions of some quarries and other extractive lands may be mistakenly included in this class.

Tree Canopy over Impervious Surfaces = Trees over roads and non-road impervious surfaces.

Turf Grass = Herbaceous and barren lands that have been altered through compaction, removal of organic material, and/or fertilization. These include all herbaceous and barren lands within road rights- of-way, residential, commercial, recreational, other turf-dominated land uses (e.g., cemeteries, shopping centers, golf courses, airports, hospitals, amusement parks, etc.), and small developed parcels (<= 10 acres with >= 93 $m^2$ of total impervious cover). The 93 $m^2$ (1000 $ft^2$) threshold is meant to represent the average size of a single-wide mobile home.

Tree Canopy over Turf Grass = Trees within 30 feet to 80 feet of non-road impervious surfaces where the understory is assumed to be turf grass or otherwise altered through compaction, removal of surface organic material, and/or fertilization.

Forest = All standing trees and areas of tree harvest farther than 30 feet to 80 feet from non-road impervious surfaces and forming contiguous patches at least one acre in extent. The variable range of distances result from the application of multiple filtering algorithms (e.g., focal moving windows) to identify areas covered by tree canopy with an undisturbed/unmanaged understory[1].

Floodplain Wetlands = National Wetlands Inventory (NWI) non-pond, non-lake wetlands, emergent wetlands mapped from high-resolution imagery outside Virginia, state designated wetlands, and state

[1] Developed areas are mapped using a series of four circular focal filters corresponding to 10-acre, 1-acre, ¾-acre, and ½-acre areas with respective radii of 113m, 37m, 27m, and 18m. These represent different concentrations of non-road impervious surfaces and serve to create variable width buffers around developed areas. The largest filter, 10-acres, is only applied to Census Urbanized Areas and Clusters and helps to fill gaps created by the smaller filters. The smaller filters help define the interface between densely developed and rural areas. Large filters over-generalize and therefore have high commission errors, e.g., classifying forests as tree canopy over turf or cropland as turf grass. Small filters under-generalize and may not fully cover areas maintained as turf grass or trees over turf grass. Therefore, all four filters are needed. Many different filter sizes, combinations of filters, and filter density thresholds were evaluated. Through trial and error, observing the effect of each set of filters and decision rules on resultant forest vs non-forest classifications in Prince George's county, we settled on the above set of four. The exact filter sizes are not as important as having a set that captures a range of relevant scales.

identified potential non-tidal wetlands located within the FEMA designated 100-year floodplain or on frequently flooded soils (SSURGO).

Other Wetlands = National Wetlands Inventory (NWI) non-pond, non-lake wetlands, emergent wetlands mapped from high-resolution imagery outside Virginia, state designated wetlands, and state identified potential non-tidal, non-floodplain wetlands. These are typically headwater wetlands or isolated wetlands.

Tidal Wetlands = Wetlands classified as marine and estuarine wetland systems (E2EM, ESFO, W2SS) according to the NWI Wetlands and Deepwater Habitats Classification chart (https://www.fws.gov/wetlands/Documents/Wetlands-and-Deepwater-Habitats-Classificationchart.pdf), NWI palustrine wetlands (PEM, PFO, PSS) with water regime modifiers associated with tidal hydrological conditions (e.g., saltwater tidal or freshwater tidal), and all wetlands mapped from imagery that could be influenced by tidal characteristics/processes by having an elevation less than or equal to 2 meters above sea level according to the 10m-resolution NED (downloaded July 2015). Note that Tidal Wetlands are excluded from the watershed model but are being mapped for future input to the Water Quality and Sediment Transport Model (WQSTM) of the tidal Bay..

Water = Wide streams and canals, large ponds and swimming pools, wet detention basins, reservoirs, etc. mapped from the high-resolution imagery, National Wetlands Inventory (NWI) ponds and lakes, and large waterbodies identified in the 1:24,000-scale National Hydrography Dataset. Note that small-to-medium width (< 20-30m) streams, small waterbodies (< 1 acre) and heavily eutrophic ponds could not be consistently detected from NAIP imagery and therefore may absent from this class. The Water land use also includes synthetic streams derived from a 10m-resolution National Elevation Dataset using a similar density to those mapped in the 1:24,000-scale National Hydrography Dataset and with widths inferred from published relationships between drainage area and stream width.

Mixed Open = Small patches of trees (< 1 acre) outside developed areas, and all scrub-shrub, herbaceous, and barren lands that have been minimally disturbed, e.g., periodically bush hogged, meadows, etc., reclaimed, or that have internal and/or regulated drainage. Mixed Open also includes small patches of trees < 1 acre that are classed as active, abandoned and reclaimed mines, landfills, unconventional oil & gas, beaches, waterbody margins, natural grasslands, and utility rights-of-way. The class includes 70 percent of herbaceous and barren lands within industrial, transitional (early stages of construction), and warehousing land uses, and 30 percent of herbaceous and barren lands within large developed parcels (> 10 acres and >= 10 percent impervious),small parks and small federal facilities (<= 10 acres), 50 percent of herbaceous within medium parks and federal facilities (10-1000 acres), and 60 percent of herbaceous within large parks and federal facilities (>1000 acres).
Theis class includes 70% percent of herbaceous and barren lands within large developed parcels (> 10 acres and >= 10% percent impervious) and small parks and small federal facilities (<= 10 acres), 50% percent of herbaceous within medium parks and federal facilities (10-1000 acres), and 30% percent of herbaceous within large parks and federal facilities (>1000 acres).

Cropland = This class was only mapped at 1-meter resolution in Virginia. The Virginia Department of Conservation and Recreation has a spatial dataset of points and polygons to differentiate between cropland and pasture. These data were overlaid on the land cover to classify herbaceous lands as either cropland or pasture at 1-meter resolution. Outside of Virginia, all herbaceous and barren lands that are not classed as turf grass or mixed open are simply classed as “agriculture”. This explains why there are

17 classes in the Virginia portion of the dataset compared to outside Virginia, where there are only 16 classes. In addition, 5 percent of herbaceous in large parks and federal facilities (>1000 acres) is classed as crops unless otherwise specified in the Federal Facility Editor Tool discussed in Section 5.3.7.
Note that cropland is mapped everywhere as part of the aggregated 10m land use dataset. In Virginia, the 1m cropland and 1m pasture cells are simply aggregated to each overlaying 10m cell. Outside Virginia, the portion of a 10m cell that is classed as "agriculture" at 1m is reclassed as part cropland and part pasture using eight years of the annual, 30m-resolution NASS Cropland Data Layer (CDL 2008 through 2015). The frequency at which each 30m CDL cell was classified as crops over the eight-year period determines the proportion of crops in each of the nine underlying 10m cells. For example, if a 10m cell (100 m2) includes 80 1-m "agriculture" cells (i.e., it's 80% agriculture) and the overlaying 30m CDL cell was classed as some form of crop in 2 out of 8 years, 25% of the portion of the 10m cell that is agriculture would be considered to be cropland and the remaining 75% of the portion that is agriculture would be considered to be pasture. Therefore, this cell would have 20m2 (25% of 80m2) of crop, 60m2 of pasture, and 20m2 of some other land use.

<u>Pasture/Hay</u> = This class was only mapped at 1-meter resolution in Virginia. Outside of Virginia, all herbaceous and barren lands that are not classed as turf grass or mixed open are simply classed as "agriculture". Pasture is mapped everywhere as part of the aggregated 10m land use dataset (see the more detailed description of the "Cropland" class). Note that hay is grouped with pasture because they are difficult to differentiate through image interpretation.

### 5.3.4 Ancillary Data Used To Inform Mapped Land Uses

The main challenge in translating land cover into land use is the classification of herbaceous vegetation. Herbaceous vegetation, i.e., low vegetation, can represent cropland, pasture, turf grass, or mixed open, e.g., fallow/unmanaged vegetation, all of which vary significantly in their nutrient and sediment characteristics, and hence are important to distinguish. Ancillary data combined with contextual information derived from the high-resolution land cover were used to differentiate among the potential herbaceous land uses and to help define all other land use classes. Among the different ancillary datasets, county land use data proved the most useful for this process. For each county that provided the CBPO with land use polygons or parcels attributed with land use codes, USGS student contractors translated the land use codes into binary (1/0) classifications of turf grass, mixed open, and fractional (part turf grass, part impervious, or part mixed open). These binary datasets were then overlaid on the high-resolution land cover to reclassify herbaceous vegetation as either turf grass, mixed open, or fractions of both. Contextual information such as parcel size combined with impervious surface area per parcel were also used in the process as were a variety of distance measures to approximate the potential area of lawns and/or compacted soils surrounding roads and structures. All rules were vetted through the Land Use Workgroup. The Forestry Workgroup determined the rules for separating forests from trees with managed understories, i.e., trees over impervious or trees over turf grass.

| Ancillary Dataset | Description | Source |
|---|---|---|
| Beaches | Sandy areas along coastlines and lakes | NAVTEQ Land Use Features (A) v5.0 10/01/2013, HERE |
| Chesapeake Conservancy- emergent wetlands | Emergent wetlands classified from aerial imagery and not present in the NWI. Edited extents of NWI wetlands where land use change and/or sea-level rise has altered their obersvable extent. (for MD and DE only) | Chesapeake Conservancy |
| County Land Use: Fractional Impervious | Partially mixed open and impervious areas including railyards, industrial sites, and transitional areas | County Planning and GIS offices |
| County Land Use: Fractional Turf Grass | Partially mixed open and turf grass areas including universities and colleges, and large developed parcels | County Planning and GIS offices |
| County Land Use: Mixed Open | Rangeland, beaches, extractive areas, waterbody margins, and utility rights-of-way | County Planning and GIS offices |
| County Land Use: Turf Grass | Residential, commercial, recreational, farmstead, cemeteries, hospitals, shopping centers, golf courses, and parking lots. | County Planning and GIS offices |
| Cropland Data Layer | 30m-resolution representation of the relative frequency of cropland and pasture designations in the annual Cropland Data Layers (2008 - 2015). | USDA-NASS Cropland Data Layer, 2008 - 2015 |
| Extractive Areas | 60m-resolution representation of surface mines derived from state (WV and VA) databases, the 1992 NLCD, and digitized areas from point locations in USEPA's Envirofacts database | USGS National Wall-to-Wall Anthropogenic Land Use Trends (NWALT) |
| Federal Lands | Federally owned and managed properties | USGS Protected Areas Database of the United States and various federal and state agencies |
| Floodplains | 100-year floodplain (FEMA DFIRMs) and frequently flooded soils (gSSURGO) | FEMA DFIRMs and gSSURGO |
| Institutional Turf | Golf courses, university campuses, cemeteries, shopping centers | NAVTEQ Land Use Features (A&B) v5.0 10/01/2013, HERE |
| Landfills | Landfills by points and then digitized from 2013/14 NAIP imagery | Chesapeake Bay Program Office |
| Non-Tidal Wetlands | All non-open water, non-riverine, and non-tidal wetlands | U.S. Fish and Wildlife Service, National Wetlands Inventory |
| Parcels | Tax parcel polygons attributed with area | County Planning and GIS offices |
| Park Lands | All county and state parklands and non-agricultural conserved lands. | Protected Areas Database- United States, v1.3 |
| Pennsylvania Potential Wetlands | Potential wetlands identified from a probabilistic model of presence/absence derived from LiDAR terrain features | Upper Susquehanna Coalition; University of Vermont's Spatial Analysis Laboratory |
| Road Rights-of-Way | Streets buffered by 4m on either side | NAVSTREETS Street Data v5.0 10/01/2013, HERE |
| Synthetic Streams | Streams derived from a hydrologically conditioned version of the 10m-resolution National Elevation Dataset using a 60-acre minimum drainage area threshold. | Chesapeake Bay Program Office |
| Tidal Wetlands | All tidal wetlands | U.S. Fish and Wildlife Service, National Wetlands Inventory |
| Tidal zone | All lands 2m above sea level and contiguous to the Bay and tidal tributaries | Chesapeake Bay Program Office, USGS National Elevation Dataset |
| Water | Ponds and lakes | U.S. Fish and Wildlife Service, National Wetlands Inventory |

*Figure 5-3: Ancillary datasets*

### 5.3.5 Land Use Classification Workflow

The complete translation of land cover and ancillary data into a regionally consistent land use dataset was coded in Python 2.7.12 using algorithms from ArcGIS 10.4.1. Python provided the flexibility, transparency, and repeatability necessary for the task. Two process diagrams were developed to guide the workflow and coding process: one for all non-Virginia counties (Figure 5-4) and one for just Virginia counties (Figure 5-5) to accommodate its unique land cover classification schema. All counties in the watershed were simulated individually to accommodate the unique data potentially available for each county. Depending on the size of each county and quantity of data available, processing took between 6-24 hours of continuous computation per county. Six new GIS workstations equipped with 32GB RAM and i7 multi-core processors (3.5 – 4.0GHz) were dedicated to this task and all 206 counties were completed over a 6-week period once the scripts were finalized in December 2016.

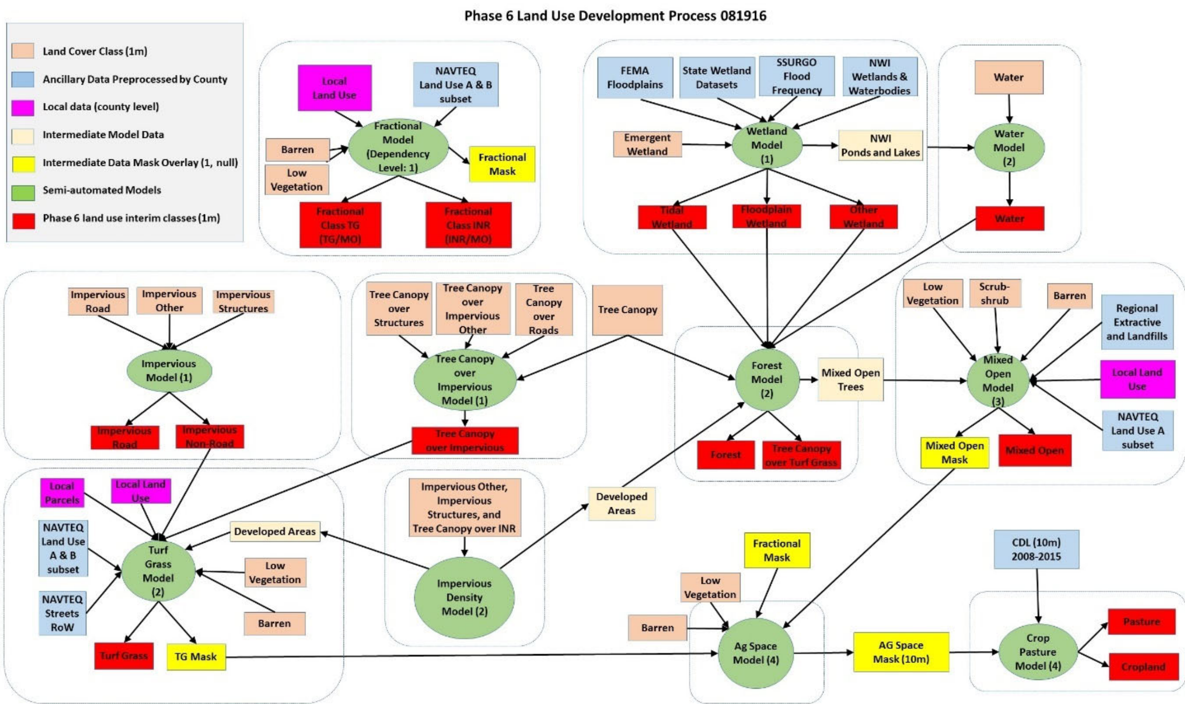


*Figure 5-4: Phase 6 land use development process*

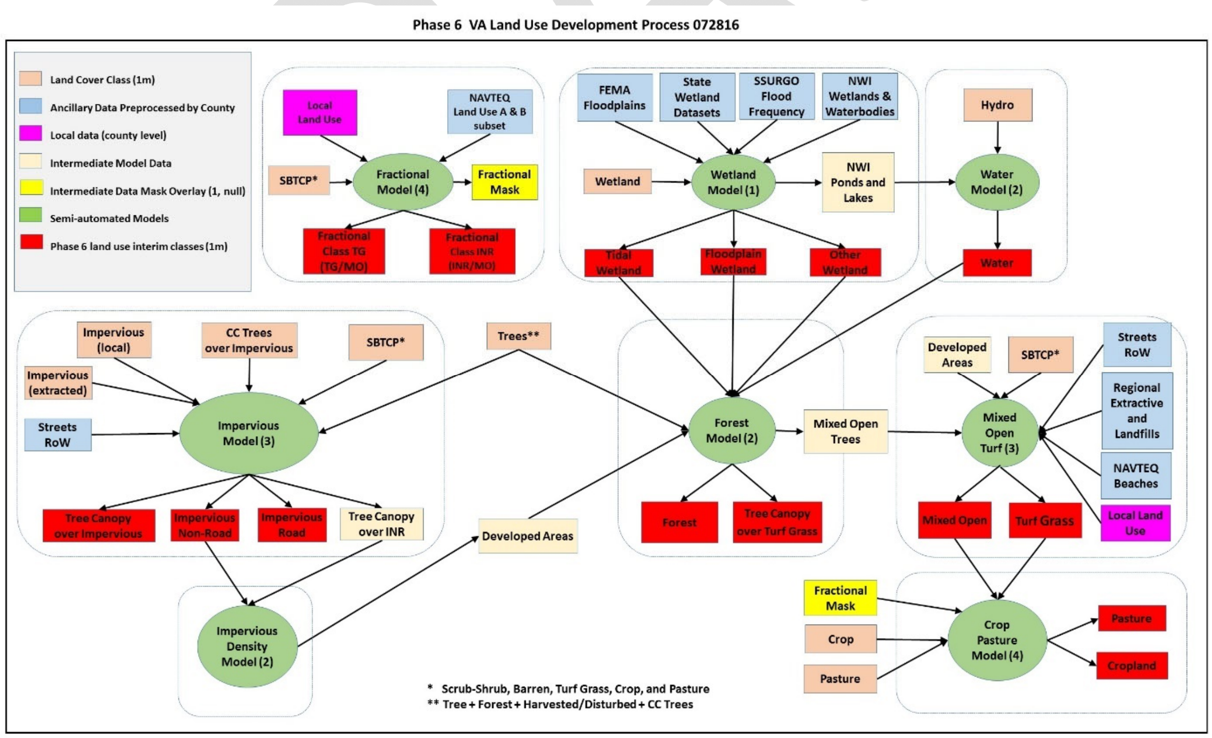


*Figure 5-5: Phase 6 Virginia land use development process*

### 5.3.6 Rescaling Land Use

Each of the thirteen mapped 1m-resolution land use classes were aggregated into individual 10m-resolution raster datasets with values ranging from 0 to 100 representing the percentage of each cell composed by each class. This process enabled more efficient use of the data and the incorporation of synthetic streams which could only be mapped at 10m resolution due to limited availability of LiDAR in some parts of the watershed. Most 10m cells are composed of multiple classes, e.g., 50 percent turf grass, 10 percent tree canopy over turf grass, 10 percent tree canopy over impervious roads, and 30 percent impervious roads. The mapped land use classes can be viewed at: https://chesapeake.usgs.gov/phase6/map

### 5.3.7 Wetland Estimation

The National Wetlands Inventory (NWI) served as the starting point for defining the universe of mapped wetlands. In all areas outside Virginia, the Chesapeake Conservancy and the University of Vermont mapped additional emergent wetlands if visible in the NAIP imagery and they adjusted the boundaries of NWI wetlands if it were obvious that they have changed, (e.g., a former wetland which is now covered by a house and lawn. In Pennsylvania, additional wetlands were mapped by the Upper Susquehanna Coalition and University of Vermont. County-wide wetlands were mapped using an object-based image analysis which combined regression models of hydrogeologic variables with LiDAR-derived terrain variables, high resolution aerial imagery, and land cover data. Woody wetlands were predicted by landscape wetness, surface elevation, climate, and poorly drained soils. Emergent wetlands were predicted by landscape wetness, topographic dissection, landscape roughness, and forest cover. A full description is contained in Appendix 5A: A LiDAR-aided hydrogeologic modeling and object-based wetland mapping approach for Pennsylvania.

Tidal wetlands were classified using three methods: 1) identifying all wetlands classified as marine and estuarine wetland systems (E2EM, ESFO, or W2SS) according to the NWI Wetlands and Deepwater Habitats Classification chart (https://www.fws.gov/wetlands/Documents/Wetlands-and-Deepwater-Habitats-Classification-chart.pdf); 2) identifying palustrine wetlands with water regime modifiers associated with tidal hydrological conditions,(e.g., saltwater tidal or freshwater tidal: PEM, PFO, PSS; 3) identifying wetlands that could be influenced by tidal characteristics/processes by having an elevation less than or equal to 2 meters above sea level according to the Bay elevation apparent in the 10m-resolution National Elevation Dataset (Ator et al. 2003).

Floodplain wetlands were mapped by first creating a map of floodplains based on Federal Emergency Management Agency's (FEMA) Digital Flood Insurance Rate Maps in the National Flood Hazard Layer and Natural Resources Conservation Service's (NRCS) Soil Survey Geographic database (SSURGO). The primary soil attributes used to identify potential floodplains include: flooding frequency (annual probability > 1 percent), fluvial origins, e.g., fluvents, fluventic aquicambids, and fluvaquents, and floodplain geomorphic characteristics, e.g., floodplains, floodplain steps, and floodplain playa, and presence of water.

All NWI and other mapped wetlands that failed to qualify as tidal or floodplain wetlands were classified as "other". Most of these would be considered isolated and/or headwater wetlands.

### 5.3.8 Maryland 2013 Mapped Land Uses

For 2013 conditions, the Maryland Department of the Environment provided estimates of non-road, road impervious, canopy over impervious, turf and canopy over turf acres in the following counties:

Allegany
Anne Arundel
Baltimore City
Carroll
Cecil
Charles
Dorchester
Frederick
Harford
Howard
Montgomery
Prince George's
Queen Anne's
Talbot
Washington
Wicomico

For those land uses and counties not estimated, the CBPO approach for mapping the land uses was used.

### 5.3.9 Regulatory Overlay

The Chesapeake Bay region was mapped for regulatory structure. Land areas were classified as either non-regulated, Municipal Separate Storm Sewer System (MS4), or Combined Sewer Service (CSS) areas. Non-regulated areas may contain all Phase 6 land use types. MS4 areas, by definition, contain only developed land areas. CSS areas are not limited by definition, but as a practical matter do not contain agricultural land uses. The CSS land uses in the natural category were simplified to facilitate appropriate BMP applications such that all wetlands falling within CSSs were moved into the CSS forest land use and all cropland and pasture within CSSs were moved to CSS mixed open. The CSS areas may be modified by the wastewater dataset which includes the portion of the wastewater load that is eliminated due to combined sewer system (CSS) separation. Polygon datasets representing CSS and MS4 boundaries were provided to the CBPO from state and federal agencies.

### 5.3.10 Federal Agency Overlay

For the purposes of accurately attributing land use management responsibilities to federal agencies, federal lands were mapped and grouped into nine federal agency categories: Agricultural Research Service, Department of Defense, Other Federal Land, US Forest Service, US Fish and Wildlife Service, General Services Administration, National Aeronautics and Space Administration, National Park Service, Smithsonian Institution and Other Federal. Additionally, Maryland has broken out land uses into Maryland State and Maryland State Highway Administration categories in addition to the non-federal agency land use category.

While land uses on federal lands were mapped, federal agencies were offered the opportunity to designate the condition of their herbaceous lands using an online Federal Facilities Editor Tool developed by the USGS. Agencies were asked to designate the proportion of cropland, pasture, mixed open, and turf grass composing all herbaceous lands within their properties. The federal facilities editor tool allowed federal agencies to zoom into a map of their facilities edit their land use data. These estimates were explicitly accounted for in the Phase 6 mapping process. For agencies and federal lands that did not report these data to the CBPO, default rules were established based on the size of the federal properties. For federal lands less than or equal to 10 acres, herbaceous lands were assumed to be composed of 70 percent turf grass and 30 percent mixed open. For Federal lands between 10-1000 acres, herbaceous lands were assumed to be composed of 50 percent turf grass and 50 percent mixed open. Finally, for federal lands exceeding 1000 acres, herbaceous lands were assumed to be composed of 60 percent mixed open, 30 percent turf grass, 5 percent cropland, and 5 percent pasture. Note that the size of properties based on contiguity such that the area of all federal lands adjacent to each other was considered when applying these rules. This was done because many federal agencies supplied the CBPO with data consisting of multipart polygons all of which were given a single acreage of amount despite great variability in the extent of disconnected individual parts.

## 5.4 Estimating Agricultural Acres

Acres of each agricultural land use which includes crops are estimated based upon acres of crops reported by the Census of Agriculture. Section 3 discusses how nutrient applications, uptake, and other input data are crop-specific at the beginning of the input calculations. While most calculations are done on the crop level, the crops are eventually aggregated up to land uses containing crops with similar management. Table 5-2 lists the land use category for each crop. Note that some crops are also eligible for the double cropped land use which is discussed in a later section.

*Table 5-2: Census of Agriculture Crops and Associated Land Uses*

| Crop Name | Land Use | Eligible for Double Crop |
|---|---|---|
| Alfalfa Hay Harvested Area | Legume Hay | Y |
| Alfalfa Seed Harvested Area | Legume Hay | N |
| Aquatic Plants Area | Specialty Crop Low | N |
| Asparagus Harvested Area | Specialty Crop Low | N |
| Barley for Grain Harvested Area | Small Grains and Grains | Y |
| Bedding/Garden Plants Area | Specialty Crop High | N |
| Beets Harvested Area | Specialty Crop High | N |
| Berries - All Harvested Area | Specialty Crop Low | N |
| Birdsfoot Trefoil Seed Harvested Area | Legume Hay | N |
| Broccoli Harvested Area | Specialty Crop High | N |
| Bromegrass Seed Harvested Area | Other Hay | N |
| Brussels Sprouts Harvested Area | Specialty Crop High | N |
| Buckwheat Harvested Area | Small Grains and Grains | N |
| Bulbs, Corms, Rhizomes, and Tubers – Dry Harvested Area | Specialty Crop High | N |
| Canola Harvested Area | Small Grains and Grains | N |

| | | |
|---|---|---|
| Cantaloupe Harvested Area | Specialty Crop High | N |
| Carrots Harvested Area | Specialty Crop High | N |
| Cauliflower Harvested Area | Specialty Crop High | N |
| Celery Harvested Area | Specialty Crop High | N |
| Chinese Cabbage Harvested Area | Specialty Crop High | N |
| Collards Harvested Area | Specialty Crop High | N |
| Corn for Grain Harvested Area | Grain with Manure | N |
| Corn for Silage or Greenchop Harvested Area | Silage with Manure | Y |
| Cotton Harvested Area | Other Agronomic Crops | N |
| Cropland Idle or Used For Cover Crops or Soil Improvement But Not Harvested and Not Pastured Or Grazed Area | Other Agronomic Crops | N |
| Cropland In Cultivated Summer Fallow Area | Other Agronomic Crops | N |
| Cropland On Which All Crops Failed or Were Abandoned Area | Other Hay | N |
| Cropland Used Only for Pasture Or Grazing Area | Pasture | N |
| Cucumbers and Pickles Harvested Area | Specialty Crop High | N |
| Cut Christmas Trees Production Area | Specialty Crop Low | N |
| Cut Flowers and Cut Florist Greens Area | Specialty Crop High | N |
| Dry Edible Beans, Excluding Limas Harvested Area | Other Agronomic Crops | N |
| Dry Onions Harvested Area | Specialty Crop High | N |
| Eggplant Harvested Area | Specialty Crop High | N |
| Emmer and Spelt Harvested Area | Small Grains and Grains | N |
| Escarole and Endive Harvested Area | Specialty Crop High | N |
| Fescue Seed Harvested Area | Other Hay | N |
| Foliage Plants Area | Specialty Crop High | N |
| Garlic Harvested Area | Specialty Crop High | N |
| Green Lima Beans Harvested Area | Specialty Crop Low | N |
| Green Onions Harvested Area | Specialty Crop High | N |
| Greenhouse vegetables Area | Specialty Crop High | N |
| Haylage or Greenchop From Alfalfa or Alfalfa Mixtures Harvested Area | Legume Hay | N |
| Head Cabbage Harvested Area | Specialty Crop High | N |
| Herbs, Fresh Cut Harvested Area | Specialty Crop High | N |
| Honeydew Melons Harvested Area | Specialty Crop High | N |
| Kale Harvested Area | Specialty Crop High | N |
| Land in Orchards Area | Specialty Crop Low | N |
| Lettuce, All Harvested Area | Specialty Crop High | N |
| Mushrooms Area | Specialty Crop High | N |

| | | |
|---|---|---|
| Mustard Greens Harvested Area | Specialty Crop High | N |
| Nursery stock Area | Specialty Crop Low | N |
| Oats for Grain Harvested Area | Small Grains and Grains | N |
| Okra Area | Specialty Crop High | N |
| Orchardgrass Seed Harvested Area | Other Hay | N |
| Other Field And Grass Seed Crops Harvested Area | Other Hay | N |
| Other Haylage, Grass Silage, and Greenchop Harvested Area | Other Hay | Y |
| Other Managed Hay Harvested Area | Other Hay | N |
| Other Nursery And Greenhouse Crops Area | Specialty Crop High | N |
| Parsley Harvested Area | Specialty Crop High | N |
| Pastureland And Rangeland Other Than Cropland And Woodland Pastured Area | Pasture | N |
| Peanuts For Nuts Harvested Area | Other Agronomic Crops | N |
| Peas, Chinese (Sugar And Snow) Harvested Area | Specialty Crop Low | N |
| Peas, Green (Excluding Southern) Harvested Area | Specialty Crop Low | N |
| Peas, Green Southern (Cowpeas) – Black-Eyed, Crowder, Etc. Harvested Area | Specialty Crop Low | N |
| Peppers, Bell Harvested Area | Specialty Crop High | N |
| Peppers, Chile (All Peppers – Excluding Bell) Harvested Area | Specialty Crop High | N |
| Popcorn Harvested Area | Specialty Crop High | N |
| Potatoes Harvested Area | Specialty Crop High | N |
| Potted Flowering Plants Area | Specialty Crop High | N |
| Pumpkins Harvested Area | Specialty Crop High | N |
| Radishes Harvested Area | Specialty Crop High | N |
| Red Clover Seed Harvested Area | Legume Hay | N |
| Rhubarb Harvested Area | Specialty Crop High | N |
| Rye For Grain Harvested Area | Small Grains and Grains | N |
| Ryegrass Seed Harvested Area | Other Hay | N |
| Short-Rotation Woody Crops Harvest Area | Specialty Crop Low | N |
| Small Grain Hay Harvested Area | Other Hay | Y |
| Snap Beans Harvested Area | Specialty Crop Low | N |
| Sod Harvested Area | Other Agronomic Crops | N |
| Sorghum For Grain Harvested Area | Grain with Manure | Y |
| Sorghum For Silage or Greenchop Area | Silage with Manure | N |
| Soybeans For Beans Harvested Area | Full Season Soybeans | Y |
| Spinach Harvested Area | Specialty Crop High | N |
| Squash Harvested Area | Specialty Crop High | N |

| | | |
|---|---|---|
| Sunflower Seed, Non-Oil Varieties Harvested Area | Specialty Crop Low | N |
| Sunflower Seed, Oil Varieties Harvested Area | Specialty Crop Low | N |
| Sweet Corn Harvested Area | Other Agronomic Crops | N |
| Sweet Potatoes Harvested Area | Specialty Crop High | N |
| Timothy Seed Harvested Area | Other Hay | N |
| tobacco Harvested Area | Other Agronomic Crops | N |
| Tomatoes Harvested Area | Specialty Crop High | N |
| Triticale Harvested Area | Small Grains and Grains | Y |
| Turnip Greens Harvested Area | Specialty Crop High | N |
| Turnips Harvested Area | Specialty Crop High | N |
| Vegetable & Flower Seeds Area | Specialty Crop High | N |
| Vegetables, Mixed Area | Specialty Crop High | N |
| Vetch seed Harvested Area | Legume Hay | N |
| Watermelons Harvested Area | Specialty Crop High | N |
| Wheat for Grain Harvested Area | Small Grains and Grains | Y |
| Wild hay Harvested Area | Ag Open Space | N |

In years for which acres of crops are provided by the Census of Agriculture (1982, 1987, 1992, 1997, 2002, 2007, and 2012), those acres are used directly in estimating the total land use acres after considering any acres upon which two crops may have been grown. Acres of crops and pasture in intervening years are interpolated. For example, if the Census of Agriculture reported 1,000 acres of pasture in a county in 1992 and 500 acres in 1997, then it is assumed that the county lost 100 acres of pasture each year from 1993 through 1997.

### 5.4.1 Estimating Double-Cropped Acres

The Census of Agriculture reports harvested acres of over 115 individual crops but does not indicate if these crops were grown upon the same acre. In reality, many acres of row crops contain two harvested crops within a single year. This is most common within the widely-maintained corn/soybean/wheat crop rotation. Fortunately, the Census of Agriculture does provide acres of "Harvested Cropland" which represents the total acres harvested within a county. Thus an estimate of acres upon which two crops were grown can be made by comparing the acres of individual crops harvested to acres of harvested cropland.

The first step to estimating double cropped acres is to compare the acres of harvested crops listed in Table 5.3 to the acres of "Harvested Cropland" in a county. Note that Table 5.3 does not contain all 115 crops because many smaller crops are encompassed by a crop category, such as "Vegetables, Harvested Area." The resulting acres represents an initial estimate of all crops upon which two crops were harvested.

*Table 5-3: Crop types to compare to harvested cropland*

| Crop Name | Multiple Crop Category |
|---|---|
| Alfalfa Hay Harvested Area | N |
| Alfalfa Seed Harvested Area | N |
| Barley for Grain Harvested Area | N |
| Bedding/Garden Plants Area | N |
| Berries- All Harvested Area | Y |
| Birdsfoot Trefoil Seed Harvested Area | N |
| Bromegrass Seed Harvested Area | N |
| Buckwheat Harvested Area | N |
| Canola Harvested Area | N |
| Corn For Grain Harvested Area | N |
| Corn For Silage Or Greenchop Harvested Area | N |
| Cotton Harvested Area | N |
| Cut Christmas Trees Production Area | N |
| Dry Edible Beans, Excluding Limas Harvested Area | N |
| Emmer And Spelt Harvested Area | N |
| Fescue Seed Harvested Area | N |
| Haylage or Greenchop From Alfalfa Or Alfalfa Mixtures Harvested Area | N |
| Land In Orchards Area | Y |
| Nursery, Greenhouse, Floriculture, Aquatic Plants, Mushrooms, Flower Seeds, Vegetable Seeds, and Sod Harvested Area | Y |
| Oats For Grain Harvested Area | N |
| Orchardgrass Seed Harvested Area | N |
| Other Field and Grass Seed Crops Harvested Area | N |
| Other Haylage, Grass Silage, and Greenchop Harvested Area | N |
| Other Managed Hay Harvested Area | N |
| Popcorn Harvested Area | N |
| Potted Flowering Plants Area | N |
| Red Clover Seed Harvested Area | N |
| Rye For Grain Harvested Area | N |
| Ryegrass Seed Harvested Area | N |
| Short-Rotation Woody Crops Harvest Area | N |
| Small Grain Hay Harvested Area | N |
| Sorghum For Grain Harvested Area | N |
| Sorghum For Silage Or Greenchop Area | N |
| Soybeans For Beans Harvested Area | N |

| | |
|---|---|
| Sunflower Seed, Non-Oil Varieties Harvested Area | N |
| Sunflower Seed, Oil Varieties Harvested Area | N |
| Timothy Seed Harvested Area | N |
| Tobacco Harvested Area | N |
| Triticale Harvested Area | N |
| Vegetables Harvested Area | Y |
| Vegetables, Mixed Area | Y |
| Vetch Seed Harvested Area | N |
| Wheat for Grain Harvested Area | N |
| Wild Hay Harvested Area | N |

The second step to the process is to determine the number of acres that states suggested could be double-cropped. Each state was asked to provide a list of the crops that are typically harvested in the spring or early summer and a second list of crops typically harvested in the late summer or fall of the same year. Those lists are provided below along with multipliers. The multipliers are a relative measure of the likelihood that a crop could be double-cropped. The only crop which has a multiplier less than one is alfalfa hay. This is because alfalfa hay is likely to be double-cropped about once every four years.

*Table 5-4: Delaware double-cropped crops and multipliers*

| DE | |
|---|---|
| Crop Group 1 | Acre Multipler |
| Wheat for Grain | 1 |
| Barley for Grain | 1 |
| Small Grain Hay | 1 |
| Other Haylage, Grass Silage and Greenchop | 1 |
| Alfalfa Hay | 0.25 |
| | |
| Crop Group 2 | Acre Multiplier |
| Soybeans for Beans | 1 |
| Sorghum for Grain | 1 |
| Corn for Silage or Greenchop | 1 |

*Table 5-5: MD Double-Cropped Crops and Multipliers*

| MD | |
|---|---|
| Crop Group 1 | Acre Multipler |
| Wheat for Grain | 1 |
| Barley for Grain | 1 |
| Small Grain Hay | 1 |
| Other Haylage, Grass Silage and Greenchop | 1 |
| Alfalfa Hay | 0.25 |
| | |
| Crop Group 2 | Acre Multiplier |
| Soybeans for Beans | 1 |
| Sorghum for Grain | 1 |
| Corn for Silage or Greenchop | 1 |

*Table 5-6: NY Double-Cropped Crops and Multipliers*

| | |
|---|---|
| NY | |
| Crop Group 1 | Acre Multipler |
| Wheat for Grain | 1 |
| Barley for Grain | 1 |
| Triticale | 1 |
| Small Grain Hay | 1 |
| Other Haylage, Grass Silage and Greenchop | 1 |
| | |
| Crop Group 2 | Acre Multiplier |
| Alfalfa Hay | 0.25 |
| Corn for Silage or Greenchop | 1 |

*Table 5-7: PA Double-Cropped Crops and Multipliers*

| | |
|---|---|
| PA | |
| Crop Group 1 | Acre Multipler |
| Wheat for Grain | 1 |
| Barley for Grain | 1 |
| Small Grain Hay | 1 |
| Other Haylage, Grass Silage and Greenchop | 1 |
| Alfalfa Hay | 0.25 |
| | |
| Crop Group 2 | Acre Multiplier |
| Soybeans for Beans | 1 |
| Sorghum for Grain | 1 |
| Corn for Silage or Greenchop | 1 |

*Table 5-8: VA Double-Cropped Crops and Multipliers*

| | |
|---|---|
| VA | |
| Crop Group 1 | Acre Multipler |
| Wheat for Grain | 1 |
| Barley for Grain | 1 |
| Rye for Grain | 1 |
| Triticale | 1 |
| Small Grain Hay | 1 |
| Other Haylage, Grass Silage and Greenchop | 1 |
| | |
| Crop Group 2 | Acre Multiplier |
| Soybeans for Beans | 1 |
| Sorghum for Grain | 1 |
| Corn for Silage or Greenchop | 1 |
| Alfalfa Hay | 0.25 |

*Table 5-9: WV Double-Cropped Crops and Multipliers*

| | |
|---|---|
| WV | |
| Crop Group 1 | Acre Multipler |
| Wheat for Grain | 1 |
| Barley for Grain | 1 |
| Small Grain Hay | 1 |
| Other Haylage, Grass Silage and Greenchop | 1 |
| | |
| Crop Group 2 | Acre Multiplier |
| Soybeans for Beans | 1 |
| Corn for Silage or Greenchop | 1 |

If the total acres in either Crop Group 1 or Crop group 2 are less than the initial estimated double-cropped acres, then the initial estimate is adjusted downward. For example, if the initial estimate was 10,000 acres of double crops in a county in WV, but there were only 8,000 acres of Soybeans and Corn for Silage, then the initial estimate would be adjusted downward to produce a final estimate of 8,000 acres.

The final estimate of 8,000 acres is then distributed amongst the crops based upon the proportion of each crop within a group. For example, if that same West Virginia county contained only 6,000 acres of wheat for grain and 4,000 acres of barley for grain in Crop Group 1, then 60 percent of all double-cropped acres would be assumed to be wheat for grain while 40 percent would be assumed to be barley for grain. Note that often the total acres of eligible crops in a crop group exceed the final estimate of double-cropped acres because not all acres of small grains or soybeans or corn are double-cropped.

### 5.4.2 Estimating Grains with Manure and Silage with Manure Acres

The Agricultural Modeling Subcommittee wished to separate the most commonly grown crop in the watershed – corn – into land uses that could and could not receive manure. By doing so, a fraction of corn (and sorghum) acres simulated across the watershed receive only inorganic fertilizer applications. This was recommended to account for producers who do not have access to manure or other organic nutrient sources.

The Census of Agriculture does not provide a breakout of acres of each crop type that received manure and those that did not in a given year. However, the Maryland Department of Agriculture's Annual Implementation Reports (AIRs) does ask producers across the state to estimate the number of acres receiving manure. The Agriculture Workgroup found that the percent of corn receiving manure in any given county was related to the number of animals within a county, as shown in the figure below. The relationship shown in the figure between percent of corn receiving manure and stocking rate of total animal units per acre is used to estimate the percent of corn and sorghum receiving manure which is then multiplied by the acres of corn and sorghum for grain to determine acres of Grain with Manure in a county.

$$\text{Fraction of Corn receiving manure} = 0.5196 + 0.1311 \cdot \ln(\text{AnimalUnits}/\text{AgAcres})$$

The fraction receiving manure is constrained to be between 0.18 and 0.81.

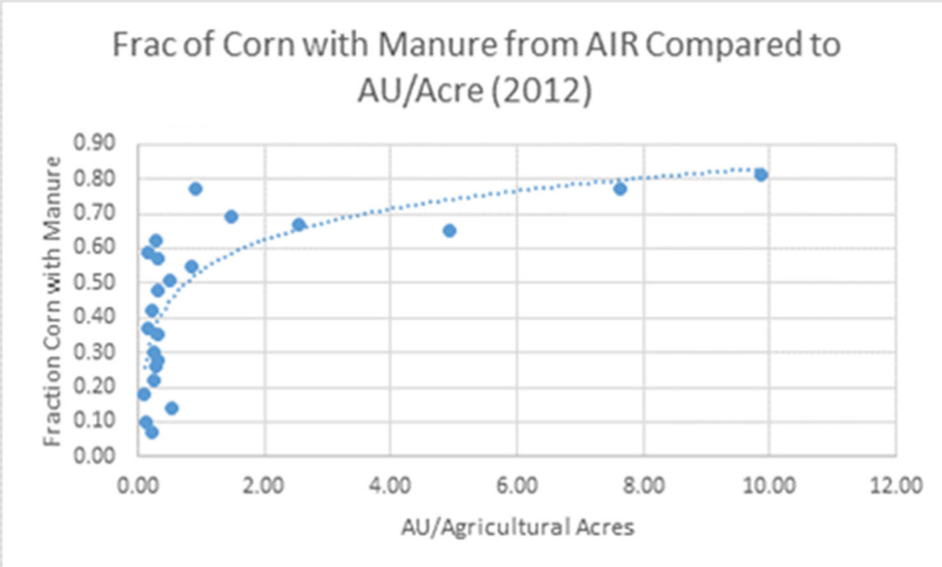


*Figure 5-6: Relating fraction of corn acres receiving manure with animal stocking rates*

Additionally, the AIR data indicated that nearly all of silage grains received manure. However, the Agriculture Workgroup elected to assume 85 percent of corn and sorghum for silage acres received manure, assuming that some producers do not apply manure.

### 5.4.3 Acres of Feeding Space

The Census of Agriculture fails to provide an estimate of animal production areas. These areas include barnyards or feedlots and structures such as dairy barns or poultry houses. The production areas can be large sources of nutrient runoff if improperly maintained with BMPs. Average areas per animal of roofed structure and, for some animal types, barnyard are provided in the Table 5-10. These are multiplied by the estimated number of animals produced in each county.

*Table 5-10: Estimated animal production area requirements*

| Source Name | Open-Air Barnyard (sq feet) | | | Roofed Structures (sq feet) | | | All Area (sq feet) | Cycles (NRCS) | Adjusted All Area (sq ft) | All Area (acres/animal) |
|---|---|---|---|---|---|---|---|---|---|---|
| | MAX | MIN | MED | MAX | MIN | MED | Total | Total | Total | Total |
| **Pullets*** | | | | | | 1.0 | 1.0 | 2.25 | 0.44 | 0.000010 |
| **Turkeys** | | | | 2.0 | 2.0 | 2.0 | 2.0 | 2.00 | 1.02 | 0.000023 |
| **Broilers*** | | | | | | 0.85 | 0.85 | 6.00 | 0.14 | 0.000003 |
| **Layers** | | | | 1.7 | 1.7 | 1.7 | 1.7 | 1.00 | 1.72 | 0.000040 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Hogs for Slaughter** | | | | 9.7 | 9.7 | 9.7 | 9.7 | 2.00 | 4.84 | 0.000111 |
| **Hogs and Pigs for Breeding** | | | | 13.6 | 13.6 | 13.6 | 13.6 | 1.00 | 13.56 | 0.000311 |
| **Beef (Beef Heifers)** | 60.3 | 50.6 | 55.4 | 35.5 | 18.3 | 26.9 | 82.3 | 1.00 | 82.31 | 0.001890 |
| **Dairy (Dairy heifers)** | 96.8 | 96.8 | 96.8 | 28.6 | 28.6 | 28.6 | 125.5 | 1.00 | 125.46 | 0.002881 |
| **Other Cattle**** | 50.6 | 39.8 | 45.2 | 24.7 | 11.8 | 18.3 | 63.5 | 1.00 | 63.48 | 0.001458** |
| **Horses** | 147.3 | 147.4 | 147.4 | 147.3 | 147.3 | 147.3 | 294.7 | 1.00 | 294.66 | 0.006765 |
| **Sheep and Lambs*** | | | | | | 25.0 | 25.0 | 1.00 | 25.02 | 0.000574 |
| **Goats*** | | | | | | 15.0 | 15.0 | 1.00 | 15.00 | 0.000344 |

**Maximum, minimum and median values provided by Maryland Department of Agriculture, 2015.*
***Other Cattle was adjusted to 0.002386 to account for the average size of beef and dairy.*
*All other maximum, minimum and median values provided by FASS, 2010.*

The values in the table were provided by the Federation of Animal Science Societies (FASS) and by the Maryland Department of Agriculture. The median values for open-air barnyard and roofed structures were combined to create the average square footage required to raise a single animal. However, some farms have multiple animals which share the same space at different times during the year. For example, a broiler may require 0.85 square feet of production area, but a producer may move flocks of broilers in and out of the house six times over a single year. Thus, the 0.85 square feet is used by six broilers. To avoid counting the same area six times, the median values were divided by the average number of cycles (or flocks) of animals produced, as provided by NRCS, 2003 as shown in the equation below.

*Equation 5-1: Acres of feeding operations*

Countywide Acres of Feeding Operations = All Area (sq ft)/Yearly Cycles of Production X 2.296e-5 (acres/sq ft) X Animals Produced in County

Total acres of feeding operations are then broken further into permitted and non-permitted feeding space land uses based upon the fraction of animals that are permitted and non-permitted in each county. The fractions are provided by each jurisdiction and can vary by year. The Phase 6 Watershed Model does not treat nutrients deposited on permitted feeding operations differently than those deposited on non-feeding operations.

### 5.4.4 Filling in the Missing Data for Crops and Animals

The Census of Agriculture withholds data at the county level for crops and animals that could identify individual farm operations. These data are reported with a “D.” All data reported with a D must be estimated based upon other data available in the Census of Agriculture. Fortunately, the Census of Agriculture reports state totals for crops and animals. This allows a comparison of all county-level data to the state total to determine how many animals or acres of crops should be distributed back down to counties with D's.

For a given crop, the difference between the statewide total and the known county values is distributed to each D county based upon the number of farms with harvested cropland acres in that county. For example, if a county has 20 percent of all the farms with harvested acres out of all counties reported as D's, then the county receives 20 percent of the difference between the statewide total acres of that crop and the known values.

A similar process is done for animals. Instead of the number of farms with harvested cropland, the number of farms with that type of animal operation dictates the relative percent of unknown animals that are distributed back to the county. Forecasting Agricultural Acres

Agricultural land use acres for any year after the last available census year, 2012, for the Phase 6 calibration are projected for each county using a double-exponential smoothing projection method approved by the Agriculture Workgroup.

Double-exponential smoothing (NIST/SEMATECH 2016) is a short-term data forecasting method that is most often used when future values are believed to be related to both long-term and short-term trends in historic values. The method allows users to combine predictions of long-term and short-term trends by placing different weights or emphasis on each type of trend. The Agriculture Workgroup was asked to determine the weights of the alpha and beta values. The choices of the alpha and beta weighting factors, of 0.8 and 0.2 respectively, were chosen based upon an analysis of which factors best predicted both poultry and cattle populations reported in the 2007 Census of Agriculture.

A formula, explanation of terms, and example projections are provided below.

*Equation 5-2: double exponential smoothing*

$S_t = a * y_t + (1-a) * (S_{t-1} + b_{t-1})$

Where:

$y_t$ = Actual county value as reported by Census of Agriculture at time t
$S_t$ = Smoothed value for time t
$b_t$ = Estimated trend for time t
$AF_t$ = Trend-adjusted forecast for time t
a = Alpha value is the weight placed upon the most recent Census of Agriculture value
Beta = Beta value is the weight placed upon the long-term trend in Census of Agriculture values
$S_1 = y_1$

$b_t = Beta * (S_t - S_{t-1}) + (1 - Beta) * b_{t-1}$

$b_1 = average((y_2 – y_1), (y_3 – y_2), (y_4 – y_3))$

$AF_t = S_{t-1} + b_{t-1}$

$AF_1$ = undefined

*Table 5-11: Hypothetical projection of a county's legume hay acres*

| Period | Year | $y_t$ (Reported Acres Value) | St | bt | Aft |
|---|---|---|---|---|---|
| 1 | 1982 | **2,000** | 2,000 | -367 | |
| 2 | 1987 | **1,250** | 1327 | -428 | 1633 |
| 3 | 1992 | **1,000** | 980 | -412 | 899 |
| 4 | 1997 | **900** | 834 | -359 | 568 |
| 5 | 2002 | **850** | 775 | -299 | 475 |
| 6 | 2007 | **900** | 815 | -231 | 476 |
| 7 | 2012 | **800** | 757 | -196 | 584 |
| *8 | 2017 | | | | **561** |
| 9 | 2022 | | | | **364** |

*For periods t >= T, $Af_t = Af_T + (t-T) * b_T$

**Blue text indicates the value – reported or projected – that would be used by the Watershed Model.**



In the hypothetical projection above, the long-term trend showed a steep decline in acres from 1982 through 2012. When coupled with a short-term trend showing another sharp decline from 2007 to 2012, the projection methodology predicts a continued loss of acres in 2017 and 2022.

The projections are done for each agricultural land use aside from the farmstead and feeding operation land uses. Once the projections at the land use level are complete, the model assumes that the mixture of crops within each land use is the same as reported in the 2012 Census of Agriculture. In the hypothetical example above, the model projected the county would have 688 acres of the land use, "Legume Hay." That land use actually combines acres of six unique crops reported by the Census of Agriculture. Table 5-12 provides an example of how 2017 projected acres of Legume Hay are converted into acres of each individual crop.

*Table 5-12: Creating 2017 crop acres of legume hay for a county*

| Census of Agriculture Crop | Census of Agriculture Acres 2012 | Fraction Census of Agriculture Acres 2012 | 2017 Projected Acres |
|---|---|---|---|
| Alfalfa Hay Harvested Area | 150 | 0.1875 | 129 |
| Alfalfa seed Harvested Area | 150 | 0.1875 | 129 |
| Birdsfoot trefoil seed Harvested Area | 150 | 0.1875 | 129 |
| Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area | 150 | 0.1875 | 129 |
| Red clover seed Harvested Area | 100 | 0.125 | 86 |
| Vetch seed Harvested Area | 100 | 0.125 | 86 |
| Total | 800 | 1 | 688 |

## 5.5 Backcasting Land Uses to Years 1985-2012

For the backcast, it is more important to get the trend correct rather than the absolute value since the land use is being used in a model that is estimating the trend in pollutants due to changes in inputs. To illustrate the point, if land cover is estimated from different data sets in 2012 and 2013, then there will be a change in land use between them that may be more due to errors in both years than to actual changes on the ground. To minimize this effect, trends were calculated based on consistent information and then the trends were applied to the 2013 land use.

### 5.5.1 Mapped Land Use Backcast

Analysis units are the smallest spatial discretization used by the Phase 6 Watershed Model. Each analysis unit may contain all land uses or only certain classes, depending on the type of analysis unit. An analysis unit represents a unique combination of land-river segment (Section 11), regulatory overlay (Section 5.3.9), and federal agency overlay (Section 5.3.10). The extent of aggregated mapped Phase 6 land uses representing conditions in 2013 were backcast for the years for which land cover conditions are represented in the 2011 edition of the Chesapeake Bay Land Cover Data Series (CBLCD) (Irani and Claggett 2010). The thirteen mapped land uses and the sixteen land cover classes in the five CBLCD years (1984, 1992, 2001, 2006, and 2011) were aggregated into the following macro-classes to be comparable:

1) Development = Impervious Roads + Impervious Non-Roads + Tree Canopy over Impervious + Turf Grass + Tree Canopy over Turf Grass
2) Herbaceous = Cropland + Pasture + Mixed Open
3) Natural = Forest + Floodplain Wetlands + Other Wetlands
4) Water = Water

For each analysis unit, data on total housing units for 2013, 2006, 2001, 1992, and 1984 were generated from 2010 Census Block Group estimates reported in the American Community Survey's five-year estimates (2010-2015) and 2010 Decennial Census. The first step in the backcast process was to estimate the extent of development in 2006 based on the percentage change in housing units from 2013 to 2006. Transitions from forest, herbaceous, water to development were estimated by examining the land use transitions evident between the 2011 and 2006 CBLCD. Transitions among forest, herbaceous, and water were estimated by comparing the 2011 and 2006 CBLCD. Once the extents of net change in each of the macro classes were estimated, the changes were applied to each of the thirteen mapped land uses based on their relative proportion to their parent macro class. For example, if Development decreased by 100 acres between 2013 and 2006 in a particular analysis unit and Impervious Roads composed 30 percent of the Developed macro class, then the extent of Impervious Roads was reduced by 30 acres to represent 2006 conditions

### 5.5.2 Agricultural Land Use Backcast

Agricultural land use acreages were interpolated for all years between 1985 – 2012.

## 5.6 Chesapeake Bay Land Cover Model

Section 5.6 will discuss the projections from 2013 to 2025

## 5.7 Developing the Watershed Model land use from the mapped land use

As shown in **Error! Reference source not found.** the high-resolution land cover data set acts as a starting point for the backcasted land use using the CBLCD and the forecasted land use using the CBLCM. This produces a consistent land use data set for select years between 1984 and 2025, however this is not the final land use data set used in the Phase 6 Watershed Model. For use in the Watershed Model, the land use must be checked for consistency, interpolated to all years, and combined with the Census of Agriculture, harvested forest acres reported by the states, and the proportion of land between regulated and non-regulated feeding space reported by the states. The steps for adjusting the mapped land use to the tabular version used in the model are described below.

### 5.7.1 Initial adjustments to the mapped land use

The first steps are to confirm that the CSS acres remain constant in the pre-BMP land use. Changes to CSS due to sewer hookups are handled in the wastewater inputs, not in the land use. Thus, they are accounted for only once. The CSS crop and pasture mapped land uses are moved to the CSS mixed open load source. The CSS forest, wetland, and water are moved to CSS forest load source.

It was decided in the Federal Facility Workgroup and approved by the Water Quality Goal Implementation Team that there would be no agricultural land attributed as federal. The federal, Maryland State, and Maryland State Highway agencies within the mapped crop and pasture land uses are moved to the nonfederal classification. In addition, the decision was made that the total area of each agency in a land-river segment remains constant. Where necessary, proportional adjustments are made for years other than 2013 such that the total for each agency in each land-river segment is the same as 2013.

The regulated and CSS construction and harvested forest acres are all considered non-federal agency types per the Federal Facility Workgroup. These areas are submitted by the states or a default is used. The harvested forest default is 1.5 percent of true forest.. The construction default = 1.29 * (current year + 1 developed acres - current year's developed acres). Construction acres are taken proportionally from developed land uses. Harvest forest is taken from true forest.

As detailed in prior sections, the mapped land uses are provided for 1984, 1991, 2001, 2006, 2013, and 2025. The land use is linearly interpolated to all years 1984-2025.

For interpolation, the land-river segment total acres are set equivalent to the CBLCM 2013 total acres. Note that the GIS total acre data includes tidal wetlands, whereas the Watershed Model does not.

### 5.7.2 Maryland Adjustments to the Land Cover Data

Maryland received the land use by land-river segment, agency, and land use for 1984 to 2013. The Maryland land use data are altered with data provided by the Maryland Department of the Environment for each year. Generally, adjustments are made to developed classes. Upon return to the CBPO a proportional adjustment is made to the Maryland CSS acres to force a match to the total CSS acres for each land-river segment and agency.

Maryland <u>did not edit</u> CBP USGS's land-cover dataset for the following counties:

| | | |
|---|---|---|
| Baltimore County | Calvert County | Caroline County |
| Garrett County | Kent County | Somerset County |
| St. Mary's County | Worchester County | |

For the remaining counties and Baltimore City, MDE edited the Mapped Land Use data as follows, for the developed land-cover classifications only:

1. Replace CBP Turf Grass acres with MDE calculated Turf Grass.
    a. Calculated by applying average turf to low vegetation ratios using the Chesapeake Conservancy land cover data and digitized turf data. The average turf to low vegetation ratios for individual parcel types (Residential < 2 acres, residential 2-5 acres, residential > 5 acres, commercial, etc.) were calculated from sample datasets of digitized turf grass. Ratios also vary by MS4 grouping (Large Phase I, Medium phase I, and Phase II/non-MS4s).
2. Replace CBP Impervious Road and Impervious Non-Road acres with MDE acres. MDE estimates generated using local, planimetric impervious cover data with adjustments to account for any missing feature types, e.g., sidewalks, and any temporal differences, e.g., projected to 2013 conditions if based on older imagery.
3. Remove CBP Tree Canopy Over Impervious estimates from MDE Impervious road and non-road acres proportionally. MDE road and non-road impervious surface estimates did not account for tree canopy over impervious, so to avoid double counting, these had to be removed from MDE estimates.
4. Replace CBP Tree Canopy Over Turf acres with MDE acres. MDE applied same methodology as CBP for distinguishing between forest and tree canopy over turf; however, MDE used state-specific 1 meter resolution tree canopy data developed by the University of Vermont for the entire State of Maryland rather than the Chesapeake Conservancy land-cover data.
5. MDE's urban land-cover estimates were derived in aggregate, both for federal and non-federal lands. Federally owned lands were lumped in with MDE's non-regulated urban delineation. Therefore, in order to parse out federal from non-federal lands, CBP's federal urban land-cover acres were subtracted from MDE's nonregulated urban land-cover estimates.
6. CSS acres need to be held constant throughout the model calibration. Therefore, MDE adjusted all CSS land-cover acres to match CBP CSS land-cover acres.
7. In order to account for construction acres, MDE artificially inflated all urban land-cover acres within a land-river segment proportionally. Then, once MDE's final land-cover and construction files are combined within Scenario Builder, construction acres are subtracted from the urban land-cover estimates in the same proportions that they were artificially inflated.



### 5.7.3 Adjustments to the Census of Agriculture

Virginia has 39 cities in the Chesapeake Region that have unique Federal Information Processing (FIPs) codes. The Agricultural Census does not include records for these cities; however, the mapped land use includes agricultural classes for some. These cities are assigned a fraction of Agricultural Census crop, yield, and animal data based on a neighboring county that has agricultural data. The Virginia City Agricultural Census value for each category is equal to the associated county Agricultural Census value multiplied by the ratio of relevant mapped acres in the city to relevant mapped acres in the county. For example, if a county with Agricultural Census data has 500 acres of crop and the associated Virginia city has 50 acres of crop in the mapped land use, then the city is assigned a crop fraction of 0.1 to apply to Agricultural Census values relevant to crop. The same procedure is used for all relevant Agricultural Census values including pasture acres, animal numbers, and crop yield.

Agricultural crop, pasture and animal amounts are available only at the county scale. Some counties are located partially in and partially outside of the Chesapeake Bay watershed. The amount of crop and pasture within the watershed portion of a county is determined using the fraction of crop and pasture within the watershed from the Mapped Land Use. The fraction can vary between zero and one. This fraction is calculated for each year of the Mapped Land Use and interpolated for all other years.

For states that did not supply the number of animals within the watershed portion of the county, the fraction of animals in the Chesapeake Bay Watershed is the same as the fraction of agricultural land use acres in the Chesapeake Bay Watershed in that county.

### 5.7.4 Proportioning of Ag Census

The Agricultural Census crop acres are used in the calculation of county land use acres for the following land uses: soybeans, grains with manure, silage with manure, small grains and grains, other agronomic crops, specialty crop high, specialty crop low, agricultural open space, pasture, leguminous hay, and other hay. The amount of double cropped acres are used to determine the amount of acres in the double cropped land use. The double crop method is discussed in Section 5.4.1. The grains and silage with manure are split from the acres without manure, using the ratio discussed in Section 5.4.2. The fractions of crop and pasture that were projected through 2025 are used to split these county total acres into land-river segments.

The estimated annual extent of agricultural land uses were apportioned from the county level to land-river segments based on the relative proportion of land-river segment acres to county acres using the three classes total agriculture, pasture, or cropland. Relative proportions of total agriculture were used to allocate: Permitted Feeding Space and Non-Permitted Feeding Space. Relative proportions of pasture were used to allocate: Ag Open Space, Legume Hay, Other Hay, and Pasture. Relative proportions of cropland were used for all other agricultural land uses.

The number of acres per animal is used to determine the county feeding space acres. The number of animals is based on the animal counts as described in Section 5.4.3. The animal counts originated with the Agricultural Census and are projected using methods described in Section 3. This county number is disaggregated to land-river segments assuming that the animals per land-river segment are proportional to the agricultural land use acres in each land-river segment.

### 5.7.5 Maintaining Constant Land-River Segment Size

Once apportioned to land-river segments, the annualized Census of Agriculture agricultural land use acreages are combined with the Mapped Land Use acres for each year from 1985 – 2013. The Mapped Land Use categories of pasture and cropland are combined and the Census of Agriculture is used to determine the individual land uses that are categorized as pasture or crop. Generally, the sum of Agricultural Census-based land use acres and mapped natural and developed acres did not match the total area of the land-river segment from the Mapped Land Use. To maintain a constant land-river segment size through time, all land uses were adjusted using relative error rates in a 'true-up' process. Land uses with high error were adjusted a greater percentage than land uses with a low error rate.

Prior to the true-up process in Virginia, crop and pasture acres are adjusted to match the spatially-explicit acres from the mapped land uses based on error rates. While agricultural land error rates originate with the Agricultural Census for all other states, in Virginia they are lower since those agricultural areas were spatially mapped through a more accurate process.

The true-up process began by comparing the total acreage in the land-river segment to the total of all of the land use acreages assigned to that land-river segment. Then, the error rate for each land use was multiplied by the estimated acres of that land use to arrive at an available adjustment for each land use type. An adjustment fraction was calculated by dividing the total necessary acreage adjustment by the sum of the available adjustment. The available adjustment multiplied by the adjustment fraction for each land use was then subtracted from the land use acres to arrive at the final land use acreage in the land-river segment. To illustrate the method, suppose a land-river segment of 100 acres had only three land uses that were estimated as 15 acres of CSS roads, 50 acres of mixed open, and 50 acres of pasture. Note that the total of the land uses is 15 acres above the available acres in the land-river segment. Assume that the error rate is 0% for CSS roads, 5% for mixed open and 10% for pasture. Available adjustment is 0 acres for CSS roads, 2.5 acres for mixed open and 5 acres for pasture. The total adjustment needed is 15 acres and the available adjustment totals 7.5 acres giving an adjustment ratio of 2. The final acres would be 15 acres of CSS roads, 45 acres of mixed open, and 40 acres of pasture.

In general, mapped land uses were adjusted according to their state-wide mapping accuracies and Census of Agriculture acreages were adjusted based on their county-level reporting standard error rates. The mapped land use accuracies apply to 2013 conditions and not necessarily to historic conditions because the backcast process introduces additional errors. Therefore, the mapped error rates used in this "true up" process were adjusted for historic years depending on if the reported acreages in the Census of Agriculture exceeded the mapped acreages, representing a "space-constrained scenario", or if the reported acreages were less than the mapped acreages, representing an "unconstrained scenario". For the space-constrained scenario, the mapped error rates for 1985 were assumed to be the lesser of the 2013 error rates or 85 percent. For the unconstrained scenario, the mapped error rates were held constant through time except for mixed open which was given the same error rates as reported in the 2012 Census of Agriculture. For the Census reported acreages, the 2012 Census of Agriculture reporting standard errors were applied to all historic years. The rates are reported in Table 5-13.

*Table 5-13: Error Rates Used in the True-up Procedure*

| Phase 6 Land Use | State | 2013 SpaceConstrained | 1985-2012 SpaceConstrained | 2013 Unconstrained | 1985-2012 Unconstrained |
|---|---|---|---|---|---|
| Cropland | DC | Census | Census | Census | Census |
| Cropland | DE | Census | Census | Census | Census |
| Cropland | MD | Census | Census | Census | Census |
| Cropland | NY | Census | Census | Census | Census |
| Cropland | PA | Census | Census | Census | Census |
| Cropland | VA | Census | Census | Census | Census |
| Cropland | WV | Census | Census | Census | Census |
| Forest | DC | 0.98 | 0.85 | 0.98 | 0.98 |
| Forest | DE | 0.99 | 0.85 | 0.99 | 0.99 |
| Forest | MD | 0.98 | 0.85 | 0.98 | 0.98 |
| Forest | NY | 0.96 | 0.85 | 0.96 | 0.96 |
| Forest | PA | 0.98 | 0.85 | 0.98 | 0.98 |
| Forest | VA | 0.98 | 0.85 | 0.98 | 0.98 |
| Forest | WV | 0.98 | 0.85 | 0.98 | 0.98 |
| Impervious Non-Roads | DC | 0.95 | 0.85 | 0.95 | 0.95 |
| Impervious Non-Roads | DE | 0.97 | 0.85 | 0.97 | 0.97 |
| Impervious Non-Roads | MD | 0.96 | 0.85 | 0.96 | 0.96 |
| Impervious Non-Roads | NY | 0.92 | 0.85 | 0.95 | 0.95 |
| Impervious Non-Roads | PA | 0.93 | 0.85 | 0.95 | 0.95 |
| Impervious Non-Roads | VA | 0.94 | 0.85 | 0.95 | 0.95 |
| Impervious Non-Roads | WV | 0.88 | 0.85 | 0.95 | 0.95 |
| Impervious Roads | DC | 0.95 | 0.85 | 0.95 | 0.95 |
| Impervious Roads | DE | 1.00 | 0.85 | 1.00 | 1.00 |
| Impervious Roads | MD | 0.91 | 0.85 | 0.95 | 0.95 |
| Impervious Roads | NY | 0.95 | 0.85 | 0.95 | 0.95 |
| Impervious Roads | PA | 0.96 | 0.85 | 0.96 | 0.96 |
| Impervious Roads | VA | 0.94 | 0.85 | 0.95 | 0.95 |
| Impervious Roads | WV | 0.74 | 0.74 | 0.95 | 0.95 |
| Mixed Open | DC | 0.87 | 0.85 | 0.95 | Census |
| Mixed Open | DE | 0.87 | 0.85 | 0.95 | Census |
| Mixed Open | MD | 0.87 | 0.85 | 0.95 | Census |
| Mixed Open | NY | 0.87 | 0.85 | 0.95 | Census |
| Mixed Open | PA | 0.87 | 0.85 | 0.95 | Census |
| Mixed Open | VA | 0.87 | 0.85 | 0.95 | Census |
| Mixed Open | WV | 0.87 | 0.85 | 0.95 | Census |
| Pasture | DC | Census | Census | Census | Census |
| Pasture | DE | Census | Census | Census | Census |
| Pasture | MD | Census | Census | Census | Census |
| Pasture | NY | Census | Census | Census | Census |
| Pasture | PA | Census | Census | Census | Census |
| Pasture | VA | Census | Census | Census | Census |
| Pasture | WV | Census | Census | Census | Census |
| Tree Canopy over Impervious | DC | 0.70 | 0.70 | 0.95 | 0.95 |
| Tree Canopy over Impervious | DE | 0.77 | 0.77 | 0.95 | 0.95 |
| Tree Canopy over Impervious | MD | 0.92 | 0.85 | 0.95 | 0.95 |
| Tree Canopy over Impervious | NY | 0.47 | 0.47 | 0.95 | 0.95 |
| Tree Canopy over Impervious | PA | 0.34 | 0.34 | 0.95 | 0.95 |
| Tree Canopy over Impervious | VA | 0.75 | 0.75 | 0.95 | 0.95 |
| Tree Canopy over Impervious | WV | 0.19 | 0.19 | 0.95 | 0.95 |
| Tree Canopy over Turf | DC | 0.95 | 0.85 | 0.95 | 0.95 |
| Tree Canopy over Turf | DE | 0.99 | 0.85 | 0.99 | 0.99 |
| Tree Canopy over Turf | MD | 0.97 | 0.85 | 0.97 | 0.97 |
| Tree Canopy over Turf | NY | 0.95 | 0.85 | 0.95 | 0.95 |
| Tree Canopy over Turf | PA | 0.95 | 0.85 | 0.95 | 0.95 |
| Tree Canopy over Turf | VA | 0.83 | 0.83 | 0.95 | 0.95 |
| Tree Canopy over Turf | WV | 0.97 | 0.85 | 0.97 | 0.97 |
| Turf Grass | DC | Census | Census | 0.95 | 0.95 |
| Turf Grass | DE | Census | Census | 0.95 | 0.95 |
| Turf Grass | MD | Census | Census | 0.95 | 0.95 |
| Turf Grass | NY | Census | Census | 0.95 | 0.95 |
| Turf Grass | PA | Census | Census | 0.95 | 0.95 |
| Turf Grass | VA | 0.72 | 0.72 | 0.95 | 0.95 |
| Turf Grass | WV | Census | Census | 0.95 | 0.95 |
| Water | DC | 1.00 | 1.00 | 1.00 | 1.00 |
| Water | DE | 0.96 | 0.96 | 0.96 | 0.96 |
| Water | MD | 0.99 | 0.99 | 0.99 | 0.99 |
| Water | NY | 0.98 | 0.98 | 0.98 | 0.98 |
| Water | PA | 0.99 | 0.99 | 0.99 | 0.99 |
| Water | VA | 1.00 | 1.00 | 1.00 | 1.00 |
| Water | WV | 0.97 | 0.97 | 0.97 | 0.97 |
| Wetlands_Floodplain | DC | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Floodplain | DE | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Floodplain | MD | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Floodplain | NY | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Floodplain | PA | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Floodplain | VA | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Floodplain | WV | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | DC | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | DE | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | MD | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | NY | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | PA | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | VA | 0.95 | 0.95 | 0.95 | 0.95 |
| Wetlands_Other | WV | 0.95 | 0.95 | 0.95 | 0.95 |

The rationale for using a different approach for the unconstrained scenario is illustrated in the following example. Suppose that there should be 1,000 acres of cropland in a land-river segment according to the Census of Agriculture, but the mapped acreage is 1,500 acres. There is high confidence that the surplus 500 acres is composed of pervious herbaceous vegetation, but lower confidence that it's all agriculture. Therefore, it would be inappropriate to expand mapped roads, buildings, and forests by any significant amount into this known herbaceous area. Rather, it would be better to assume that the Census of Agriculture must have underestimated the extent of agriculture and the extent of mixed open was underestimated to the same degree. In the true-up process, mixed open, pasture, and cropland would be expanded up to, but not exceeding, the limits of the Census of Agriculture reporting error rates.

The CSS and feeding space acres have an error rate of zero so do not ever change.

Following the error-based true-up process, it was found that a few land-river segments had developed land uses that decreased in a few years. It was determined that this was a fatal flaw and so the following algorithm was implemented. Starting with 2013 as the year of least uncertainty and working backwards for each land-river segment, the prior year is compared to the current year. If the prior year has a higher total developed area, the developed land uses for the prior year are lowered proportionally such that the total matches the current year. The total subtracted acres are added proportionately to the mixed open and hay/pasture land classes as these classes are most likely to be confused with turfgrass.

### 5.7.6 Projecting 2014 – 2025 CBLCM Land Use

Land use estimates for 2014 through 2025 start from the 2013 pre-BMP land use without Maryland's 2013 adjustments and the MS4-permitted acres. A change factor is multiplied by this 2013 baseline to generate a 2025 projected land use. The change factor is calculated as the percent change in the Mapped Land Use between 2013 and 2025 for each land-river segment and agency. Then the actual 2013 and the 2025 land use are interpolated to create the interim data product of a 2014 to 2024 land use. The steps described with the "true up" in Section 5.7.5 are followed for creating the final 2014 through 2025. The difference in the true up error rates between projected and historical years are that the error rates are set to zero for developed and natural, except for open space. The open space error rate is equivalent to the agricultural error rate from the Agricultural Census.