Maryland Animal Waste Technology Assessment and Strategy Planning

FINAL REPORT APPENDICES | SEPTEMBER 2 0 2 3

APPENDICES CONTENT

Appendix A: Additional Results from Topic 1

Topic 1a: Estimated livestock and poultry count by county for 2018, 2019, 2020, & 2021

County-level estimates of the number of livestock and poultry for 2018-2021 were constrained by animal inventories in the Census of Agriculture only being conducted every five years, with the most recent data available from 2017. The AIR estimates for these years for all species were provided for livestock (excluding poultry), so this data was used to calculate a county-year specific proportion of the total count of a particular species. Estimates generated from NASS data were used to benchmark the AIR data to the 2017 Census of Agriculture. For example, 20% of the NASS statewide estimate for dairy cows for 2018 was assigned to Frederick County based on these calculations. The AIR data and NASS statewide totals therefore combined to create a separate measure of animal inventories in each county for 2018-2021. For poultry, only the 2017 data in the Ag Census was used, since we did not have reliable poultry AIR data. This resulted in estimated proportions for poultry that do not vary by year, only by county.

Tables 1a.3 - 1a.12 present the county-by-year-by data-source estimates in total animal units (AU) (in 1000 lbs) for each animal species. In the tables, '-' indicates no data available and '*' that data was missing for that county/year but was available for other county/year combinations in that dataset. As livestock categories differed across the two sources, aggregation was required. Beef cows and bulls, and dairy cows were directly compared between the AIR and 2017 Ag Census data. The "All other cattle" category combined non-beef and non-dairy cow categories into a single category. All AU estimates were rounded to the nearest multiple of ten to avoid false precision.

Table 1a.3: County-by-year estimated Animal Units (AU, 1000 lbs) for beef cows and bulls.

County	2018		2019		2020		2021	
	AIR	NASS	AIR	NASS	AIR	NASS	AIR	NASS
Allegany	1,780	2,430	1,790	2,540	1,930	2,520	1,950	2,440
Anne Arundel	530	720	530	760	530	690	460	580
Baltimore	1,330	1,820	1,220	1,740	2,210	2,890	1,310	1,640
Calvert	450	620	440	630	360	480	480	600
Caroline	400	550	390	560	400	530	130	160
Carroll	4,570	6,250	4,660	6,630	4,790	6,260	5,910	7,420
Cecil	1,270	1,740	1,210	1,730	1,130	1,480	510	640
Charles	900	1,220	870	1,240	770	1,000	810	1,020
Dorchester	50	70	50	70	120	160	90	110
Frederick	6,020	8,230	6,060	8,640	6,380	8,350	7,200	9,030
Garrett	3,770	5,150	4,250	6,050	3,890	5,080	3,950	4,960
Harford	2,190	2,990	2,160	3,070	2,830	3,700	2,300	2,880
Howard	690	940	660	940	430	560	500	630
Kent	360	500	460	660	430	560	420	520
Montgomery	1,460	1,990	1,320	1,880	1,160	1,510	1,300	1,630
Prince George's	330	450	400	560	290	380	340	420
Queen Anne's	920	1250	870	1,240	780	1,010	850	1,070
Saint Mary's	940	1,290	1,090	1,550	1,060	1,380	940	1,170
Somerset	340	460	620	880	330	430	290	370
Talbot	190	250	190	270	190	240	270	340
Washington	4,820	6,580	5,470	7,790	5,430	7,100	5,400	6,770
Wicomico	230	320	220	320	330	430	330	420
Worcester	130	170	180	250	190	250	130	170
Total	**33,670**	**45,990**	**35,110**	**50,000**	**35,960**	**46,990**	**35,870**	**44,990**

Table 1a.4: County-by-year estimated Animal Units (AU, 1000 lbs) for dairy cows.

County	2018		2019		2020		2021	
	AIR	NASS	AIR	NASS	AIR	NASS	AIR	NASS
Allegany	10	10	10	10	10	10	0	0
Anne Arundel	0	0	0	0	0	0	0	0
Baltimore	1,260	1,340	1,810	1,760	1,140	1,090	560	700
Calvert	0	0	0	0	0	0	0	0
Caroline	1,100	1,180	1,100	1,070	1,130	1,080	1,070	1,340
Carroll	6,970	7,440	7,230	7,050	6,830	6,560	4,900	6,130
Cecil	3,780	4,030	3,950	3,850	3,930	3,770	1,850	2,320
Charles	40	40	40	40	60	60	100	130
Dorchester	0	0	0	0	0	0	0	0
Frederick	15,340	16,380	16,040	15,660	14,860	14,270	9,700	12,150
Garrett	3,680	3,930	4,000	3,900	3,670	3,530	3,510	4,400
Harford	3,730	3,980	3,040	2,960	3,090	2,960	2,470	3,090
Howard	590	630	350	340	360	350	370	460
Kent	5,690	6,070	5,380	5,250	4,880	4,690	5,550	6,950
Montgomery	380	410	290	280	230	220	170	210
Prince George's	160	170	160	160	30	30	170	210
Queen Anne's	1,740	1,850	1,880	1,840	1,970	1,890	1,430	1,790
Saint Mary's	240	260	420	410	240	230	280	350
Somerset	0	0	640	620	0	0	0	0
Talbot	780	830	660	650	680	650	450	560
Washington	16,140	17,230	16,120	15,740	17,890	17,190	15,500	19,400
Wicomico	0	0	0	0	110	100	0	0
Worcester	0	0	0	0	110	100	0	0
Total	**61,360**	**65,780**	**63,120**	**61,590**	**61,220**	**58,780**	**48,080**	**60,190**

Table 1a.5: County-by-year estimated Animal Units (AU, 1000 lbs) for all other cattle.

County	2018		2019		2020		2021	
	AIR	NASS	AIR	NASS	AIR	NASS	AIR	NASS
Allegany	850	1,070	810	1,090	870	930	1,000	1,270
Anne Arundel	430	540	460	620	420	450	330	420
Baltimore	1,350	1,710	1,590	2,140	1,080	1,160	1,010	1,280
Calvert	280	360	280	380	250	270	370	460
Caroline	2,250	2,840	590	790	580	620	2,290	2,900
Carroll	6,090	7,690	6,010	8,080	5,510	5,900	4,180	5,300
Cecil	1,950	2,470	1,880	2,530	2,150	2,300	1,280	1,610
Charles	410	520	480	640	350	380	440	560
Dorchester	50	60	50	70	50	50	40	50
Frederick	9,460	11,950	9,430	12,700	10,420	11,150	8,670	10,980
Garrett	4,230	5,350	4,050	5,450	4,290	4,590	4,390	5,550
Harford	3,730	4,720	3,220	4,330	9,590	10,260	2,950	3,730
Howard	640	810	620	840	530	560	510	640
Kent	2,490	3,150	2,350	3,160	2,250	2,410	2,710	3,430
Montgomery	870	1,090	780	1,050	700	750	670	850
Prince George's	230	300	310	410	200	210	240	310
Queen Anne's	1,550	1,960	1,300	1,750	1,490	1,590	1,130	1,430

Saint Mary's	730	930	790	1,060	730	780	800	1,010
Somerset	140	180	1,550	2,090	120	130	110	140
Talbot	570	720	490	660	480	520	440	560
Washington	12,890	16,280	12,460	16,770	11,980	12,830	11,900	15,060
Wicomico	180	230	150	200	460	500	160	200
Worcester	70	80	100	130	140	150	80	110
Total	**51,440**	**65,010**	**49,750**	**66,940**	**54,640**	**58,490**	**45,700**	**57,850**

Table 1a.6: County-by-year estimated Animal Units (AU, 1000 lbs) for chickens, layers.

County	**2018**		**2019**		**2020**		**2021**	
	AIR	**NASS**	**AIR**	**NASS**	**AIR**	**NASS**	**AIR**	**NASS**
Allegany	-	70	-	70	-	60	-	60
Anne Arundel	-	140	-	140	-	130	-	120
Baltimore	-	1,120	-	1,140	-	1,020	-	930
Calvert	-	110	-	110	-	100	-	90
Caroline	-	180	-	190	-	170	-	150
Carroll	-	-*	-	-*	-	-*	-	-*
Cecil	-	-*	-	-*	-	-*	-	-*
Charles	-	980	-	1,000	-	900	-	820
Dorchester	-	60	-	60	-	60	-	50
Frederick	-	5,020	-	5,110	-	4,580	-	4,170
Garrett	-	460	-	470	-	420	-	380
Harford	-	1,940	-	1,970	-	1,760	-	1,610
Howard	-	160	-	160	-	140	-	130
Kent	-	50	-	50	-	50	-	40
Montgomery	-	160	-	160	-	140	-	130
Prince George's	-	270	-	280	-	250	-	230
Queen Anne's	-	110	-	120	-	100	-	100
Saint Mary's	-	500	-	500	-	450	-	410
Somerset	-	-*	-	-*	-	-*	-	-*
Talbot	-	110	-	110	-	100	-	90
Washington	-	-*	-	-*	-	-*	-	-*
Wicomico	-	60	-	60	-	50	-	50
Worcester	-	1,790	-	1,820	-	1,630	-	1,490
Total	**-**	**13,290**	**-**	**13,520**	**-**	**12,110**	**-**	**11,050**

Table 1a.7: County-by-year estimated Animal Units (AU, 1000 lbs) for chickens, broilers.

County	**2018**		**2019**		**2020**		**2021**	
	AIR	**NASS**	**AIR**	**NASS**	**AIR**	**NASS**	**AIR**	**NASS**
Allegany	-	0	-	0	-	0	-	0
Anne Arundel	-	-*	-	-*	-	-*	-	-*
Baltimore	-	520	-	540	-	520	-	470
Calvert	-	20	-	20	-	20	-	20
Caroline	-	389,620	-	397,970	-	386,800	-	349,910
Carroll	-	40	-	40	-	40	-	30
Cecil	-	-*	-	-*	-	-*	-	-*
Charles	-	210	-	210	-	210	-	190
Dorchester	-	170,500	-	174,150	-	169,260	-	153,120
Frederick	-	40	-	40	-	40	-	30
Garrett	-	10	-	10	-	10	-	10

Harford	-	-*	-	-*	-	-*	-	-*
Howard	-	140	-	150	-	140	-	130
Kent	-	34,870	-	35,620	-	34,620	-	31,310
Montgomery	-	-*	-	-*	-	-*	-	-*
Prince George's	-	140	-	150	-	140	-	130
Queen Anne's	-	157,160	-	160,520	-	156,010	-	141,140
Saint Mary's	-	480	-	490	-	480	-	430
Somerset	-	424,810	-	433,910	-	421,730	-	381,510
Talbot	-	44,050	-	44,990	-	43,730	-	39,560
Washington	-	40	-	40	-	40	-	40
Wicomico	-	361,200	-	368,940	-	358,580	-	324,380
Worcester	-	441,980	-	451,440	-	438,770	-	396,920
Total	**-**	**2,025,380**	**-**	**2,069,230**	**-**	**2,011,140**	**-**	**1,819,330**

Table 1a.8: County-by-year estimated Animal Units (AU, 1000 lbs) for swine.

County	2018		2019		2020		2021	
	AIR	NASS	AIR	NASS	AIR	NASS	AIR	NASS
Allegany	0	-	0	-	0	-	0	-
Anne Arundel	0	-	0	-	0	-	20	-
Baltimore	90	-	110	-	110	-	120	-
Calvert	0	-	0	-	10	-	10	-
Caroline	30	-	50	-	40	-	10	-
Carroll	60	-	220	-	210	-	220	-
Cecil	200	-	590	-	290	-	60	-
Charles	10	-	30	-	20	-	20	-
Dorchester	40	-	80	-	60	-	120	-
Frederick	40	-	440	-	490	-	280	-
Garrett	10	-	30	-	20	-	10	-
Harford	10	-	20	-	40	-	40	-
Howard	60	-	60	-	60	-	60	-
Kent	1,220	-	1,220	-	400	-	400	-
Montgomery	0	-	0	-	10	-	0	-
Prince George's	40	-	40	-	10	-	10	-
Queen Anne's	10	-	20	-	30	-	110	-
Saint Mary's	90	-	120	-	60	-	60	-
Somerset	0	-	0	-	0	-	0	-
Talbot	0	-	0	-	0	-	0	-
Washington	170	-	420	-	350	-	360	-
Wicomico	10	-	0	-	10	-	10	-
Worcester	30	-	40	-	40	-	60	-
Total	**2,120**	**-**	**3,490**	**-**	**2,260**	**-**	**1,980**	**-**

Table 1a.9: County-by-year estimated Animal Units (AU, 1000 lbs) for horses.

County	2018		2019		2020		2021	
	AIR	NASS	AIR	NASS	AIR	NASS	AIR	NASS
Allegany	100	-	90	-	90	-	100	-
Anne Arundel	1,510	-	2,140	-	2,920	-	1,940	-
Baltimore	1,910	-	1,750	-	1,600	-	1,350	-
Calvert	130	-	140	-	110	-	120	-
Caroline	370	-	340	-	320	-	220	-

Carroll	2,340	-	970	-	1,030	-	860	-
Cecil	3,320	-	3,510	-	3,300	-	1,720	-
Charles	350	-	330	-	330	-	270	-
Dorchester	50	-	30	-	40	-	60	-
Frederick	1,530	-	1,510	-	1,240	-	1,620	-
Garrett	320	-	280	-	350	-	340	-
Harford	1,310	-	1,230	-	1,130	-	1,180	-
Howard	940	-	960	-	900	-	790	-
Kent	200	-	210	-	230	-	240	-
Montgomery	1,870	-	1,750	-	1,730	-	1,720	-
Prince George's	260	-	350	-	220	-	420	-
Queen Anne's	280	-	250	-	270	-	280	-
Saint Mary's	650	-	750	-	590	-	740	-
Somerset	20	-	30	-	10	-	10	-
Talbot	330	-	310	-	270	-	730	-
Washington	410	-	570	-	330	-	380	-
Wicomico	210	-	160	-	180	-	260	-
Worcester	120	-	150	-	180	-	170	-
Total	**18,530**	**-**	**17,810**	**-**	**17,370**	**-**	**15,520**	**-**

Table 1a.10: County-by-year estimated Animal Units (AU, 1000 lbs) for sheep.

County	**2018**		**2019**		**2020**		**2021**	
	AIR	**NASS**	**AIR**	**NASS**	**AIR**	**NASS**	**AIR**	**NASS**
Allegany	30	-	30	-	30	-	20	-
Anne Arundel	60	-	60	-	90	-	40	-
Baltimore	50	-	80	-	100	-	100	-
Calvert	30	-	0	-	50	-	70	-
Caroline	20	-	30	-	30	-	10	-
Carroll	290	-	230	-	190	-	220	-
Cecil	50	-	40	-	50	-	40	-
Charles	20	-	30	-	10	-	30	-
Dorchester	10	-	10	-	0	-	0	-
Frederick	390	-	330	-	350	-	390	-
Garrett	80	-	80	-	120	-	170	-
Harford	90	-	90	-	1,900	-	120	-
Howard	60	-	60	-	50	-	60	-
Kent	90	-	30	-	30	-	30	-
Montgomery	60	-	60	-	40	-	70	-
Prince George's	20	-	30	-	40	-	30	-
Queen Anne's	30	-	20	-	30	-	30	-
Saint Mary's	70	-	70	-	60	-	80	-
Somerset	20	-	90	-	20	-	10	-
Talbot	100	-	80	-	80	-	80	-
Washington	520	-	480	-	560	-	480	-
Wicomico	0	-	0	-	0	-	0	-
Worcester	10	-	0	-	10	-	80	-
Total	**2,100**	**-**	**1,930**	**-**	**3,840**	**-**	**2,160**	**-**

Table 1a.11: County-by-year estimated Animal Units (AU, 1000 lbs) for goats.

County	2018		2019		2020		2021	
	AIR	NASS	AIR	NASS	AIR	NASS	AIR	NASS
Allegany	20	-	30	-	20	-	40	-
Anne Arundel	10	-	0	-	0	-	0	-
Baltimore	50	-	40	-	20	-	20	-
Calvert	20	-	20	-	20	-	20	-
Caroline	10	-	20	-	20	-	10	-
Carroll	40	-	50	-	60	-	40	-
Cecil	30	-	30	-	20	-	10	-
Charles	10	-	10	-	10	-	10	-
Dorchester	10	-	10	-	10	-	10	-
Frederick	60	-	100	-	60	-	80	-
Garrett	50	-	50	-	40	-	40	-
Harford	10	-	10	-	1,150	-	10	-
Howard	20	-	30	-	30	-	30	-
Kent	10	-	0	-	0	-	0	-
Montgomery	70	-	60	-	70	-	60	-
Prince George's	10	-	20	-	20	-	20	-
Queen Anne's	0	-	0	-	0	-	0	-
Saint Mary's	30	-	30	-	30	-	20	-
Somerset	20	-	200	-	20	-	10	-
Talbot	0	-	0	-	0	-	0	-
Washington	90	-	70	-	110	-	120	-
Wicomico	30	-	40	-	20	-	30	-
Worcester	0	-	0	-	0	-	10	-
Total	**600**	**-**	**820**	**-**	**1,730**	**-**	**590**	**-**

Table 1a.12: Aggregated yearly estimated Animal Units (AU, 1000 lbs) for broilers, layers, and all cattle in NASS.

County	2018	2019	2020	2021
Allegany	3,580	3,710	3,520	3,770
Anne Arundel	1,400	1,520	1,270	1,120
Baltimore	6,510	7,320	6,680	5,020
Calvert	1,110	1,140	870	1,170
Caroline	394,370	400,580	389,200	354,460
Carroll	21,420	21,800	18,760	18,880
Cecil	8,240	8,110	7,550	4,570
Charles	2,970	3,130	2,550	2,720
Dorchester	170,690	174,350	169,530	153,330
Frederick	41,620	42,150	38,390	36,360
Garrett	14,900	15,880	13,630	15,300
Harford	13,630	12,330	18,680	11,310
Howard	2,680	2,430	1,750	1,990
Kent	44,640	44,740	42,330	42,250
Montgomery	3,650	3,370	2,620	2,820
Prince George's	1,330	1,560	1,010	1,300
Queen Anne's	162,330	165,470	160,600	145,530
Saint Mary's	3,460	4,010	3,320	3,370

Somerset	425,450	437,500	422,290	382,020
Talbot	45,960	46,680	45,240	41,110
Washington	40,130	40,340	37,160	41,270
Wicomico	361,810	369,520	359,660	325,050
Worcester	444,020	453,640	440,900	398,690
Total	**2,215,900**	**2,261,280**	**2,187,510**	**1,993,410**

Topic 1b: Estimated annual manure and nutrient content generated by livestock and poultry by county for 2018, 2019, 2020, and 2021

The total manure production at the species-county-year was estimated at the disaggregated level in Tables 1b.1 - 1b.7. Each table presents a separate animal species category. Livestock categories were combined in the same way as in Topic 1a. Additionally, due to the relatively low manure estimates from non-cattle and poultry sources, the manure estimates from all other animals (sheep, swine, horses, and goats) were combined in Table 1b.6.

All results in Tables 1b.1 - 1b.3 and 1b.6 were generated using the AIR data estimates, while results for broilers and layers in Table 1b.4-1b.5 were generated using NASS/Census estimates. For counties that were missing 2017 poultry census data, we assume that they produce no manure or nutrients from poultry in 2018-2021. As with the animal unit inventories in Topic 1a, the values were rounded to the nearest ten to avoid impressions of false precision in the estimates. Species-specific information detailing how manure estimates were generated (detailed below each table) closely follow the procedures used to estimate manure and nutrient production in the statewide projections presented in Topic 2a and in some cases are identical. Please consult Appendix B for Topic 2a for further details on trends and projections.

Table 1b.1: County-by-year estimated manure weight for Beef cows and bulls (in 100 lbs)

County	2018			2019			2020			2021		
	Manure	**N**	**P**	**Manure**	**N**	**P**	**Manure**	**N**	**P**	**Manure**	**N**	**P**
Allegany	408,390	1,550	370	410,460	1,560	380	444,030	1,690	410	447,940	1,700	410
Anne Arundel	120,950	460	110	122,790	470	110	121,410	460	110	106,700	410	100
Baltimore	306,290	1,160	280	280,770	1,070	260	507,960	1,930	470	301,000	1,140	280
Calvert	103,940	390	100	101,410	390	90	83,700	320	80	109,460	420	100
Caroline	91,980	350	80	89,910	340	80	92,670	350	80	28,740	110	30
Carroll	1,051,100	3,990	960	1,070,650	4,070	980	1,101,690	4,190	1,010	1,359,690	5,170	1,250
Cecil	292,730	1,110	270	279,160	1,060	260	260,070	990	240	117,270	450	110
Charles	206,040	780	190	199,830	760	180	176,370	670	160	187,180	710	170
Dorchester	12,420	50	10	10,810	40	10	28,050	110	30	20,930	80	20
Frederick	1,384,530	5,260	1,270	1,394,420	5,300	1,280	1,468,000	5,580	1,350	1,654,720	6,290	1,520
Garrett	867,140	3,300	800	976,140	3,710	900	893,590	3,400	820	908,760	3,450	830
Harford	503,130	1,910	460	496,000	1,880	450	650,070	2,470	600	528,430	2,010	480
Howard	158,440	600	150	151,080	570	140	98,420	370	90	115,430	440	110
Kent	83,470	320	80	106,240	400	100	99,340	380	90	95,890	360	90
Montgomery	334,580	1,270	310	303,990	1,160	280	266,050	1,010	240	299,620	1,140	270
Prince George's	75,880	290	70	91,060	350	80	66,690	250	60	77,720	300	70
Queen Anne's	210,400	800	190	199,830	760	180	178,440	680	160	195,920	740	180
Saint Mary's	217,070	820	200	250,650	950	230	243,520	930	220	215,230	820	200
Somerset	77,260	290	70	142,800	540	130	75,880	290	70	67,150	260	60
Talbot	42,770	160	40	44,150	170	40	42,540	160	40	61,860	240	60
Washington	1,107,210	4,210	1,020	1,258,520	4,780	1,150	1,249,550	4,750	1,150	1,241,500	4,720	1,140
Wicomico	53,350	200	50	51,510	200	50	75,880	290	70	76,110	290	70
Worcester	29,200	110	30	40,700	150	40	43,230	160	40	30,350	120	30
Total	**7,738,270**	**29,380**	**7,110**	**8,072,880**	**30,680**	**7,400**	**8,267,150**	**31,430**	**7,590**	**8,247,600**	**31,370**	**7,580**

Table 1b.1 Notes: A manure coefficient of 63 pounds/AU/day, a N coefficient of 0.0038 pounds N per pound of manure, and a P coefficient of 0.000917 pounds P per pound of manure were used, sourced from UMD NMP (2022). This procedure is the same as outlined in Appendix B, Table 2a.8; see that table's notes for further details.

Table 1b.2: County-by-year estimated manure weight for Dairy cows (in 100 lbs).

County	2018			2019			2020			2021		
	Total	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**
Allegany	1,940	10	0	1,940	10	0	1,940	10	0	0	0	0
Anne Arundel	970	0	0	970	0	0	970	0	0	970	0	0
Baltimore	434,940	1,780	420	624,100	2,560	600	393,330	1,610	380	192,070	790	180
Calvert	480	0	0	480	0	0	480	0	0	480	0	0
Caroline	381,230	1,560	370	378,820	1,550	360	389,460	1,600	370	370,590	1,520	360
Carroll	2,406,910	9,870	2,310	2,497,380	10,240	2,400	2,359,980	9,680	2,270	1,693,780	6,940	1,630
Cecil	1,304,810	5,350	1,250	1,363,350	5,590	1,310	1,357,540	5,570	1,300	640,070	2,620	610
Charles	14,510	60	10	15,480	60	10	22,250	90	20	35,320	140	30
Dorchester	0	0	0	0	0	0	0	0	0	0	0	0
Frederick	5,301,480	21,740	5,090	5,543,380	22,730	5,320	5,133,600	21,050	4,930	3,353,700	13,750	3,220
Garrett	1,271,430	5,210	1,220	1,381,730	5,670	1,330	1,268,040	5,200	1,220	1,214,340	4,980	1,170
Harford	1,288,840	5,280	1,240	1,048,880	4,300	1,010	1,066,300	4,370	1,020	852,460	3,500	820
Howard	205,130	840	200	121,920	500	120	124,820	510	120	127,240	520	120
Kent	1,965,680	8,060	1,890	1,858,280	7,620	1,780	1,686,040	6,910	1,620	1,918,270	7,860	1,840
Montgomery	132,080	540	130	99,180	410	100	78,860	320	80	58,540	240	60
Prince George's	53,700	220	50	56,600	230	50	9,680	40	10	59,020	240	60
Queen Anne's	599,910	2,460	580	650,710	2,670	620	681,190	2,790	650	494,440	2,030	470
Saint Mary's	84,180	350	80	144,170	590	140	81,760	340	80	97,730	400	90
Somerset	0	0	0	221,100	910	210	0	0	0	0	0	0
Talbot	269,960	1,110	260	229,320	940	220	234,460	960	230	155,780	640	150
Washington	5,575,800	22,860	5,350	5,571,440	22,840	5,350	6,183,930	25,350	5,940	5,356,150	21,960	5,140
Wicomico	0	0	0	0	0	0	36,770	150	40	0	0	0
Worcester	0	0	0	0	0	0	36,290	150	30	480	0	0
Total	**21,293,980**	**87,300**	**20,450**	**21,809,230**	**89,420**	**20,930**	**21,147,690**	**86,700**	**20,310**	**16,621,430**	**68,130**	**15,950**

Table 1b.2 Notes: We use a similar procedure as outlined in Appendix B Table 2a.7. From that table's notes: We use Maryland Nutrient Management Program (NMP) data supplemented by guidance from the NRCS Agricultural Waste Management Field Handbook. We assume that a lactating cow is milked 300 days per year and, per the NRCS Handbook, generates 137 pounds of manure per day (at 20,000 lbs of milk produced per year, near the Maryland average of 20,537 lbs for 2022). We assume that cows are dry for 65 days per year, and in that period generate 112 pounds of manure per day. NMP dairy cow manure samples indicate that, on average, semi-solid dairy cow manure is 0.41% N and 0.096% P.

Table 1b.3: County-by-year estimated manure weight for All other cattle (in 100 lbs)

County	2018			2019			2020			2021		
	Total	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**
Allegany	268,410	1,020	250	256,080	970	230	274,990	1,040	250	316,910	1,200	290
Anne Arundel	135,440	510	120	146,540	560	130	134,000	510	120	105,020	400	100
Baltimore	427,280	1,620	390	503,730	1,910	460	341,370	1,300	310	319,170	1,210	290
Calvert	88,990	340	80	88,370	340	80	80,360	310	70	115,910	440	110
Caroline	711,720	2,700	650	186,610	710	170	183,320	700	170	724,250	2,750	660
Carroll	1,924,910	7,310	1,770	1,899,010	7,220	1,740	1,742,400	6,620	1,600	1,323,140	5,030	1,210
Cecil	617,180	2,350	570	594,570	2,260	550	680,070	2,580	620	403,440	1,530	370
Charles	129,070	490	120	151,470	580	140	110,980	420	100	140,580	530	130
Dorchester	14,390	50	10	16,650	60	20	15,410	60	10	12,740	50	10
Frederick	2,992,380	11,370	2,740	2,983,130	11,340	2,740	3,294,080	12,520	3,020	2,741,850	10,420	2,510
Garrett	1,338,560	5,090	1,230	1,281,630	4,870	1,180	1,355,200	5,150	1,240	1,386,850	5,270	1,270
Harford	1,180,920	4,490	1,080	1,017,740	3,870	930	3,031,840	11,520	2,780	931,830	3,540	850
Howard	203,470	770	190	196,680	750	180	166,060	630	150	160,310	610	150
Kent	787,550	2,990	720	742,960	2,820	680	710,690	2,700	650	857,020	3,260	790
Montgomery	273,960	1,040	250	245,800	930	230	221,760	840	200	211,480	800	190
Prince George's	73,990	280	70	97,210	370	90	62,890	240	60	76,250	290	70
Queen Anne's	491,610	1,870	450	411,660	1,560	380	470,440	1,790	430	357,400	1,360	330
Saint Mary's	231,830	880	210	250,120	950	230	230,590	880	210	253,000	960	230
Somerset	45,010	170	40	490,170	1,860	450	38,020	140	30	35,760	140	30
Talbot	180,040	680	170	153,930	580	140	152,910	580	140	139,340	530	130
Washington	4,075,880	15,490	3,740	3,940,240	14,970	3,610	3,789,180	14,400	3,470	3,762,670	14,300	3,450
Wicomico	57,130	220	50	47,060	180	40	146,740	560	130	50,760	190	50
Worcester	21,170	80	20	30,620	120	30	45,210	170	40	26,510	100	20
Total	**16,270,890**	**61,810**	**14,920**	**15,731,980**	**59,780**	**14,430**	**17,278,510**	**65,660**	**15,800**	**14,452,190**	**54,910**	**13,240**

Table 1b.3 Notes: We use separate manure production coefficients for heifers (82 pounds/animal/day), bulls (76), calves (20), and other cattle (53). We multiply total inventories by NASS statewide shares, and then multiply these adjusted totals for each category by their respective manure coefficients over the course of the year. We also use the same manure coefficients as beef cows, 0.0038 and 0.000917 lbs N and P per pound of manure, respectively. This procedure is similar to the one followed in Appendix B Table 2a.9; see that table's notes for further details.

Table 1b.4: County-by-year estimated manure weight for Chickens, layers (in 100 lbs)

County	2018			2019			2020			2021		
	Total	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**
Allegany	5,770	170	60	5,860	170	60	5,250	150	60	4,790	140	50
Anne Arundel	11,860	350	130	12,060	350	130	10,810	320	120	9,860	290	110
Baltimore	94,210	2,750	1,020	95,770	2,800	1,030	85,820	2,510	930	78,300	2,290	850
Calvert	9,220	270	100	9,380	270	100	8,400	2,50	90	7,670	220	80
Caroline	15,460	450	170	15,720	460	170	14,080	4,10	150	12,850	380	140
Carroll	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Cecil	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Charles	82,500	2,410	890	83,870	2,450	910	75,150	2,190	810	68,570	2,000	740
Dorchester	5,120	150	60	5,210	150	60	4,670	140	50	4,260	120	50
Frederick	421,020	12,290	4,550	428,010	12,500	4,620	383,540	11,200	4,140	349,930	10,220	3,780
Garrett	38,560	1,130	420	39,200	1,140	420	35,130	1030	380	32,050	940	350
Harford	162,220	4,740	1,750	164,910	4,820	1,780	147,780	4,320	1,600	134,830	3,940	1,460
Howard	13,020	380	140	13,240	390	140	11,870	350	130	10,830	320	120
Kent	4,460	130	50	4,540	130	50	4,070	120	40	3,710	110	40
Montgomery	13,110	380	140	13,330	390	140	11,940	350	130	10,890	320	120
Prince George's	22,760	660	250	23,140	680	250	20,740	610	220	18,920	550	200
Queen Anne's	9,610	280	100	9,770	290	110	8,750	260	90	7,990	230	90
Saint Mary's	41,580	1,210	450	42,270	1,230	460	37,870	1,110	410	34,560	1,010	370
Somerset	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Talbot	9,430	280	100	9,590	280	100	8,590	250	90	7,840	230	80
Washington	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Wicomico	5,040	150	50	5,130	150	60	4,600	130	50	4,190	120	50
Worcester	150,450	4,390	1,620	152,950	4,470	1,650	137,060	4,000	1,480	125,050	3,650	1,350
Total	**1,115,400**	**32,570**	**12,050**	**1,133,950**	**33,120**	**12,240**	**1,016,120**	**29,040**	**10,970**	**927,090**	**27,080**	**10,030**

Table 1b.4 Notes: We use coefficients from UMD NMP (2022), which show that layers produce 39.4 lbs per bird per year, assuming an average weight of 4.7 lbs. The N and P content of this manure is 0.0292 and 0.0108 lbs per lbs manure, respectively. The process followed is identical to that described in Appendix B Table 2a.6, see that table's notes for further detail.

Table 1b.5: County-by-year estimated manure weight for Chickens, broilers (in 100 lbs)

County	2018			2019			2020			2021		
	Total	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**
Allegany	20	0	0	20	0	0	20	0	0	20	0	0
Anne Arundel	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Baltimore	2,030	50	20	2,090	60	20	2,130	60	20	1,930	50	20
Calvert	90	0	0	90	0	0	90	0	0	80	0	0
Caroline	1,506,730	40,830	16,570	1,550,800	42,030	17,060	1,5798,70	42,810	17,380	1,432,650	38,820	15,760
Carroll	140	0	0	140	0	0	150	0	0	130	0	0
Cecil	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Charles	810	20	10	830	20	10	840	20	10	770	20	10
Dorchester	659,340	17,870	7,250	678,630	18,390	7,460	691,350	18,740	7,600	626,930	16,990	6,900
Frederick	150	0	0	150	0	0	160	0	0	140	0	0
Garrett	60	0	0	60	0	0	60	0	0	50	0	0
Harford	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Howard	400	10	0	410	10	0	420	10	0	380	10	0
Kent	134,840	3,650	1,480	138,790	3,760	1,530	141,390	3,830	1,560	128,210	3,470	1,410
Montgomery	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Prince George's	550	10	10	570	20	10	580	20	10	530	10	10
Queen Anne's	607,740	16,470	6,690	625,520	16,950	6,880	637,240	17,270	7,010	577,860	15,660	6,360
Saint Mary's	1,870	50	20	1,920	50	20	1,960	50	20	1,780	50	20
Somerset	1,642,800	44,520	18,070	1,690,860	45,820	18,600	1,722,550	46,680	18,950	1,562,040	42,330	17,180
Talbot	170,330	4,620	1,870	175,320	4,750	1,930	178,600	4,840	1,960	161,960	4,390	1,780
Washington	170	0	0	170	0	0	180	0	0	160	0	0
Wicomico	1,396,800	37,850	15,360	1,437,660	38,960	15,810	1,464,610	39,690	16,110	1,328,130	35,990	14,610
Worcester	1,709,180	46,320	18,800	1,759,180	47,670	19,350	1,792,150	48,570	19,710	1,625,150	44,040	17880
Total	**7,834,050**	**212,270**	**86,150**	**8,063,210**	**218,490**	**88,680**	**6,634,480**	**222,590**	**90,340**	**7,448,900**	**201,830**	**81,940**

Table 1b.5 Notes: We use a year-specific average broiler weight as well as manure-per-bird-estimates from UMD NMP (2022). We follow the process described in Appendix B Table 2a.4. From that table's notes: Our estimates are derived from data collected as part of Maryland's nutrient management program (NMP). In 2019-22, the mean nutrient concentration was 0.0271 lbs N, and 0.0110 lbs P, per lbs of litter. We estimate nutrient production per bird by combining estimates of nutrient concentration with estimates of litter generation per bird. NMP data also underlie estimates of litter generation, as expressed in the following simple equation: Litter = 0.04178 + 0.03458 (bird weight). Litter is measured in pounds, and bird weight is market weight at slaughter.

Table 1b.6: County-by-year estimated manure weight for All other animals (in 100 lbs)

County	2018			2019			2020			2021		
	Total	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**
Allegany	24,000	120	30	22,230	120	30	21,180	110	20	25,600	140	30
Anne Arundel	314,970	1,310	230	444,300	1,840	310	605,940	2,500	430	402,300	1,650	280
Baltimore	409,500	1,690	290	384,200	1,580	280	355,840	1,470	260	307,280	1,260	230
Calvert	31,040	150	30	31,420	140	30	28,670	150	30	32,380	170	40
Caroline	81,250	340	60	79,380	330	60	77,100	320	60	49,340	210	40
Carroll	511,160	2,220	410	265,520	1,120	220	274,050	1,150	220	242,620	1,020	200
Cecil	713,110	2,880	490	832,910	3,190	540	721,100	2,880	490	365,290	1,490	250
Charles	75,890	320	60	74,250	310	60	72,760	300	50	60,470	260	50
Dorchester	16,420	60	10	20,580	70	10	18,650	60	10	31,300	100	20
Frederick	352,680	1,650	330	438,980	1,790	350	385,880	1,570	320	425,130	1,840	370
Garrett	76,250	370	80	71,390	340	70	87,710	430	90	87,060	450	100
Harford	277,870	1,170	210	261,860	1,100	190	461,390	3,380	970	257,600	1,100	200
Howard	206,020	860	150	212,680	890	160	199,000	820	150	179,340	750	140
Kent	204,950	560	110	203,190	520	90	114,220	350	60	116,920	360	60
Montgomery	393,110	1,660	290	368,490	1,550	270	364,170	1,530	270	362,360	1,530	270
Prince George's	60,330	250	40	80,990	350	60	52,090	240	50	90,780	390	70
Queen Anne's	62,000	270	50	57,770	240	40	66,030	270	150	86,090	310	60
Saint Mary's	153,230	650	120	179,610	740	140	138,210	580	110	168,790	710	130
Somerset	6,890	50	10	27,160	260	80	5,340	40	10	3,280	20	10
Talbot	75,150	360	70	68,940	320	60	62,100	290	60	156,500	670	120
Washington	149,670	870	220	235,280	1,070	250	180,860	940	240	185,590	930	230
Wicomico	46,220	200	40	35,910	160	30	38,880	170	30	57,170	250	50
Worcester	30,280	120	20	36,370	140	20	43,310	170	30	41,340	230	50
Total	**4,271,990**	**18,130**	**3,350**	**4,433,410**	**18,170**	**3,3350**	**4,374,480**	**19,720**	**4,110**	**3,734,530**	**15,840**	**3,000**

Table 1b.6 Notes: Estimates for swine, horses, goat, and sheep were combined, following the procedure outlined in Appendix B Table 2a.12, with sheep and goats producing 4 lbs of manure per day, of which 1.09% is N and 0.362% is P. For horses, the procedure outlined Appendix B Table 2a.11 was used using NRCS estimates of manure generation for an 1,100 lb animal: sedentary horses were estimated to produce 56 lbs of manure per day, compared to 57 lbs for a horse in an intense regimen. Maryland NMP tests found that sedentary horses generated 0.2 lbs of N and 0.029 lbs of P in daily manure compared to 0.34 and 0.073 lbs, respectively, for horses in an intense regime. Annual per horse estimates were made by multiplying daily estimates by 365 days, with 80% of the horse inventory in a sedentary regime. Swine numbers were generated using only AIR data, as outlined in Appendix B Table 2a.10, with separate manure coefficients for sows and boars than for growers (35.25 lbs/AU/day and 63, respectively, sourced from UMD NMP, 2022). The liquid hog manure nutrient coefficient numbers from UMD NMP were scaled up by 10%. These horse and swine estimates differ slightly than Topic 2a, as the AIR data was used here and the equine and swine census data was used in Topic 2a. The AIR data may miss horses kept off-farm, and therefore, is an underestimate of total manure and nutrients from horses statewide.

Table 1b.7: Yearly aggregated estimated manure weight across species (in 100 lbs)

County	2018			2019			2020			2021		
	Total	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**	**Total**	**N**	**P**
Allegany	708,530	2,870	710	696,590	2,830	700	747,410	3,000	740	795,260	3,180	780
Anne Arundel	584,190	2,630	590	726,660	3,220	680	873,130	3,790	780	624,850	2,750	590
Baltimore	1,674,250	9,050	2,420	1,890,660	9,980	2,650	1,686,450	8,880	2,370	1,199,750	6,740	1,850
Calvert	233,760	1,150	310	231,150	1,140	300	201,700	780	270	265,980	1,250	330
Caroline	2,788,370	46,230	17,900	2,301,420	45,420	17,900	756,630	45,780	18,210	2,618,420	43,790	16,990
Carroll	5,894,220	23,390	5,450	5,732,700	22,650	5,340	5,478,270	21,640	5,100	4,619,360	18,160	4,290
Cecil	2,927,830	11,690	2,580	3,069,990	12,100	2,660	3,018,780	12,020	2,650	1,526,070	6,090	1,340
Charles	508,820	4,080	1,280	525,730	4,180	1,310	458,350	3,690	1,150	492,890	3,660	1,130
Dorchester	707,690	18,180	7,340	731,880	18,710	7,560	758,130	19,110	7,700	696,160	17,340	7,000
Frederick	10,452,240	52,310	13,980	10,788,070	53,660	14,310	10,665,260	51,920	13,760	8,525,470	42,520	11,400
Garrett	3,592,000	15,100	3,750	3,750,150	15,730	3,900	3,639,730	15,210	3,750	3,629,110	15,090	3,720
Harford	3,412,980	17,590	4,740	2,989,390	15,970	4,360	5,357,380	26,060	6,970	2,705,150	14,090	3,810
Howard	786,480	3,460	830	696,010	3,110	740	600,590	2,690	640	593,530	2,650	640
Kent	3,180,950	15,710	4,330	3,054,000	15,250	4,230	2,755,750	14,290	4,020	3,120,020	15,420	4,230
Montgomery	1,146,840	4,890	1,120	1,030,790	4,440	1,020	942,780	4,050	920	942,890	4,030	910
Prince George's	287,210	1,710	490	349,570	2,000	540	212,670	1,400	410	323,220	1,780	480
Queen Anne's	1,981,270	22,150	8,060	1,955,260	22,470	8,210	2,042,090	23,060	8,490	1,719,700	20,330	7,490
Saint Mary's	729,760	3,960	1,080	868,740	4,510	1,220	733,910	3,890	1,050	771,090	3,950	1,040
Somerset	1,771,960	45,030	18,190	2,572,090	49,390	19,470	1,841,790	47,150	19,060	1,668,230	42,750	17,280
Talbot	747,680	7,210	2,510	681,250	7,040	2,490	679,200	7,080	2,520	683,280	6,700	2,320
Washington	10,908,730	43,430	10,330	11,005,650	43,660	10,360	11,403,700	45,440	10,800	10,546,070	41,910	9,960
Wicomico	1,558,540	38,620	15,550	1,577,270	39,650	15,990	1,767,480	40,990	16,430	1,516,360	36,840	14,830
Worcester	1,940,280	51,020	20,490	2,019,820	52,550	21,090	2,097,250	53,220	21,330	1,848,880	48,140	19,330
Total	**58,524,590**	**441,460**	**144,030**	**59,244,660**	**449,600**	**147,030**	**58,718,430**	**455,140**	**149,120**	**51,431,740**	**339,160**	**131,740**

Table 1b.6 Notes: This table sums estimates from Tables 1b.1-1b.6 across species by county in each year.

Topic 1C: Estimated volume and average nutrient content of nitrogen and phosphorus in Dissolved Air Flotation (DAF)
Below is one table (Table 1c.1) detailing dissolved air flotation (DAF) transport by county for 2019, 2020, and 2021.

Table 1c.1: Dissolved air flotation (DAF) sludge import and export to MD counties, 2019-2021.

	2019				2020				2021			
County	Import (gal)	Import (ton)	Export (gal)	Export (ton)	Import (gal)	Import (ton)	Export (gal)	Export (ton)	Import (gal)	Import (ton)	Export (gal)	Export (ton)
Allegany	0	0	0	0	0	0	0	0	0	0	0	0
Anne Arundel	0	0	0	0	0	0	0	0	0	0	0	0
Baltimore	0	0	0	0	0	0	0	0	0	0	0	0
Calvert	0	0	0	0	0	0	0	0	0	0	0	0
Caroline	1,650,000	0	0	0	4,800,000	5,800	0	120	666,000	935	0	0
Carroll	0	0	0	0	0	0	0	0	0	0	0	0
Cecil	204,000	0	0	0	204,000	0	0	0	205,000	0	0	0
Charles	0	0	0	0	0	0	0	0	0	0	0	0
Dorchester	7,620,000	200	0	0	9,030,000	1,050,000*	0	0	5,920,000	18,000	0	0
Frederick	0	0	0	0	0	0	0	0	0	0	0	300
Garrett	0	0	0	0	0	0	0	0	0	0	0	0
Harford	0	0	0	0	0	0	0	0	0	0	0	0
Howard	0	0	0	0	0	0	0	0	0	0	0	0
Kent	0	0	0	0	0	0	0	0	0	0	0	0
Montgomery	0	0	0	0	0	0	0	0	0	0	0	0
Prince George's	0	0	0	0	0	0	0	0	0	0	0	0
Queen Anne's	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	0	0	0	924	0	0	0	0	0	0	0	833
St Mary's	0	0	0	0	0	0	0	0	0	0	0	0
Talbot	1,470,000	2,030	0	0	2,410,000	0	0	0	774,000	4,120	0	0
Washington	330,000	40	0	0	0	0	0	0	0	108	0	0
Wicomico	18,300,000	152	0	0	15,700,000	0	4,800,000	0	12,000,000	0	3,186,000	200
Worcester	0	3	0	776	5,120,000	1,320	0	107	1,370,000	0	0	1
Sum	**29,600,000**	**2,430**	**0**	**1700**	**37,300,000**	**5,800**	**4,800,000**	**227**	**20,900,000**	**23,200**	**3,186,000**	**1,330**

*Outlier, excluded from all calculations in Table 1c.1 and Table 1c.3.

Topic 1d:

Data analyzed for section 1d included manure storage and transport facilities in Maryland. Data used to compose the tables and figures in this section are detailed in the Materials and Methods section for Topic 1d.

Table 1d.1: Estimated current operational capacity for amendments for the treatment of agricultural waste and number of on-farm animal compost structures in Maryland as of 2021, using data from the Maryland Watershed Implementation Plan (WIP) report for the Chesapeake Bay. AU = Animal unit.

County	Amendments for the Treatment of Agricultural Waste (AU)	Animal Compost Structure RI (Count)	Animal Mortality Compost Facilities (Count)
Allegany	0	0	0
Anne Arundel	0	0	0
Baltimore	0	0	0
Calvert	0	0	0
Caroline	43,300	4	176
Carroll	0	0	1
Cecil	0	1	1
Charles	0	0	0
Dorchester	5,400	0	121
Frederick	0	0	5
Garrett	0	0	0
Harford	0	0	0
Howard	0	0	0
Kent	2	0	11
Montgomery	0	0	0
Prince George's	0	0	1
Queen Anne's	19,000	0	58
Somerset	0	0	200
St Mary's	0	0	0
Talbot	840	0	22
Washington	0	0	0
Wicomico	27,200	0	269
Worcester	2,160	0	220
Total	**97,900**	**5**	**1,085**

Table 1d.2: Estimated operational animal waste storage facility capacity in Maryland as of 2021, using data from the Maryland Watershed Implementation Plan (WIP) report for the Chesapeake Bay. AU = Animal unit.

County	Waste Storage Facility (Beef AU)	Waste Storage Facility (Dairy AU)	Waste Storage Facility (Poultry AU)	Waste Storage Facility (Goats AU)	Waste Storage Facility (Horses AU)	Waste Storage Facility (Other AU)	Waste Storage Facility (Sheep AU)	Waste Storage Facility (Swine AU)
Allegany	486	35	0	2	3	0	0	0
Anne Arundel	36	0	0	0	162	0	6	0
Baltimore	710	955	2,290	0	273	0	5	0
Calvert	62	0	0	0	9	0	0	0
Caroline	9,600	11,400	529,000	1	212	4	0	10
Carroll	6,250	26,500	3,200	1	336	2	34	5
Cecil	378	7,450	580	1	391	0	0	0
Charles	15	0	0	5	32	0	0	0
Dorchester	80	0	182,000	0	0	35	0	15
Frederick	5,460	41,100	3,390	15	783	15	27	5
Garrett	1,950	4,040	0	30	0	0	88	55
Harford	1,120	5,300	0	30	294	0	0	40
Howard	243	753	0	0	1,460	0	0	0
Kent	395	3,450	38,800	0	149	0	10	5
Montgomery	169	675	0	0	718	0	0	4
Prince George's	0	187	0	0	44	0	10	0
Queen Anne's	1,110	5,680	227,000	0	143	5	3	100
Somerset	375	0	648,000	0	4	0	0	0
St Mary's	496	156	0	14	118	1	0	580
Talbot	105	835	77,800	0	50	0	0	0
Washington	1,760	16,700	0	0	148	0	68	194
Wicomico	56	200	654,000	0	195	0	0	0
Worcester	3	341	339,000	0	0	0	0	35
Total	**30,900**	**126,000**	**2,710,000**	**99**	**5,530**	**62**	**251**	**1,050**

Table 1d.3: Estimated operational animal waste storage pond capacity in Maryland as of 2021, using data from the Maryland Watershed Implementation Plan (WIP) report for the Chesapeake Bay. AU = Animal unit.

County	Waste Storage Pond (Beef AU)	Waste Storage Pond (Dairy AU)	Waste Storage Pond (Poultry AU)
Allegany	30	0	0
Anne Arundel	0	0	0
Baltimore	0	0	0
Calvert	0	0	0
Caroline	6,390	1,990	0
Carroll	0	220	0
Cecil	0	0	0
Charles	0	0	0
Dorchester	0	0	0
Frederick	0	0	0
Garrett	100	777	0
Harford	0	397	0
Howard	20	0	0
Kent	0	380	0
Montgomery	0	0	0
Prince George's	0	0	0
Queen Anne's	0	672	0
Somerset	0	0	0
St Mary's	0	0	0
Talbot	0	0	0
Washington	0	0	0
Wicomico	0	0	0
Worcester	0	0	0
Total	**6,540**	**4,440**	**0**

Table 1d.4: Estimated operational animal waste treatment lagoon capacity in Maryland as of 2021, using data from the Maryland Watershed Implementation Plan (WIP) report for the Chesapeake Bay. AU = Animal unit.

County	Waste Treatment Lagoon (Beef AU)	Waste Treatment Lagoon (Dairy AU)	Waste Treatment Lagoon (Poultry AU)
Allegany	0	0	0
Anne Arundel	0	0	0
Baltimore	0	0	0
Calvert	0	0	0
Caroline	0	0	0
Carroll	0	0	0
Cecil	0	80	100
Charles	0	1	2
Dorchester	0	0	700
Frederick	0	3,000	0
Garrett	52	462	0
Harford	0	1	2
Howard	0	200	0
Kent	5	10	0
Montgomery	109	0	0
Prince George's	0	0	0
Queen Anne's	0	0	0
Somerset	0	0	0
St Mary's	100	0	0
Talbot	0	0	0
Washington	0	0	0
Wicomico	0	0	0
Worcester	0	0	3,250
Total	**266**	**3,750**	**4,050**

Table 1d.5: Estimated surface area of treatment lagoons and storage ponds at Maryland's Confined Animal Feeding Operations (CAFOs) farms as of 2022.

County	CAFOs Storage Lagoon Surface Area (m^2)
Allegany	0
Anne Arundel	0
Baltimore	4,420
Calvert	0
Caroline	45,900
Carroll	30,900
Cecil	19,900
Charles	0
Dorchester	0
Frederick	99,700
Garrett	0
Harford	0
Howard	0
Kent	174,000
Montgomery	0
Prince George's	0
Queen Anne's	3,050
Saint Mary's	0
Somerset	0
Talbot	0
Washington	2,690
Wicomico	0
Worcester	3,300
Total	**383,000**

Table 1d.6: Anaerobic digestion units operational or planned in Maryland as of 2023.

County	Total Digesters	Digester Type	Digester Feedstocks	Digester Operational Status
Baltimore	1	Wastewater treatment facility	Municipal wastewater sludge	Operational
Caroline	1	On-Farm	Dairy manure and DAF	Planned
Cecil	2	On-farm	Dairy manure, food waste, DAF	Operational
		On-farm	Dairy manure, food waste, DAF	Planned
Frederick	1	Wastewater treatment facility	Municipal wastewater sludge	Operational
Harford	3	Wastewater treatment facility	Municipal wastewater sludge	Operational
		Wastewater treatment facility	Municipal wastewater sludge	Operational
		Wastewater treatment facility	Municipal wastewater sludge	Operational
Howard	2	Wastewater treatment facility	Municipal wastewater sludge	Operational
		Commercial digestion facility	Food waste, DAF	Operational
Prince George's	1	On-farm	Dairy manure	Decommissioned
Saint Mary's	1	Wastewater treatment facility	Municipal wastewater sludge	Operational
Somerset	2	On-farm	Poultry litter	Operational
		On-farm	Poultry litter, food waste	Planned
Washington	1	Wastewater treatment facility	Municipal wastewater sludge	Operational
Worcester	2	On-farm	Poultry waste	Operational
		On-farm	Poultry waste, cover crops	Planned
Total	**17**			

Topic 1e: Estimated the volume of animal waste being field applied, transported to waste treatment technology, or land-filled by county for 2018, 2019, 2020, and 2021.

Table 1e.1: Estimated cost-shared transport of animal waste for land application in Maryland in 2018.

	Beef (dry tons)		**Broilers (wet tons)**		**Dairy (wet tons)**		**Horses (wet tons)**		**Layers (wet tons)**		**Poultry (wet tons)**		**Pullets (wet tons)**		**Swine (wet tons)**		**Turkeys (wet tons)**	
County	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Allegany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anne Arundel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baltimore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calvert	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caroline	0	0	0	0	0	0	0	0	0	0	445	0	0	0	0	0	0	0
Carroll	675	675	0	0	164,000	30,200	0	0	0	0	0	0	0	0	889	889	1,180	0
Cecil	0	0	0	0	24,200	23,900	0	0	761	0	699	0	0	0	0	0	921	0
Charles	0	0	0	0	0	0	0	0	0	0	122	0	0	0	0	0	0	0
Dorchester	0	0	0	0	0	0	0	0	0	0	600	0	0	0	0	0	0	0
Frederick	379	379	0	0	55,800	60,800	0	0	0	0	530	0	0	0	0	0	0	0
Garrett	0	0	2,630	0	11,900	11,900	0	0	1,140	0	0	0	0	0	0	0	0	0
Harford	0	0	0	0	4,370	4372	0	0	6,000	0	0	0	0	0	0	0	0	0
Howard	0	0	238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kent	0	0	4,173	0	25,700	25,700	0	0	0	0	5,860	0	0	0	0	0	0	0
Montgomery	0	0	0	0	523	523	0	0	0	0	0	0	0	0	0	0	0	0
Prince George's	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queen Anne's	0	0	0	0	8,760	8,760	0	0	0	0	0	0	0	0	0	0	0	0
St. Mary's	0	0	4,940	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	0	0	0	5,390	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Talbot	0	0	0	0	0	0	0	0	0	0	936	0	0	0	0	0	0	0
Washington	0	0	0	0	23,000	18,000	0	0	1,470	0	1,950	1952	0	0	0	0	0	0
Wicomico	0	0	0	402	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worcester	0	0	0	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**1,050**	**1,050**	**11,980**	**9,510**	**318,000**	**184,200**	**0**	**0**	**9,370**	**0**	**11,100**	**1,950**	**0**	**0**	**889**	**889**	**2,101**	**0**

Table 1e.2: Estimated cost-shared transport of animal waste for land application in Maryland in 2019.

	Beef (dry tons)		**Broilers (wet tons)**		**Dairy (wet tons)**		**Horses (wet tons)**		**Layers (wet tons)**		**Poultry (wet tons)**		**Pullets (wet tons)**		**Swine (wet tons)**		**Turkeys (wet tons)**	
County	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Allegany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anne Arundel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baltimore	0	0	3,280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calvert	0	0	238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caroline	0	0	578	578	0	0	0	0	0	0	198	0	0	0	0	0	0	0
Carroll	0	0	18,900	18,900	201,000	0	0	0	0	0	0	0	0	0	0	0	1,570	0
Cecil	0	0	13,200	13,200	0	0	0	0	0	0	133	0	1,200	0	0	0	0	0
Charles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorchester	0	0	0	0	0	519	0	0	0	0	597	0	0	0	0	0	0	0
Frederick	5,800	5,800	16,900	20,700	39,000	31,900	0	0	0	0	201	0	0	0	0	0	0	0
Garrett	0	0	2,680	0	11,800	11,800	0	0	1,460	0	0	0	0	0	0	0	241	0
Harford	0	0	0	3,280	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Howard	0	0	0	0	1,470	0	0	0	0	0	0	0	0	0	0	0	0	0
Kent	0	0	0	0	41,200	35,800	0	0	0	0	8,530	0	0	0	0	0	0	0
Montgomery	0	0	0	0	2,450	9,700	0	0	0	0	0	0	0	0	0	0	0	0
Prince George's	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queen Anne's	0	0	0	0	4,620	4,800	0	0	0	0	0	0	0	0	0	0	0	0
St. Mary's	0	0	0	167	4,850	4,810	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	0	0	0	238	0	5,670	0	0	0	0	0	0	0	0	0	0	0	0
Talbot	0	0	0	0	427	210	0	0	0	0	435	0	0	0	0	0	0	0
Washington	0	0	30,200	26,400	0	0	0	0	0	0	0	0	0	0	1,660	0	0	0
Wicomico	0	0	0	116	0	762	0	0	0	0	0	0	0	0	0	0	0	0
Worcester	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**5800**	**5800**	**86,000**	**83,600**	**307,000**	**106,000**	**0**	**0**	**1,460**	**0**	**10,100**	**0**	**1,200**	**0**	**1,660**	**0**	**1,810**	**0**

Table 1e.3: Estimated cost-shared transport of animal waste for land application in Maryland in 2020.

	Beef (dry tons)		**Broilers (wet tons)**		**Dairy (wet tons)**		**Horses (wet tons)**		**Layers (wet tons)**		**Poultry (wet tons)**		**Pullets (Wet tons)**		**Swine (Wet tons)**		**Turkeys (Wet tons)**	
County	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Allegany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anne Arundel	0	0	411	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baltimore	0	0	0	0	4,980	0	0	0	0	0	0	0	0	0	0	0	0	0
Calvert	0	0	371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caroline	0	0	407	180	3,910	0	0	0	0	0	0	0	0	0	0	0	0	0
Carroll	0	0	545	0	239,000	19,000	0	0	0	0	0	0	0	0	0	0	1,230	0
Cecil	0	0	180	114	21,100	21,100	0	0	0	0	0	0	0	0	0	0	0	0
Charles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorchester	0	0	695	792	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frederick	0	0	0	0	85,700	96,800	0	0	0	0	0	0	0	0	0	0	0	0
Garrett	0	0	2,750	0	11,200	11,200	0	0	2,220	0	0	0	0	0	0	0	0	0
Harford	0	0	0	0	0	4,980	0	0	0	0	0	0	0	0	978	0	0	0
Howard	0	0	0	0	4,260	4,260	0	0	0	0	0	0	0	0	0	0	0	0
Kent	0	0	9,430	0	35,800	35,800	0	0	0	0	9,300	0	0	0	0	0	0	0
Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prince George's	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queen Anne's	0	0	6,080	0	3,880	7,790	0	0	0	0	0	0	0	0	0	0	0	0
St. Mary's	0	0	8,650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	0	0	0	6,520	0	0	0	0	0	0	140	0	0	0	0	0	0	0
Talbot	0	0	2,320	0	1,030	1,030	0	0	0	0	343	0	0	0	0	0	0	0
Washington	0	0	0	0	34,600	23,500	0	0	0	0	0	0	0	0	1,850	0	0	0
Wicomico	0	0	0	6,190	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worcester	0	0	0	15,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**31,800**	**29,400**	**446,000**	**226,000**	**0**	**0**	**2,220**	**0**	**9,780**	**0**	**0**	**0**	**2,830**	**0**	**1,230**	**0**

Table 1e.4: Estimated cost-shared transport of animal waste for land application in Maryland in 2021.

	Beef (dry tons)		**Broilers (wet tons)**		**Dairy (wet tons)**		**Horses (wet tons)**		**Layers (wet tons)**		**Poultry (wet tons)**		**Pullets (Wet tons)**		**Swine (Wet tons)**		**Turkeys (Wet tons)**	
County	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Allegany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anne Arundel	0	0	79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baltimore	0	0	0	0	11,600	0	0	0	0	0	0	0	0	0	0	0	0	0
Calvert	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caroline	0	0	773	7,350	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carroll	0	0	533	0	0	0	0	0	0	0	0	0	0	0	1,000	0	1,870	0
Cecil	0	0	2,640	0	0	0	0	0	986	0	0	0	0	0	0	0	1,520	0
Charles	0	0	345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorchester	0	0	8,630	2,190	0	0	0	0	0	0	101	0	0	0	0	0	0	0
Frederick	0	0	0	0	0	0	0	0	16,000	0	0	0	0	0	0	0	0	0
Garrett	0	0	1,570	0	0	0	0	0	2,620	0	0	0	0	0	0	0	0	0
Harford	0	0	900	0	0	11,600	0	0	0	0	0	0	0	0	0	0	0	0
Howard	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kent	0	0	25,100	0	0	0	0	0	122	0	0	0	0	0	0	0	0	0
Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prince George's	0	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queen Anne's	0	0	2,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Mary's	0	0	5,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	0	0	0	6,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Talbot	0	0	3,410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,900	0	0	0
Wicomico	0	0	0	6,740	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worcester	0	0	0	15,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**52,600**	**38,100**	**11,600**	**11,600**	**0**	**0**	**19,700**	**0**	**101**	**0**	**0**	**0**	**2,900**	**0**	**3,390**	**0**

Table 1e.5: Animal waste (wet tons) transported from Maryland counties for non-land disposal processing in animal waste technology.

County	2018	2019	2020	2021
Allegany	0	0	0	0
Anne Arundel	0	0	0	0
Baltimore	0	0	0	0
Calvert	0	0	0	0
Caroline	50	0	0	0
Carroll	0	0	0	0
Cecil	0	0	0	0
Charles	0	0	0	0
Dorchester	0	114	194	239
Frederick	0	0	0	0
Garrett	0	0	0	0
Harford	0	0	0	0
Howard	0	0	0	0
Kent	0	0	0	0
Montgomery	0	0	0	0
Prince George	0	0	0	0
Queen Anne	0	538	0	0
St. Mary	0	15,700	0	0
Somerset	16,400	17,100	16,000	22,700
Talbot	0	0	0	0
Washington	0	0	0	0
Wicomico	19,600	21,700	20,500	20,400
Worcester	15,900	0	17,800	19,700
Total	**52,000**	**55,200**	**54,500**	**63,000**

Table 1e.6: Analysis of 2019-2021 AIR questions for reporting transport and use of animal waste-derived organics. Numbers refer to the question number in the AIR that addresses the topic at the top of each column.

Animal waste type	On-farm organics, stored over preceding winter	On-farm organics, stored over the preceding winter, and land- applied	On-farm organics land applied	On-farm-generated organics stored for next season	Imported organics stored over preceding winter	Imported organics stored over preceding winter and applied	Imported organics applied	Imported organics stored for next season
Poultry	33	Question not asked	34	Question not asked	Question not asked	35	51	
Other than poultry (unspecified total)	48		Covered in more specificity below	=49-(47+48)		50	Covered in more specificity below	
Dairy, beef, swine, horse sheep (individually)	Not available at this level of specificity		49	=49-(47+48) if only one manure type		Not available at this level of specificity	51	
Other than any type specified above			49	=49-(47+48)			Covered in more specificity below	
Compost, biosolids, poultry DAF, food residuals (individually)			Not available at this level of specificity	Not available at this level of specificity			51	

Appendix B: Additional Results from Topic 2

Topic 2a: Current Industry Trends that May Affect Animal Waste Characteristics and Growth Trends in Animal Waste Volume in Maryland

Broiler Production Trends

Increases in Maryland production have come about almost entirely through increases in the average weight of birds. The annual number of broilers produced rose from 1988 through 1993, but then remained stable from 1993 through 2017. Head counts declined modestly through 2019, followed by a sharp decline over 2020-2022. Due to the pandemic, firms reduced chick placements nationwide and especially on the Delmarva Peninsula.

Our estimate of average bird weight (figure 2.a.3 in the main text) has been revised from the NASS series for liveweight pounds produced. NASS relies on hatchery reports to count the number of chicks placed on Maryland farms, and then adjusts those counts with estimates of chick mortality to reach the number of broilers removed from Maryland farms. The agency estimates liveweight production by multiplying the headcount by the average weight of broilers slaughtered in Maryland processing facilities (personal communication with NASS official, April 20, 2023). However, average reported Maryland weights are consistently below average Delaware weights, because small birds produced in each state go to a Maryland plant that specializes in small birds. As a result, the NASS series understates the average weight of birds raised in Maryland and overstates that for birds raised in Delaware. We use average weights across all Maryland and Delaware production to revise the NASS estimates for liveweight (Maryland) production.

Stakeholder Interviews - Broiler

Interview quotes and responses from a range of broiler industry stakeholders, including growers, integrator staff, extension agents, and consultants.

Increasing Trend Responses:

- "I personally think they're [number of birds] going to increase due to the proximity of the market and available land. That's how I envision it. Because of the demand and location of the market."
- "I think it [number of birds] increases because it's been decreasing. I know by the amount of poultry houses that have fallen, by the wayside that haven't. People getting old, retiring, not competing. Just simply because of demand. There's more people, chicken. We're close to all the metropolises. As long as the environmentalists don't shut us down. I mean, there's a demand there for it, without a doubt."
- "Boy, I'm torn. I would want to say increase just due to demand, but then I got to look at the flip side of the pancake. It may decrease based on regulation preventing that growth, but I'm going to stick with an increase based on demand."
- "Probably looking at past trends they might increase slightly… We're processing 590,000,000 [note: Maryland plus Delaware]. I think at our peak, we were and even just three or four years ago, we're over 60 [million]. So I'd say that it's very likely we'd try to get back up close to around that 600, but that's not necessarily due to new processing plants. So we're not going to

double that number. I think it's really just bringing us back in line with full capacity at all of our processing plants."

Steady or Decreasing Production Trend Responses:

- "I think that they [number of birds] will remain pretty constant. Not that the production of poultry won't increase just globally and in the United States, but I think there are requirements in Maryland specifically and on the Eastern Shore that make it a little bit harder to grow poultry. So as far as companies expanding in this area, I'm not sure if they will make that decision. They may choose to expand in other areas."
- "I think it [number of birds] will decrease. I believe the cost of doing business in Maryland is a little higher than in some other areas due to Chesapeake Bay and that type of environmental regulations. And poultry is such a penny business that I see the expansions going elsewhere."
- "I think we're going to have less, actually, it's my opinion, because I don't think they'll be able to afford to do new housing, which they want to do because of the cost of materials, labor, everything out there, and finding skilled people to be able to do the work and regulations. And regulations."
- "Well, they're [number of birds] going to decrease, I think. The 'why' question is really, it's dependent upon the harvest plants. There will be no my guess is there will be no new harvest plants built on the shore. And some of them are pretty old. So all this is going to take is one of them to shut down and you'll have less chickens on the shore. Now to maintain our current level. Or you could have a plant increase harvest line which is pretty expensive. So to me that's the only way you're going to see any increases if they either speed the line speed or speeds up or they add a harvest."

Broiler Weight Trends:

- "Yeah. I'm thinking weight will increase and maybe the birds [number of head] are going to stay consistent."
- "Weight [will increase]. Weight is a big thing because of further processing and doing cut ups and breasts and everything else. I think the weight of birds has been increased. Definitely. I know what I grew on a bird in 2010, 2008, and if you got a male bird that was an average of 9 pounds, you were doing great. Now we strive for 10 pounds or better a lot of times."
- "I think weight will stay the same and I believe most of the shore is either large bird or for retail markets. And I don't think larger is better."
- "The abbreviated version is I think we are just going to perfect nutrition and the science. And so I don't expect to see any big gains in weight."
- "There's all these influences from the NGOs. On bird health. And animal welfare. That's really focused on these jumbo birds. So my sense of it is I think we've got to be getting close to maximum weight on these birds, but we have small birds on the shore. So if a plant went from small to medium or medium to jumbo, that would increase the total weight. But I struggle to see birds getting too much bigger than this 10 pounds."

<u>Egg Layers Trends</u>

In contrast to several other animal species, layer inventories in Maryland do not show a strong and persistent trend, so there is greater uncertainty in our projections of inventories in 2032. USDA/NASS reports annual inventories of laying hens in Maryland from 1997 in the publication

Chickens and Eggs (USDA 2023a). Inventories remained at 3.3 to 3.4 million hens from 1997-2002 before beginning a steady decline over 2002-2011, when the inventory reached 2 million layers. Inventories recovered after 2011, reaching 2.9 million in 2017, before falling back to 2 million again in 2022. These trends are illustrated in Figure 2a.6. We do not project any marked increase in Maryland layer inventories in the next decade. US production is projected to grow by 11% over 2022-2032, but Maryland is a small share of US production. Current inventories remain well below the levels of 25 years ago. However, we see no reason to project a decline and cautiously project an inventory of 2.7 million laying hens in 2032.

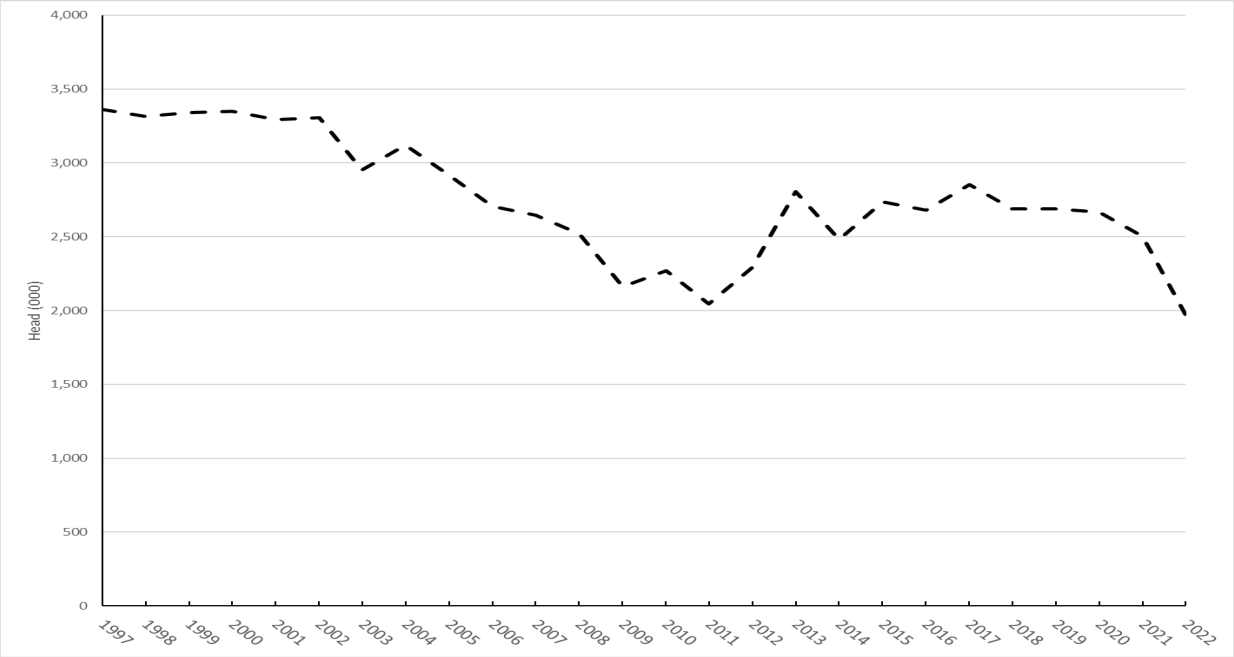


Figure 2a.6: Layer Inventory, Maryland, 1997-2022.

Stakeholder interviews – Dairy and Beef Cattle

Stakeholders are quite familiar with the long-term trends in Maryland and across the United States, and with the economic forces driving those trends. Some expect those trends to continue, as we do in our projections. Only one respondent forecast the expansion of smaller-scale production.

- "So, we've seen an overall, obviously, decrease in dairy. Like pretty precipitous decrease in dairy operations. Especially on the Eastern shore. I think we only have seven left. Honestly."
- "Nationally, there has been rapid and consistent consolidation in dairy, similar cow numbers, just fewer farms. In MD, we've seen a loss of operations AND cow numbers. Most land is too valuable to run cattle and the ROI isn't there. There are more profitable things that can be done."
- "And then the dairy industry is continuing to decline. It'll probably get to a critical minimum here within the next probably decade. And we'll probably have what we have. I don't see it growing by any means at all. But I don't see us losing it completely either."

- "Over the last few decades, we've seen a lot of decrease in cow numbers and farm numbers, but I think that's going to slow a little bit. Seems like there are opportunities for growth in the size of dairies (number of cows) but not number of dairies."
- "…but as far as beef cattle, I would say that that'll be pretty stagnant to reduced numbers. We just don't have the commercial entities anymore. And quite frankly, it's going to be small, niche type operations. Probably revolve around 4H or FFA type programs in the purebred animals--purebred stock--but not a lot of commercial beef cattle people. I don't see that growing."
- "There are a lot of "hobby" farms with beef cattle, but very few at-scale operations. Don't foresee any increases in beef cattle in the future…People with funds bring cattle in, realize the limited profit potential, and then end the enterprise. Direct marketing beef is an option, but is it really profitable with higher input costs?"

'Other Cattle' Trends

Farmers and ranchers generally aim to produce a calf from each cow each year. Those efforts are not always successful, but trends in the annual calf crop should mirror trends in cow inventories. Some female calves may be retained as replacement heifers for cow herds, while others, along with male calves, are raised for beef. Replacement heifers may move in or out of the state before entering a herd, while animals intended for beef may be sold to out of state feedlots and leave Maryland cattle inventories at varying times in their lives. As a result, trends in inventories of replacement heifers, feeder cattle, and bulls may not closely match trends in cow inventories due to changes in the timing of movements in or out of state as well as variations in assignment of animals to classes (for example, decisions to denote an animal as a replacement heifer may be reversed).

We originally aimed to project separate series for dairy replacement heifers, beef replacement heifers, bulls, calves, and all other cattle. However, they showed some unexpected movements in annual state-wide NASS data. Beef replacement heifers showed a steady decline, even as the beef cow inventory stabilized, while dairy replacement heifers showed stability even as dairy cow inventories declined. We concluded that assignments to cattle classes may not be consistent, and so tracked the combined inventory of all non-cow classes, designated in this report as "other cattle." This is consistent with how we reported inventory and manure estimates in Topics 1a and 1b. We tracked Maryland inventories of "other cattle" over 1980-22. They show a steady decline throughout the period, at a rate of about 2% per year, as illustrated in Figure 2a.7. If the 1980-2022 trend were to continue to 2032, and the projected decline in dairy cows should support that continued trend decline, then we would expect the inventory of all other cattle (except cows) to decline further, to a projected 68,132 animals in 2032 from an estimated 83,217 in 2022 (Table 2a.3).[1]

[1] The actual 2022 inventory of all other cattle was 82,000; the fitted trend line for 1980-2022 generated a projection of 83,217 for 2022, with that trendline used for the 2032 projection.

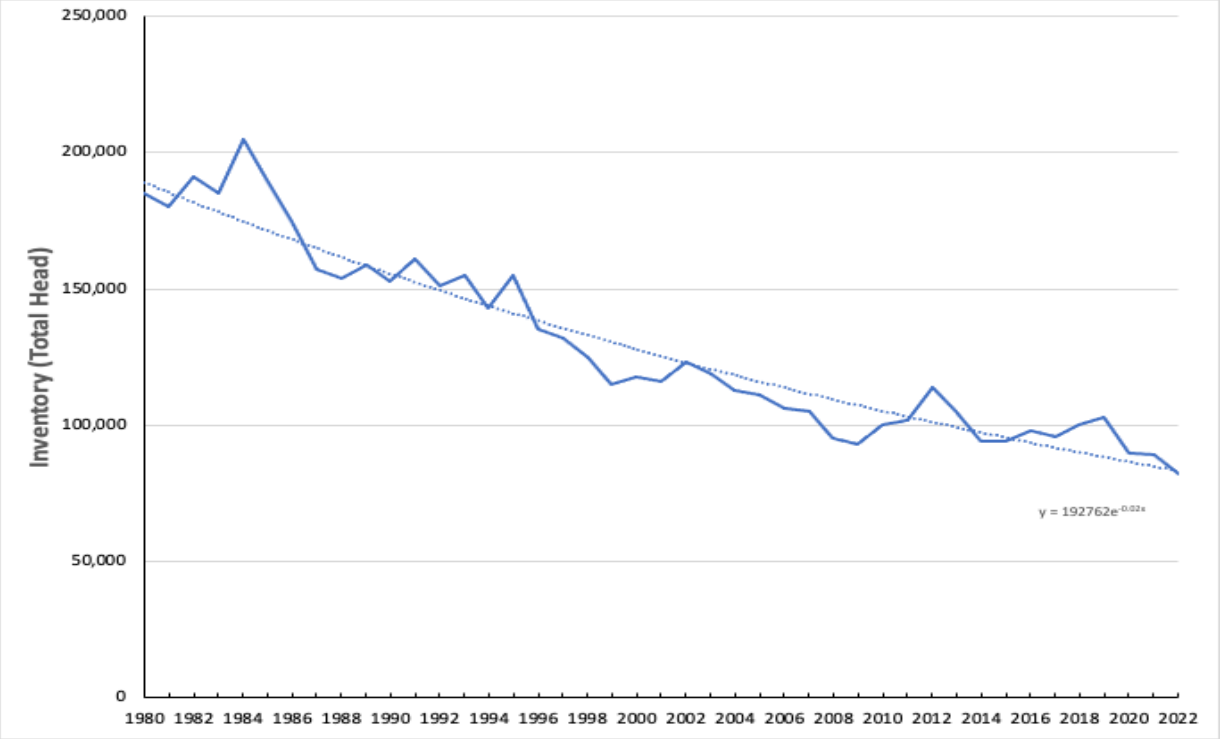


Figure 2a.7: Other Cattle Inventory, Maryland, 1980-2022.

Hog Production Trends

USDA projects a 14% increase in pork production over 2022-2032. Unlike broilers, average weights have not been increasing, so increases in production will likely be reflected in increases in hogs produced. However, Maryland is far from a major hog state, with inventories far below their levels in the early 1990s. Maryland production fell by over 75% during the 1990s, and after 2000 fell by more, albeit at a much slower rate, with stability after 2012 (Figure 2a.8). Hog inventories, measured as of December 1, averaged 20,550 hogs (market and breeding animals) over 2012-2021, with no discernable trend, after declining from 180,000 in 1989.

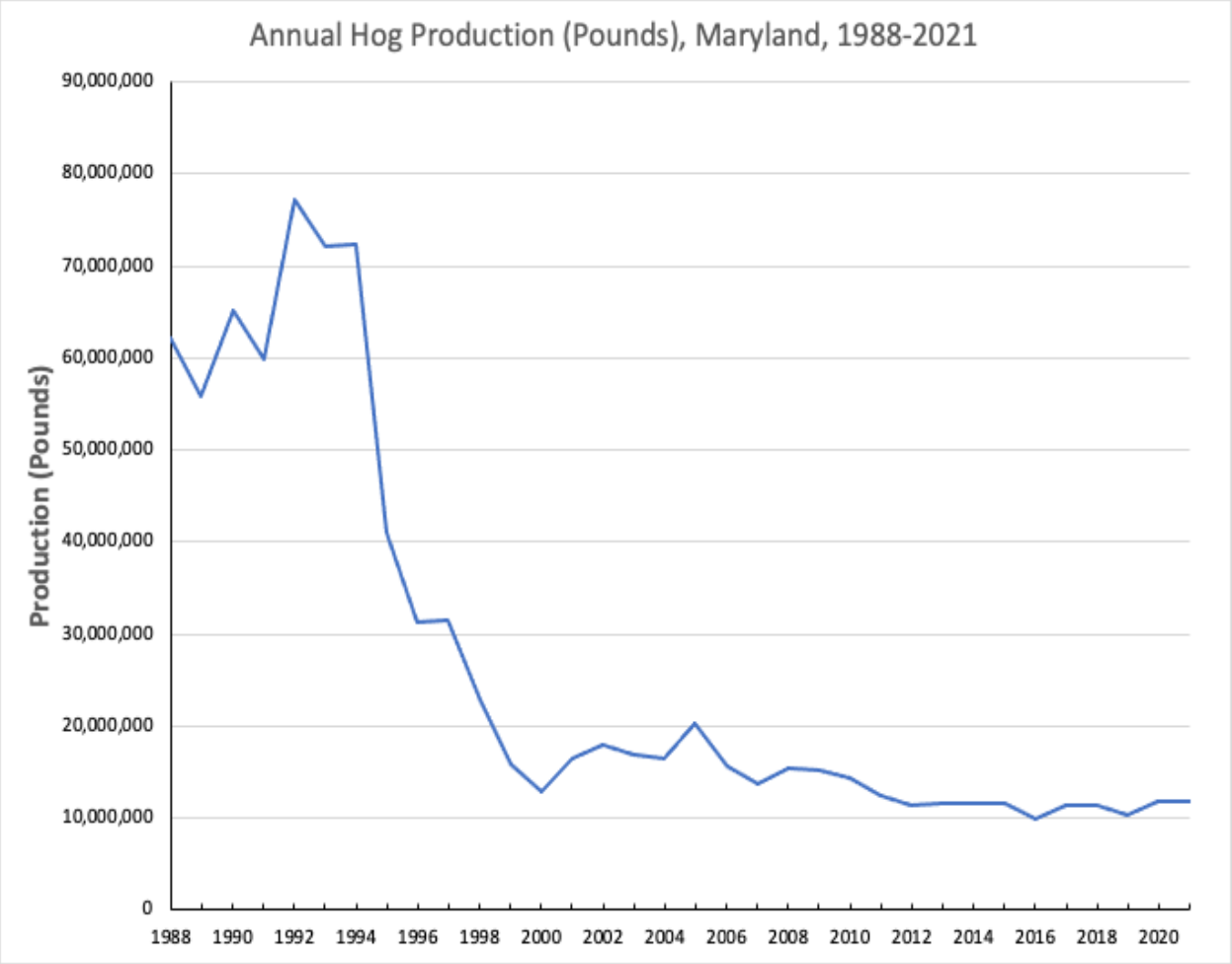


Figure 2a.8: Annual Hog Production (pounds), Maryland, 1988-2021.

Maryland hog farms have birthed about 40,000 pigs per year in recent years; some of those are moved out of state for finishing, while other feeder pigs are moved into the state for finishing. We do have reliable annual data on the total liveweight production of hogs within the state and can infer the equivalent number of market hogs raised by dividing liveweight production by 275 lbs, which is the average weight of hogs slaughtered in the US over the last decade. With this calculation, it is estimated that 42,600 market hogs were produced in Maryland in 2021. When we generated estimates of annual manure production, we combined that number with the number of breeding hogs in the state.[2] Maryland accounts for no more than 0.03% of US hog production and inventories, and Maryland's production does not move in conjunction with industry-wide developments. Having shown stable inventories and production over the last decade, Maryland is likely to maintain its current inventories of about 20,000 hogs at any point in time and annual production of 40-45,000 market hogs per year.

[2] Hog marketing can include feeder pigs (which weigh far less than 230 pounds), sows (over 300 pounds), and market hogs (260-290 pounds), and the average reflects a mix of those types.

Stakeholder interviews – Hog Production

- "We have seen a pretty precipitous decline in the number of commercial hog operations. And when I say commercial, I mean those that are selling into the integrated or processing market. And so we only have about five operations that qualify as Animal Feeding Operations in Maryland now for pork. We are seeing an increase in what we would refer to as the show pig industry, so breeding, for purebred, for hog shows."

Turkey Production Trends

Maryland is not a major turkey production state, and NASS does not report annual estimates of inventories or production for the state. Maryland underwent a large expansion of turkey production after 1992 but went into sharp decline after 2007. In that year, the Ag census reported an inventory of 222,233 birds and annual production of 739,398 birds (note that like broilers, production exceeds inventories because it takes less than a year to raise a bird to maturity). However, by 2017, the state's inventory of turkeys had fallen by 75% to about 55,000 birds, while annual production fell by 86%. We see no evidence that production in Maryland has recovered, and as a result we project only minimal inventories and production for 2032.

Sheep, lambs, and goats

Maryland is a minor producer of sheep, lambs, and goats. The state accounted for 0.4% of the US inventory of sheep and lambs in the 2017 Census of Agriculture, and 0.5% of the nationwide goat inventory. The Maryland share has grown over successive census years since 1997, when it held 0.3% of US sheep and lambs and 0.2% of goats. USDA does not make baseline 2032 projections for goats or for sheep and lambs, so we have little long-term guidance. However, annual US sheep and lamb slaughtered under federal inspection declined by 60% over 1990-2022, while US wool production declined by 75% over the same period, according to annual USDA/NASS reports. It is hard to see a recovery of US production under those conditions or a substantial expansion of Maryland production. We therefore expect Maryland inventories of 23,000 head in 2022 (slightly below 2017) and a further decline to 22,000 head in 2032. US goat slaughter fell by 16% over 2006-2022, according to USDA/NASS summaries of federal inspection data. Maryland goat inventories have shown growth over time, so we anticipate an inventory of 15,000 in 2022 (compared to 14,000 in 2017) and some further growth to 17,000 in 2032 (Figure 2a.9).

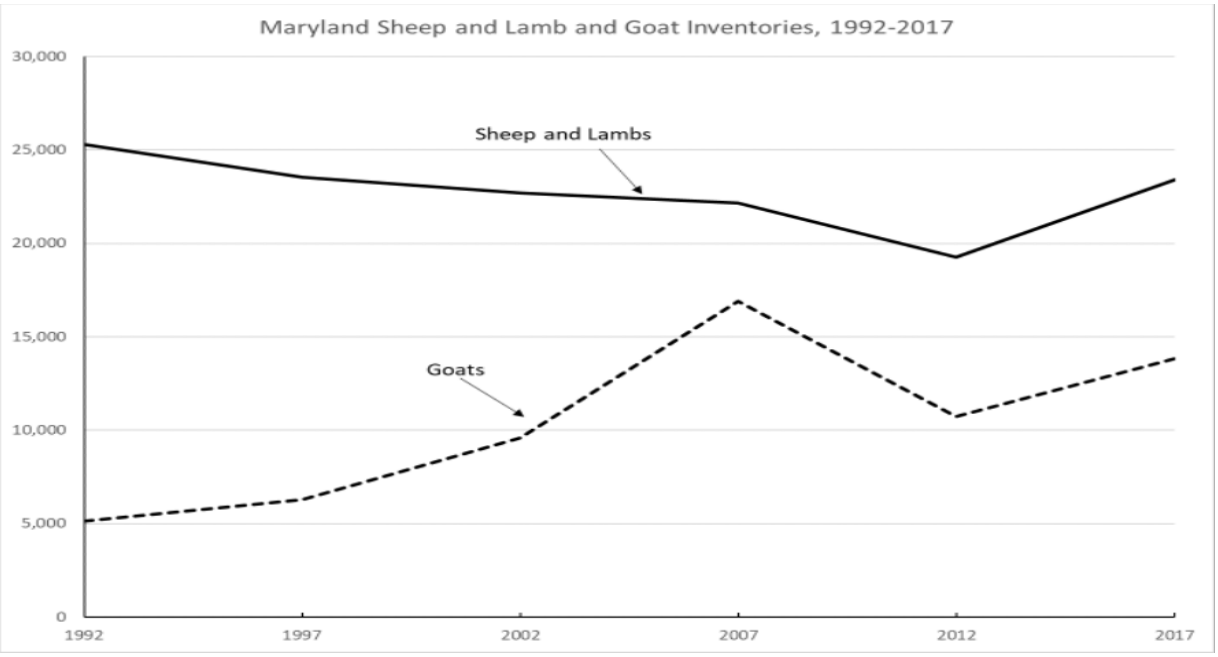


Figure 2a.9: Maryland Sheep, Lamb, and Goat Inventories (Total Head), 1992-2017.

Species-Specific Manure Estimates

We present more detailed estimates and projections, by species, below. In the notes to each species table, we detail our aggregation steps (by which we go from per-animal coefficients to state-wide aggregates) and discuss industry developments that may affect our estimates.

Table 2a.4: Species-specific manure estimates: Broilers

Item	Units	2022	2032
Production	Number of head	300,000,000	275,000,000
Annual manure (per head)	Pounds	11	11
Total head produced	Millions	269.2	275
Total liveweight production	Billion pounds	1.75	2.12
Total annual manure			
Total solids	Million pounds	549	611
Total nitrogen	Million pounds	20.86	22.95
Total phosphorus	Million pounds	8.47	9.32

Table 2a.4 Notes: Our estimates are derived from data collected as part of Maryland's nutrient management program (NMP). In 2019-22, the mean nutrient concentration was 0.0271 lbs of N, and 0.0110 pounds of P, per lbs of litter.

We estimate nutrient production per bird by combining estimates of nutrient concentration with estimates of litter generation per bird. NMP data also underlie estimates of litter generation, as expressed in the following equation:

$$\text{Litter} = 0.04178 + 0.03458 \text{ (bird weight)}.$$

Litter is measured in pounds, and bird weight is market weight at slaughter. We use an average weight of 7 lbs in 2022 and 7.7 lbs in 2032. This relationship is important, as bird sizes have been rising steadily across the US and in MD. Our source data and methods comport with the approach used in estimates produced by the Chesapeake Bay Program (CBP) for 1998-2013. Our projections assume that nutrient concentrations remain unchanged from 2022. Increases in projected N and P arise from projected increases in broiler production, driven largely by increasing bird weights. Work by the CBP found that P concentrations in manure fell during the early 2000s as diets were changed and integrators added phytase (which facilitates absorption of P in feed); however, P concentrations later stabilized, and there has not been a trend in P concentrations since that time.

Table 2a.5: Species-specific manure estimates: Turkeys

Item	Units	2022	2032
Production	Number of head	100,000	100,000
Total annual manure	Million pounds		
Total manure	Million pounds	1.5	1.5
Total nitrogen	Million pounds	0.08	0.08
Total phosphorus	Million pounds	0.03	0.03

Table 2a.5 Notes: The ASABE manual provides estimates for the life of the animal, but separately for males and females, with male manure volumes about double those for females. Males spend more days on feed than females, and are raised to a larger size. We assumed a 50-50 split for males and females in Maryland, and created a weighted average total for all turkeys. We project no change in turkey production in 2032, and we assume no change in manure generation and nutrient concentrations. Thus, we project no change in aggregate nutrient production in 2032.

Table 2a.6: Species-specific manure estimates: Laying Hens

Item	Units	2022	2032
Annual inventory	Number of head	2,500,000	2,700,000
Total annual manure			
Total manure	Million pounds	97.5	105.3
Total nitrogen	Million pounds	2.8	3.1
Total phosphorus	Million pounds	1.1	1.2

Table 2a.6 Notes: We assume spent hens are replaced to maintain inventory throughout the year. We used NMP estimates of daily manure generation of 39 lbs per animal in inventory per year, assuming an average weight of 4.7 lbs (0.0047 animal units). We applied NMP estimates of nutrient concentrations (2.92% N and 1.08% P) to generate estimates of N and P production. Expected changes in 2032 were driven entirely by projected population growth, with the same coefficients for manure generation and N and P concentration utilized.

Table 2a.7: Species-specific manure estimates: Milk Cows

Item	Units	2022	2032
Inventory	Number of head	41,000	29,900
Total annual manure			
Total manure	Million pounds	1,975	1,405
Total nitrogen	Million pounds	8.1	6.2
Total phosphorus	Million pounds	2.0	1.4

Table 2a.7 Notes: We use Maryland Nutrient Management Program (NMP) data supplemented by guidance from the NRCS Agricultural Waste Management Field Handbook. We assume that a lactating cow is milked 300 days per year and, per the NRCS Handbook, generates 137 lbs of manure per day (at 20,000 lbs of milk produced per year, near the Maryland average of 20,537 lbs for 2022). We assume that cows are dry for 65 days per year, and in that period generate 112 lbs of manure per day. NMP dairy cow manure samples indicate that, on average, semi-solid dairy cow

manure is 0.41% N and 0.096% P. These coefficients were used to estimate that a cow generates 197.9 lbs of N in a year, and 46.5 lbs of P. With an estimated cow herd of 41,000, we estimate aggregate N of 8.1 million lbs and aggregate P of 2 lbs pounds.

Three key factors drive our N and P projections for 2032. First, we project that the number of milk cows will fall to 29,900. Second, and slightly offsetting the impact of a shrinking inventory, we project that milk production per cow will increase by 10%. Per-cow milk yields have been increasing steadily in the U.S. and Maryland for many years, and we should expect the trend to continue. NRCS and NMP estimates indicate that greater milk production is associated with greater manure and nutrient production. Finally, we assume that nutrient concentrations (N and P per pound of manure) will remain unchanged.

Table 2a.8: Species-specific manure estimates: Beef Cows

Item	Units	2022	2032
Inventory	Number of head	42,000	40,000
Total annual manure			
Total manure	Million pounds	966	920
Total nitrogen	Million pounds	3.8	3.7
Total phosphorus	Million pounds	0.9	0.9

Table 2a.8 Notes: We rely on Maryland NMP estimates drawn from manure samples taken over 2019-21, which show a mean N concentration of 0.38% for semi-solid (83% moisture) manure and a P concentration of 0.0917%. We further apply NRCS estimates of manure generation, of 63 lbs per day for a beef cow (assuming a cow weight of 1,000 pounds (1 AU), smaller than national averages but in line with Maryland beef cow sales data reported by USDA's Agricultural Marketing Service). We retain the same coefficients for manure generation and nutrient concentrations for 2032, and changes in aggregates are driven by the modest projected decline in inventory.

Table 2a.9: Species-specific manure estimates: All Other Cattle

Item	Units	2022	2032
Inventory	Number of head	82,000	68,000
Total annual manure			
Total manure	Million pounds	1,676	1,370
Total nitrogen	Million pounds	6.4	5.2
Total phosphorus	Million pounds	1.5	1.3

Table 2a.9 Notes: All other cattle include calves, replacement dairy and beef heifers, stocker and feeder cattle, and bulls. According to NASS estimates (from the publication "Cattle and Calves"), beef and dairy replacement heifers accounted for 42.7% of all other Maryland cattle in 2022, while calves represented 30.5%, bulls represented 4.3%, and all others represented 22.6%. Many Maryland beef cattle are shipped out of state for finishing, with the result that heifers and calves represent high shares of the Maryland cattle inventory. We used Maryland NMP estimates for manure generation per animal (adjusted from animal units to animals using average weights): 82 lbs per day for heifers, 76 lbs for bulls, 20 lbs per day for calves, and 53 lbs per day for all others. We then use Maryland NMP estimates for N and P concentrations in semisolid manure for beef cattle: 0.38% N and 0.0917% P.

For 2032 projections, we expect the population of all other cattle to decline, largely due to the projected decline in dairy (hence, fewer dairy calves and replacement heifers). Relatedly, we anticipate that the composition of all other cattle will change to 35.7% heifers, 5.5% bulls, 28.5%

calves, and 30.3% other (largely yearling cattle). The compositional shift leads to a slight decline in N and P production, but the driving force is the population decline.

Table 2a.10: Species-specific manure estimates: Hogs

Item	Units	2022	2032
Annual production (market)	Number of head	42,600	40,600
Inventory (breeding)	Number of head	3,000	2,800
Total annual manure			
Total manure	Million pounds		
Total nitrogen	Million pounds	0.15	0.14
Total phosphorus	Million pounds	0.02	0.02

Table 2a.10 Notes: Maryland NMP provides estimates of daily manure generation for boars, lactating sows, gestating sows, nursery pigs, and grow-finish pigs. NMP tests also provide nutrient concentrations for liquid hog manure, which we increase by 10% to align with moisture levels in NRCS manure generation estimates. We use data from USDA's National Animal Health Monitoring Surveys (NAHM) to calculate the average number of days that a pig is in nursery and grow-finish stage. We use those estimates to calculate a life-of-the-animal estimate, and then multiply by annual market hog production to generate an estimate of total annual manure and nutrient production by market hogs. We assume that sows are 95% of the breeding herd (boars are 5%), and that sows spend 75% of their time in gestation (based on a 115-day gestation cycle, 21 days until weaning, and 7 days until breeding). We then generate weighted-average manure and nutrient generation estimates based on those shares, and multiply by the breeding inventory to get total annual generation by breeding animals. Projections for 1992 are driven by change in animal populations: manure generation and nutrient concentration estimates are kept constant.

Table 2a.11: Species-specific manure estimates: Horses

Item	Units	2022	2032
Annual inventory	Number of head	68,500	60,650
Total manure	Million pounds	1,405	1,244
Total nitrogen	Million pounds	5.7	5.0
Total phosphorus	Million pounds	0.9	0.8

Table 2a.11 Notes: We relied on NRCS estimates of manure generation for an 1,100 lb animal: sedentary horses were estimated to produce 56 lbs of manure per day, compared to 57 lbs for a horse in an intense regimen, but the nutrient composition differed markedly. Maryland NMP tests found that sedentary horses generated 0.2 lbs of nitrogen and 0.029 lbs of phosphorous in their daily manure, compared to 0.34 and 0.073 lbs, respectively, for horses in an intense regime. We generated annual per horse estimates by multiplying the daily estimates by 365 days. We then assumed that 80% of the horse inventory was in a sedentary regime, and used the resulting numbers to generate annual manure generation estimates for all horses. We assumed that the share of sedentary horses was the same in 2032, so changes in 2032 projected manure generation were driven by changes in inventories.

Table 2a.12: Species-specific manure estimates: sheep and goats

Item	Units	2022	2032
Annual inventory, sheep	Number of head	23,000	22,000
Annual inventory, goats	Number of head	15,000	17,000
Total manure	Million pounds	55.5	57.0
Total nitrogen	Million pounds	0.60	0.62
Total phosphorus	Million pounds	0.20	0.21

Table 2a.12 Notes: Our sources (NMP and NRCS) use the same manure generation and nutrient concentration coefficients for sheep and goats. We estimate that each animal produces 4 lbs of manure per day (1,460 over a year, for constant inventory), and that the manure contains 1.09% N and 0.362% P. We assume no change in coefficients between 2022 and 2032, so that the modest changes in aggregates are driven entirely by changes in inventory.

Topic 2d. Strengths and weaknesses of animal waste technologies to address climate change goals.

SimaPro life cycle assessment (LCA)

SimaPro is a LCA software developed by PRé Consultants that is widely used in industry and academia for LCA studies to determine environmental impacts for categories including greenhouse gas emissions, eutrophication, and human toxicity based on nutrient mass balance, energy balance, and carbon flows of the system for a given product, or functional unit. The LCA scenarios consider all GHG emissions from material input into a system through installation and operation, and include methane, carbon dioxide, and nitrous oxide emissions.

The SimaPro LCA model was used to analyze GHG emissions from anaerobic digestion in Maryland. The functional unit used was one ton of animal waste per treatment per day. System configurations were quantified using a consequential approach, and the LCA methodology was performed according to the international standards of operation (ISO) 14040. Additional ISO methodology used included LCA goal and scope definition (ISO 14041), inventory analysis (ISO 14041), impact assessment (ISO 14042), and interpretation (ISO 14043).

The data for the SimaPro LCA model were derived from analyses of a dairy manure, DAF, and food waste digester in Cecil County. The digester system consists of a sand separation lane, solids-liquid separation unit, covered lagoon digester, H_2S scrubber, a combined heat and power (CHP) generator (240 kWh), food waste storage tanks, and an open digester effluent storage lagoon. The system operated as an unheated covered lagoon system for many years (no CHP), where the biogas powered a 110 kW natural gas engine generator. Both heated (CHP) and unheated scenarios (generator-only) were modeled, with a focus on the total emissions generated by the system on an annual basis (Figure 2d.4).

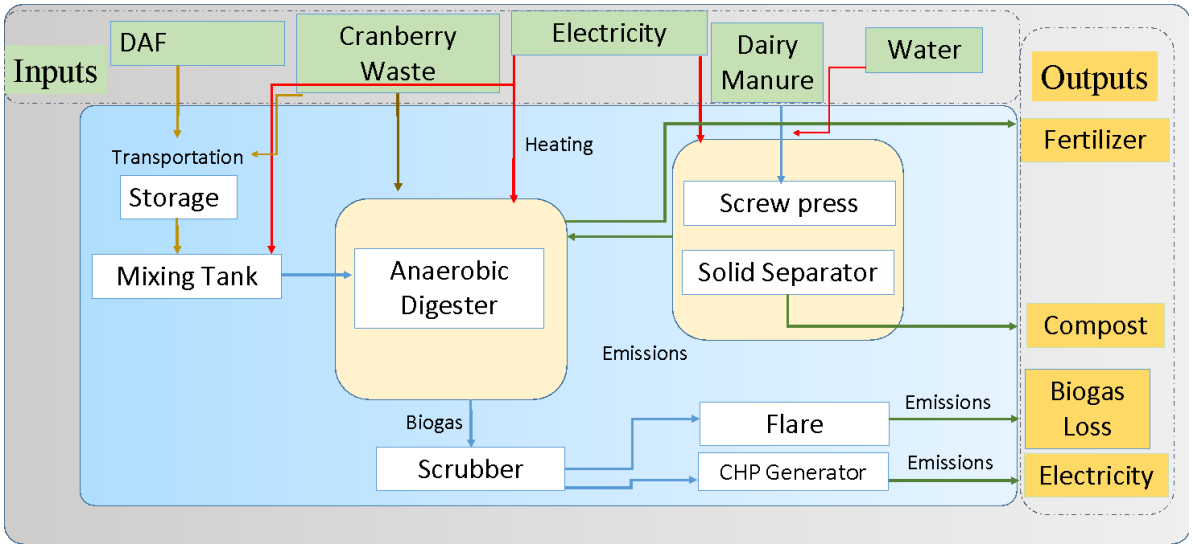


Figure 2d.4: System boundaries for the life cycle assessment (LCA) of a digester in Cecil County, which included manure, poultry processing dissolved air flotation (DAF), and food processing waste feedstock, with biogas used in a combined heat and power (CHP) generator.

The Kilby Farm digester was operated according to the following procedure: 1) the dairy manure stream was washed from the barn onto an angled concrete slab for sand-separation; 2) solids were separated from the liquids; 3) the solids were used on-site for composting; and 4) the liquids were conveyed to a covered lagoon digester, where they were digested with a food waste input stream (poultry DAF, milk waste, and cranberry processing waste). After digestion, the liquid digester effluent was used to flush the barns and/or stored in an open lagoon before field application as a fertilizer. The biogas generated during digestion was processed through the H_2S scrubbing system before being burned in the CHP to produce electricity, with excess biogas flared on-site. Heat from the CHP was used to heat the digester and maintain mesophilic operating temperatures (35 °C).

Twelve months of sampling data were incorporated into the LCA to detail the material inputs and outputs of the system. Additional system data included as inputs into the model included construction of the digester, a compost facility, and the food waste containers as well as food waste transport. System outputs included lagoon manure storage and net electricity generation. The baseline GHG emissions scenario selected for comparison was dairy manure storage in an open-air lagoon without digestion. All system inputs and outputs were translated into multiple impact categories by SimaPro and analyzed to evaluate the environmental impacts, GHG emissions, and human health impacts of a digestion and composting system.

The emissions for each scenario in the LCA were based on various factors, such as waste treatment and storage, mechanical systems used to collect and transport waste (i.e., engines and pumps for flush systems; vacuums for scrape systems), tractor use, anaerobic treatment (i.e., storage ponds), support equipment, combustion (i.e., during flaring of biogas, electric generation), project construction, and emission associated with daily operations.

EPA Anaerobic Digester Screening Tool for Greenhouse Gas (GHG) Emissions

The EPA AgSTAR program developed the AD Screening Tool to estimate GHG emissions from livestock manure management systems (Global Methane Initiative, 2022). This tool uses basic information about a proposed anaerobic digester (i.e. feedstock type, food waste co-digestion, digestion temperature, and digester type) to estimate emissions and high/low biogas generation values. The user manual for the Anaerobic Digester Screening Tool serves as a comprehensive resource for assessing the practicality of anaerobic digestion systems in managing livestock manure. A limitation identified in this model is that it does not distinguish between biogenic and fossil methane when calculating emissions from electricity production. To compensate, we supplemented the model output with manual calculations for this parameter to determine avoided emissions from generating electricity through biogenic methane.

Additional modeling and analysis methods

Past LCAs and literature analyzed for each technology were based on our previous publications on gasification/upflow bed combustion (Choudhury et al., 2020), anaerobic digestion (Hassanein et al., 2022), and composting (Saer et al., 2013), as well as the most relevant and up-to-date literature on GHG emission from agriculture and emission reductions through manure technology implementation (Climate Nexus, n.d.; Steel and West, 1998; Pronto and Gooch, 2009; Song and Guo, 2011; Artrip et al., 2013; Miranda et al., 2015; Bonanomi et al., 2017; Bartram and Barbour, 2017; Fidel et al., 2018; Simbolon et al., 2018.

Several previous LCA studies found that composting reduced GHG emissions by 20-60% compared to traditional manure management practices (storage), primarily due to a reduction in methane emissions during storage and application (Havukainen et al., 2020; Huang et al., 2022). However, there are some potential environmental impacts associated with composting that should be considered. For example, composting can generate emissions of nitrous oxide, a potent GHG, if the composting process is not properly managed. Composting also requires a significant amount of land to store the finished product. Additionally, composting requires fuel and energy to operate the composting equipment and transport the finished product (Morsink-Georgali et al., 2022).

● Fluidized Bed Combustion

A previous LCA study was conducted for a fluidized bed combustion (FBC) system that operated for 3,226 hours and processed 568 metric tons of poultry litter. Over the six flocks, the main energy produced from the system was heat for the poultry houses (859 MWh), while only a portion was used for electricity production (12.5 MWh). The LCA of the FBC system showed that climate change potential (GHG emissions) of poultry litter combustion was 32% less than using liquid propane gas (LPG) (Figure 2d.5). The GHG emissions from the FBC system included the poultry litter combustion and upstream emissions from the construction and assembly of the plant, poultry litter storage, start-up diesel use, and electricity required for daily operation of the FBC system. It was expected that the FBC system would produce excess electricity, especially during the summer when heating requirements for the poultry houses were lower. However, the electricity produced was not sufficient to offset the parasitic load required for daily operation of the system. As a result, the FBC system consumed electricity from the grid, which resulted in negative impacts on climate change potential.

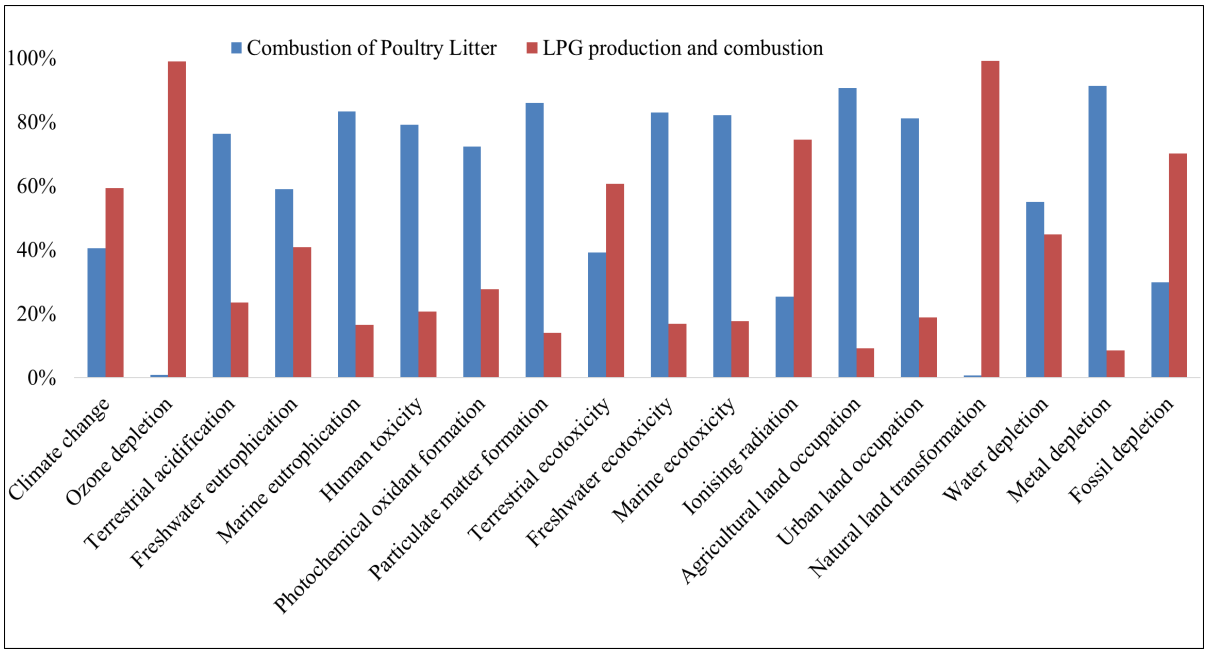


Figure 2d.5. Environmental impacts of poultry litter combustion in the baseline scenario compared to liquified propane gas (LPG) production and combustion.

In the more optimal operating condition scenario, the FBC process had 66% less GHG emissions than the baseline scenario due to an increased biomass feed rate, yearly run-time (6,720 hours), and energy output/biomass feed ratio (Figure 2d.6). In the base scenario (30% runtime), the hourly feed rate was 0.176 tons/hr, while in the more optimal scenario, it was calculated to be 0.246 tons/hr. The net positive renewable electricity led to less GHG emissions (77% lower than LPG use) due to reductions in fossil fuel-based electricity sources. The reduction in freshwater eutrophication was also 75.7% less than LPG use. The reductions in all other environmental impacts due to the improved efficiencies in the more optimal scenario ranged from 48 – 98% when compared to the actual conditions. Overall, the results showed that poultry litter combustion for energy generation could be a sustainable alternative disposal technology, especially in places where land application is restricted, such as areas with high concentration of poultry farms, like the Chesapeake Bay region. A positive electricity output would have led to a more sustainable alternative disposal technology for poultry litter.

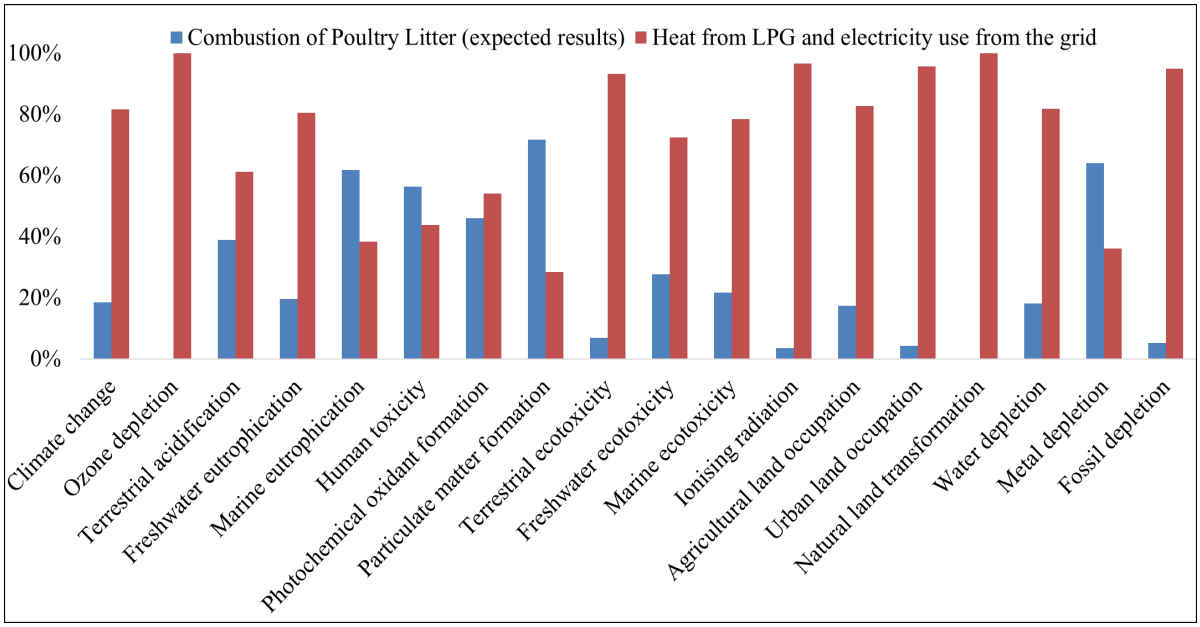


Figure 2d.6 Environmental impacts of poultry litter combustion with renewable energy production in the more optimal scenario compared to liquified propane gas (LPG) production and combustion and replacement of electricity production in Maryland.

Topic 2f: Summarize national efforts to incorporate environmental justice factors in the selection and siting of animal waste facilities and/or animal waste treatment technologies

Methods for mapping communities profile - GIS analysis

GIS or geospatial data were used to analyze spatial distribution of demographics, environmental factors, and land use data from regions with current or planned digesters or pyrolysis units. The GIS datasets and buffer zones within the regions (proximity analysis) were used to develop the communities' profiles in each location.

The buffer analysis incorporated the use of different variables, including location of health and education facilities, highways, land use/land cover (LULC), topography, urban areas, and demographic data. These analyses allowed for the identification of communities at high risk of environmental hazards. Health and education facilities data were obtained from different sources, including FEMA, HIFLD, Urgent Care Association of America, Healthcare Ready, Private School Survey, Common Core Data, Integrated Post Secondary Education System, and IMSL US Public Library Administration Entities. Road data were obtained from the US Census Bureau, and the route type codes used to describe the type of road were obtained from the Topologically Integrated Geographic Encoding and Referencing (TIGER/Line) products.

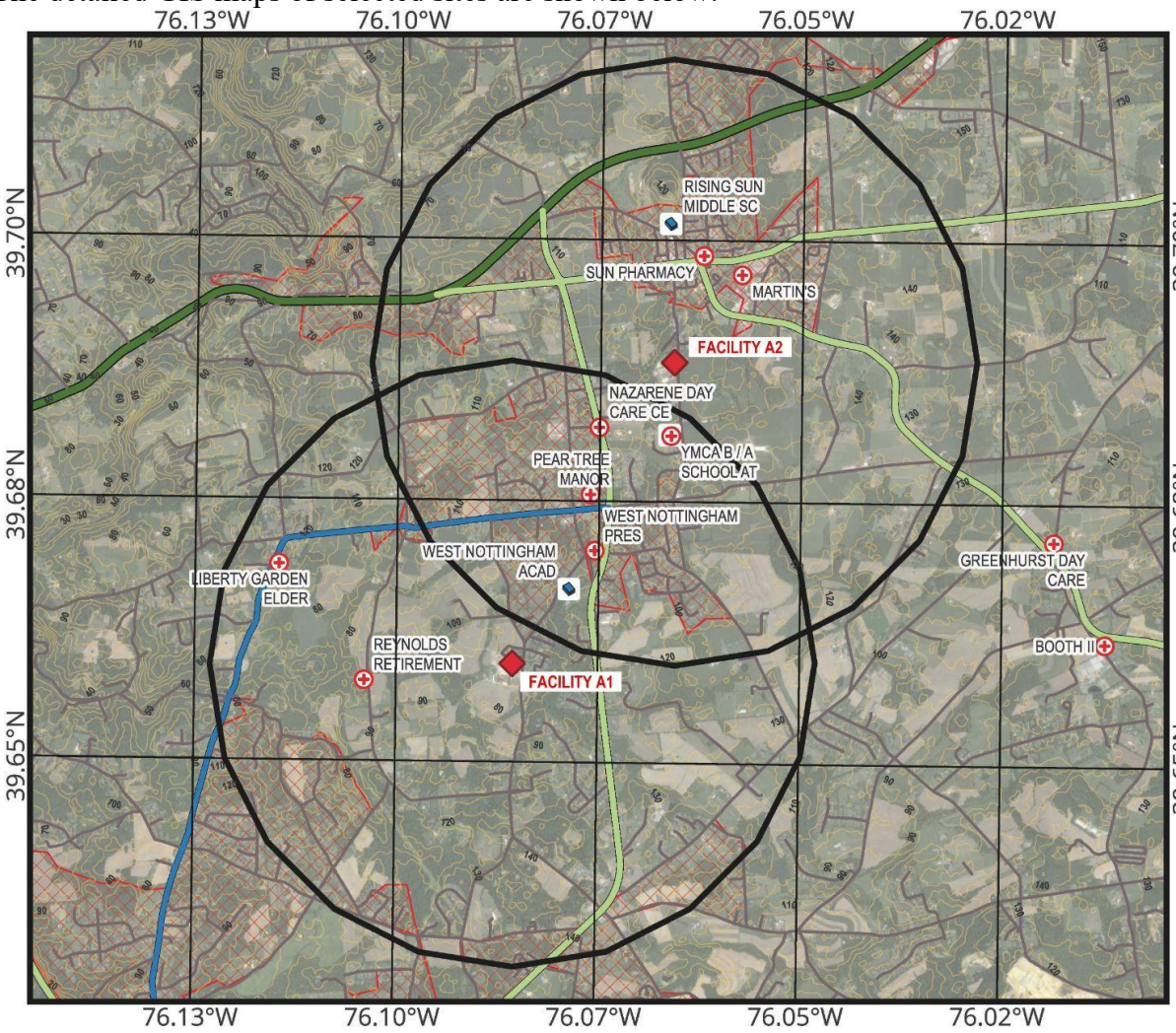
We also incorporated land cover data obtained from the National Land Cover Database (NLCD) 2019, which provides nationwide data on land cover and land cover change at a 30 m resolution with a 16-class legend. Contour lines were generated using Shuttle Radar Topography Mission (SRTM) elevation data, an international research effort that obtained digital elevation models on a near-global scale. The urban areas used were obtained from the Census Bureau, which delineates urban areas that represent the densely developed territory, encompassing residential, commercial, and other nonresidential urban land uses.

The socioeconomic vulnerability index was created at the block group level using six statistically normalized variables between 0 and 1 to provide a fair comparison. The six variables included the percentage of residents who have not completed high school, the percentage of households with limited English ability, the percentage of households under the poverty line, the percentage of individuals unemployed, the percentage of renter households, and the percentage of nonwhite people, including white Hispanic. All variables had the same significance level and were classified into five quartiles for improved visualization, ranging from "Very low" to "Very high." Table 2f.2 summarizes the data used for the spatial analysis.

Table 2f.2: Spatial data overview.

Variable	Indicator	Source	Description
Health Facilities	Number of health facilities	HIFLD	Includes hospitals (small, medium, and large hospitals), nursing and assisted care facilities, child care centers urgent care facilities, pharmacies, veterans, health administration medical facilities.
Education Facilities	Number of education facilities	HIFLD	Includes private schools, public schools, colleges and universities, supplemental colleges, public libraries.
Contour Lines	Elevation (meters)	SRTM	From Shuttle Radar Topography Mission digital elevation data.
Urban Areas	Total area	Census Bureau	Consists of areas of high population density and urban land use.
Roads	Number of roads	Census Bureau	The road network dataset developed and maintained by the U.S. Census Bureau under the TIGER/Line program.
LULC	Number of classes	NLCD	LULC change data at a resolution of 30m, with a legend of 16 classes.
Residents who have not completed high school	Percentage of residents who have not completed high school	Census Bureau	Residents who have not completed high school in the block group.
Households with limited English ability	Percentage of households with limited English ability	Census Bureau	Households with limited English ability in the block group.
Households under poverty line	Percentage of households under poverty line	Census Bureau	Households under poverty line in the block group.
Individuals unemployed	Percentage of individuals unemployed	Census Bureau	Individuals unemployed in the block group.
Renter households	Percentage of renter households	Census Bureau	Renter households in the block group.
Nonwhite people including white Hispanic	Percentage of nonwhite people (including white Hispanic)	Census Bureau	Nonwhite people including white Hispanic in the block group.
Social vulnerability index	Organized according to quartiles, classified as "Very low", "Low", "Moderate", "High" and "Very high".	Elaborated from Census Bureau data	Conducted at the block group level (2017 to 2021) and included six variables: residents who have not completed high school (%); households with limited English ability (%); households under poverty line(%); individuals unemployed (%); renter households (%); nonwhite people including white Hispanic (%).

The detailed GIS maps of selected sites are shown below.



Buffer
Selected site
Health Facilities
Education Facilities
Contour Lines
Urban Areas

Roads
Interstate
U.S.
State recognized
County
Other

HEALTH FACILITIES
SUN PHARMACY
MARTIN'S
BOOTH II
PEAR TREE MANOR
REYNOLDS RETIREMENT
LIBERTY GARDEN ELDER
YMCA B / A SCHOOL AT
GREENHURST DAY CARE
WEST NOTTINGHAM PRES
NAZARENE DAY CARE CE

EDUCATION FACILITIES
WEST NOTTINGHAM ACAD
RISING SUN ELEMENTAR
RISING SUN MIDDLE SC

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The black circles correspond to a 2-mile buffer created around the digester location.
The other elements can be checked individually on the other boards.

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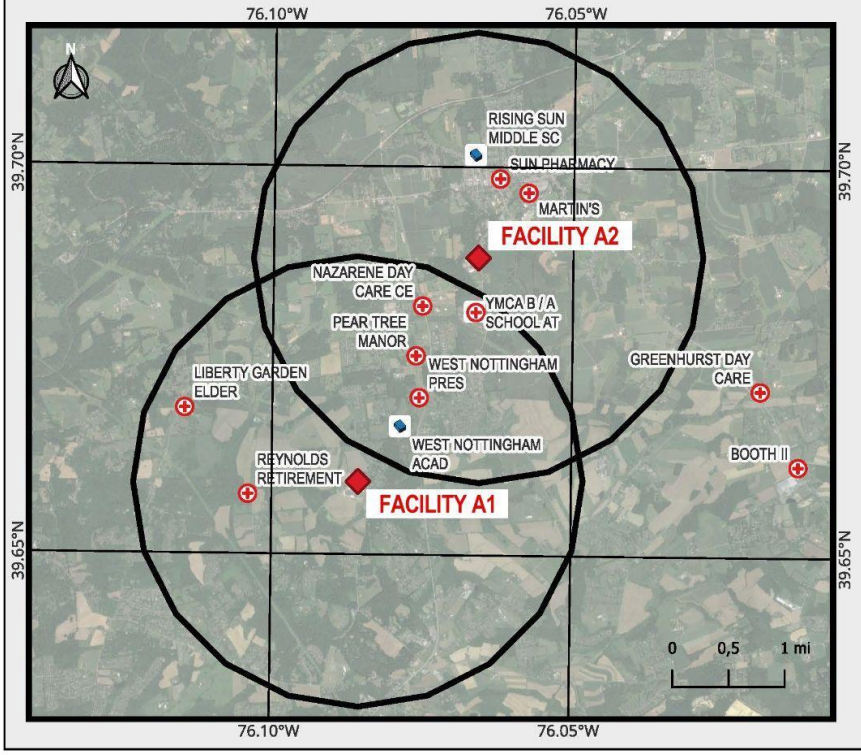
School of Architecture, Planning and Preservation
Stormwater Infrastructure Resilience and Justice (SIRJ) Lab
3835 Campus Drive / College Park, MD 20742

Health and education facilities

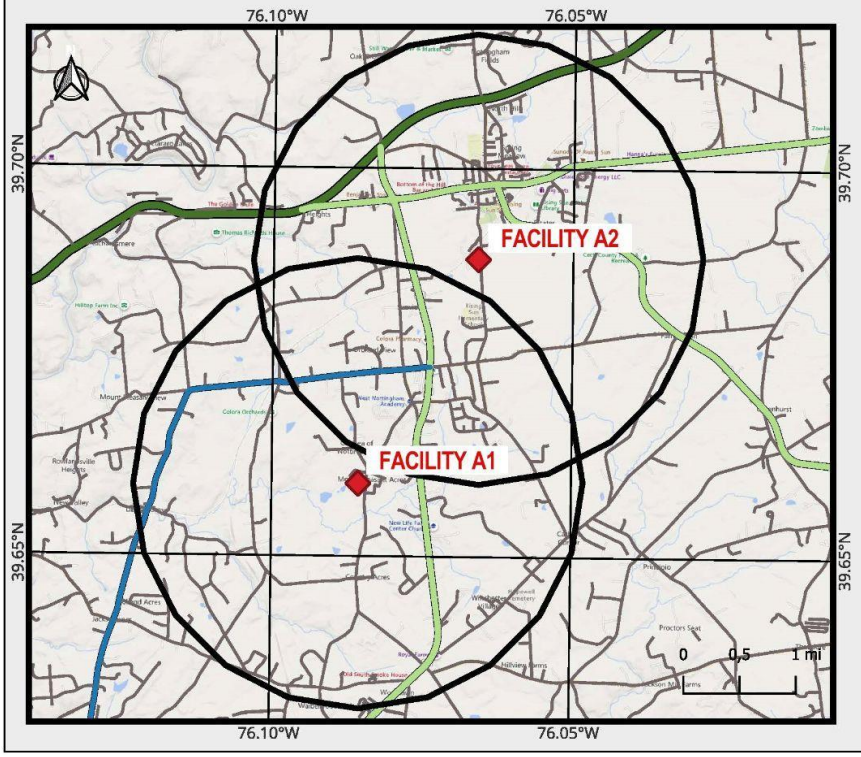


Health facilities include: Hospitals (small, medium and large hospitals) - from FEMA (Source: ORNL, 2023); Nursing and assisted care facilities (Source: HIFLD, 2022); Child Care Centers (Source: HIFLD, 2022); Urgent Care Facilities (Souce: Urgent Care Association of America, 2020); Pharmacies (Source: Healthcare Ready / HIFLD, 2018); Veterans Health Administration Medical Facilities (Source: TechniGraphics, 2022),

Education facilities include: Private Schools (Source: Private School Survey / HIFLD, 2022); Public Schools (Source: Common Core Data / HIFLD, 2022); Colleges and Universities (Source: Integrated Post Secondary Education System / HIFLD, 2022); Supplemental Colleges (Source: HIFLD, 2022); Public Libraries (Source: IMSL U.S. Public Library Administration Entities, 2020)

- Selected site
- Health Facilities
- Education Facilities

Roads



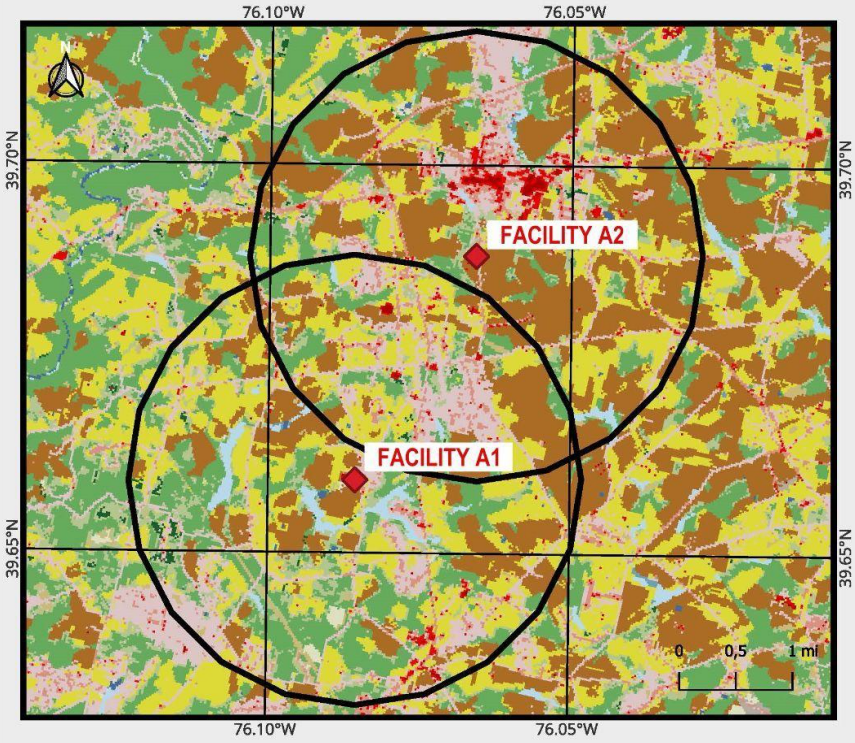
Roads were obtained from the US Census Bureau (2021). The route type code describes the type of road. These codes can be found in the TIGER/Line products. For additional information about each road, see the definitions on the MAF/TIGER Feature Class Codes (MFTCC) page.

- Selected site

Route type description

- Interstate
- U.S.
- State recognized
- County
- Other

Land Use/Land Cover

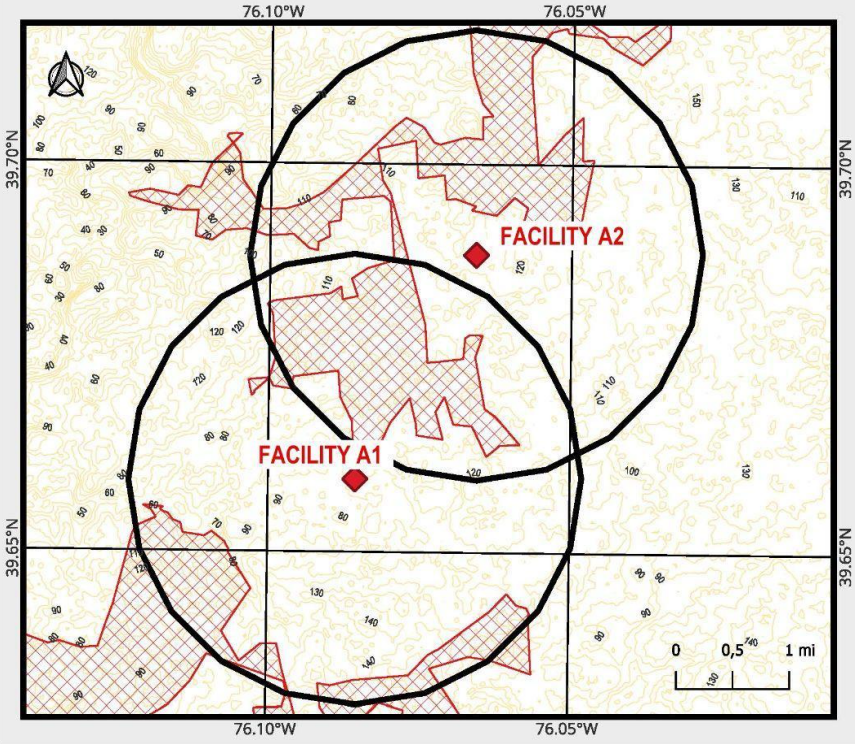


The National Land Cover Database (NLCD) provides nationwide data on land cover and land cover change at a 30m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD 2019 represents the latest evolution of NLCD land cover products focused on providing innovative land cover and land cover change data for the Nation.

Classification

- Open water
- Perennial ice/snow
- Developed, open space
- Developed, low intensity
- Developed, medium intensity
- Developed, high intensity
- Barren land (rock/sand/clay)
- Deciduous forest
- Evergreen forest
- Mixed forest
- Shrub/scrub
- Grassland/herbaceous
- Pasture/hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands
- Selected site

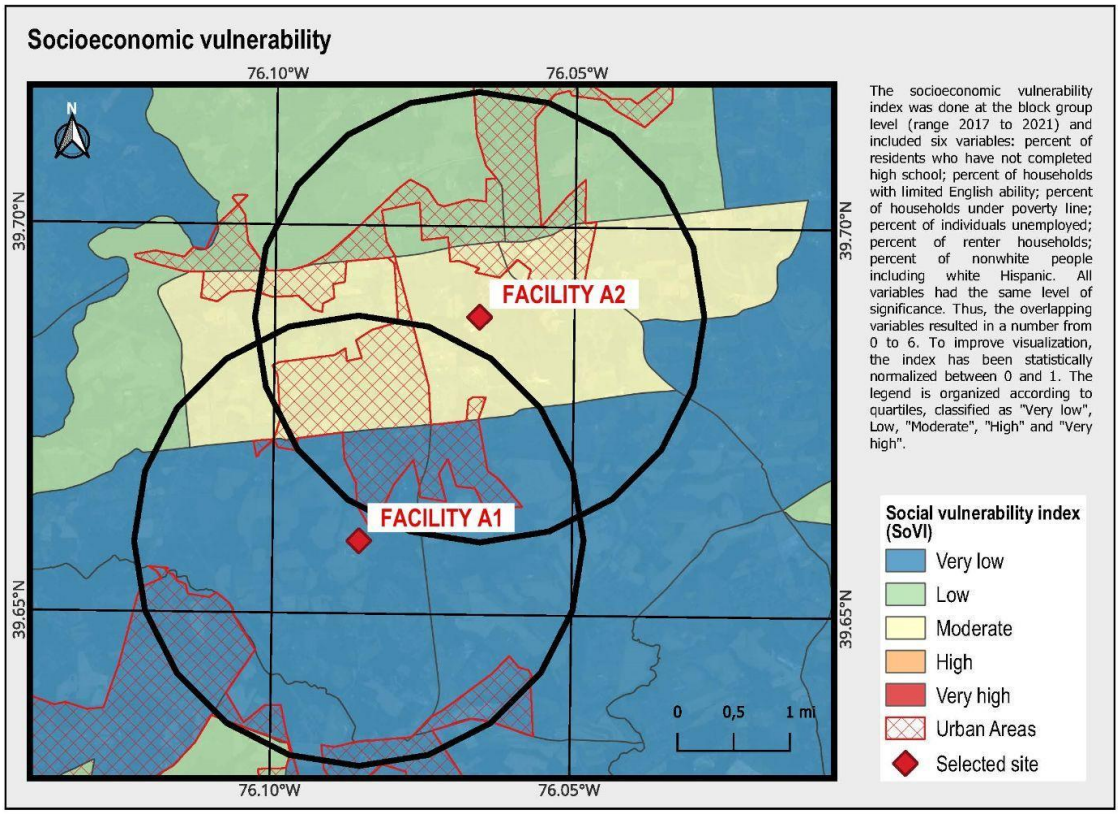
Topography and urban areas

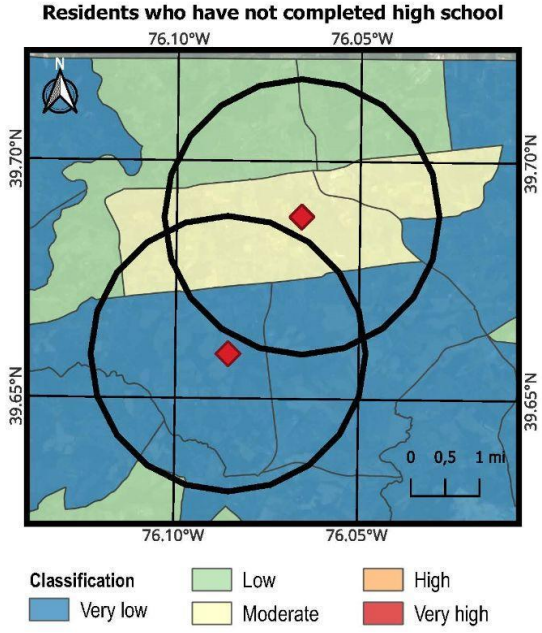


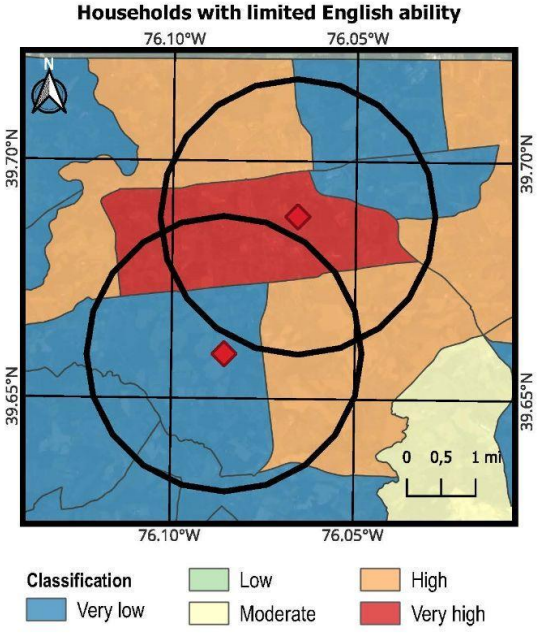
The contour lines were generated by means of SRTM elevation. The Shuttle Radar Topography Mission (SRTM, see Farr et al. 2007) digital elevation data is an international research effort that obtained digital elevation models on a near-global scale. This SRTM V3 product (SRTM Plus) is provided by NASA JPL at a resolution of 1 arc-second (approximately 30m).

The urban areas used were obtained from the Census Bureau (2010). After each decennial census, the Census Bureau delineates urban areas that represent densely developed territory, encompassing residential, commercial, and other nonresidential urban land uses. In general, this territory consists of areas of high population density and urban land use resulting in a representation of the "urban footprint."

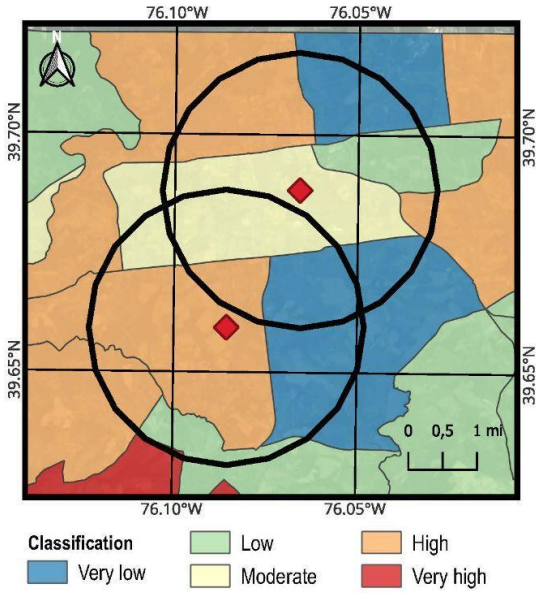
- Selected site
- Contour lines
- Urban areas


Socioeconomic vulnerability
76.10°W
76.05°W
39.70°N
39.65°N
FACILITY A2
FACILITY A1
0 0,5 1 mi
The socioeconomic vulnerability index was done at the block group level (range 2017 to 2021) and included six variables: percent of residents who have not completed high school; percent of households with limited English ability; percent of households under poverty line; percent of individuals unemployed; percent of renter households; percent of nonwhite people including white Hispanic. All variables had the same level of significance. Thus, the overlapping variables resulted in a number from 0 to 6. To improve visualization, the index has been statistically normalized between 0 and 1. The legend is organized according to quartiles, classified as "Very low", Low, "Moderate", "High" and "Very high".
Social vulnerability index (SoVI)
Very low
Low
Moderate
High
Very high
Urban Areas
Selected site

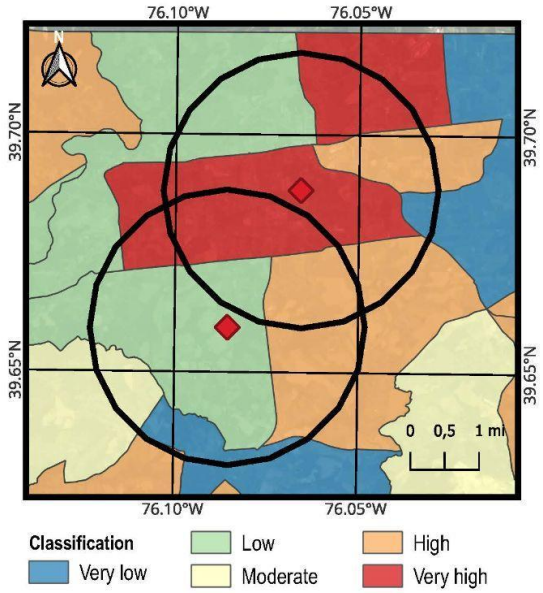

Residents who have not completed high school
76.10°W
76.05°W
39.70°N
39.65°N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high


Households with limited English ability
76.10°W
76.05°W
39.70°N
39.65°N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high

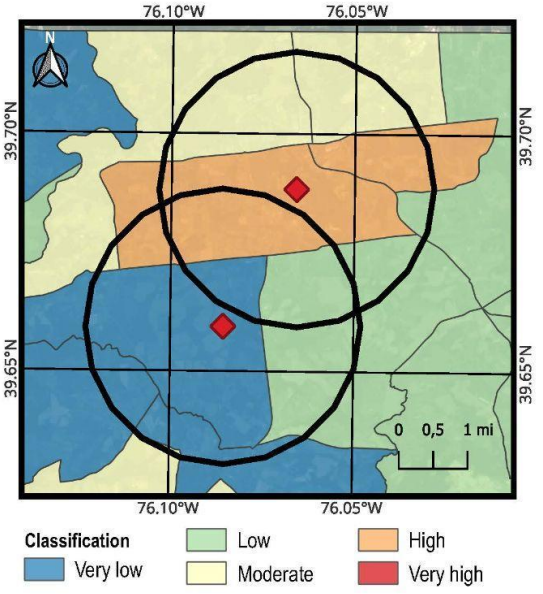
Households under poverty line



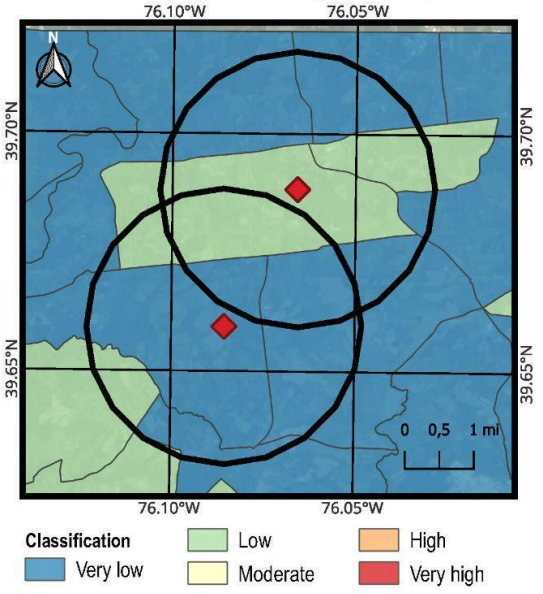
Individuals unemployed

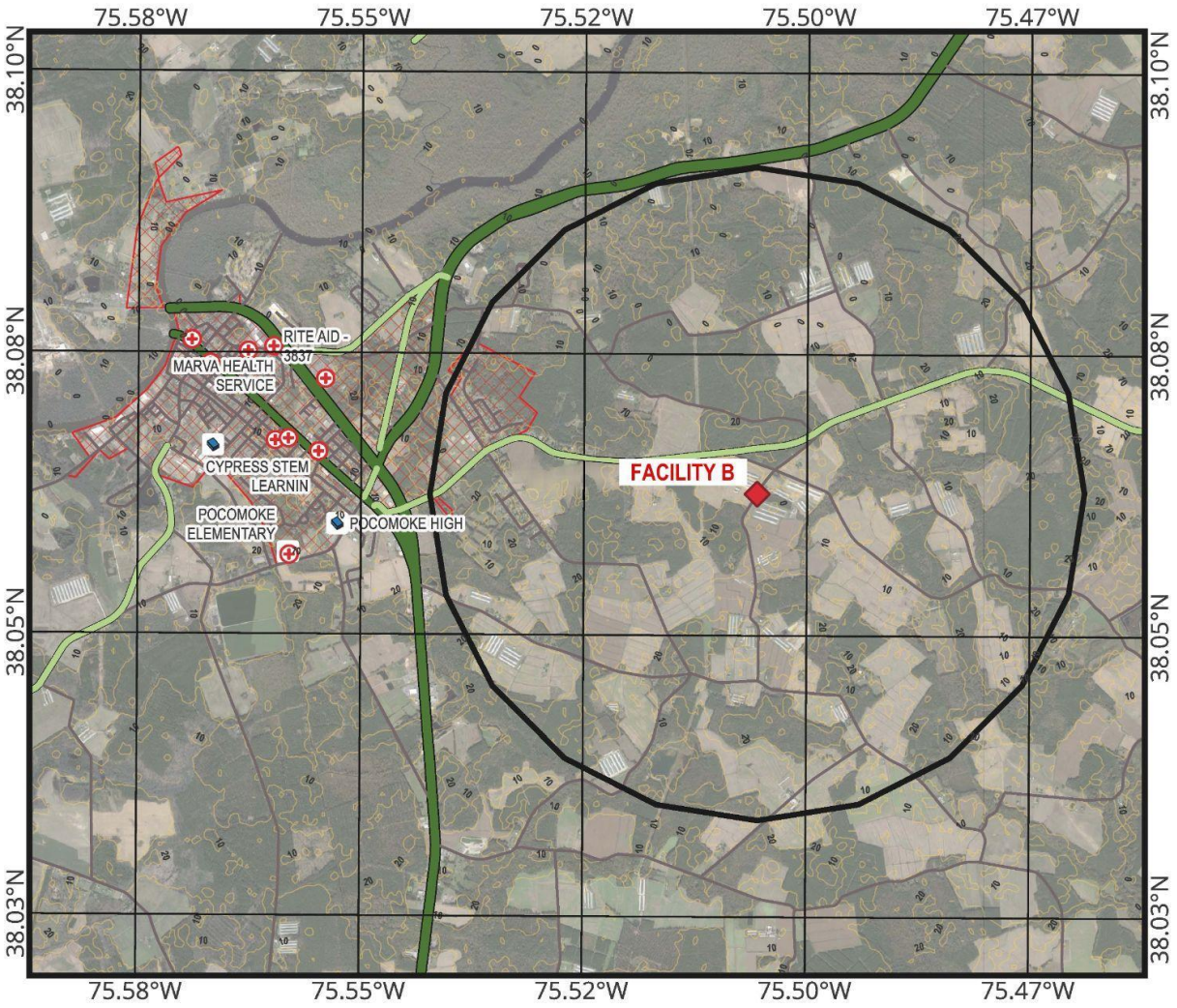


Renter households



Nonwhite people including white Hispanic





Buffer
Selected site
Health Facilities
Education Facilities
Contour Lines
Urban Areas

Roads
Interstate
U.S.
State recognized
County
Other

HEALTH FACILITIES
POCOMOKE CITY COMMUN
WAL-MART SUPERCENTER
POCOMOKE DISCOUNT HE
RITE AID - 3837
MARVA HEALTH SERVICE
PEAK HEALTHCARE AT H
BAYCARE ASSSISTED LI
CYPRESS STEM LEARNIN
POCOMOKE ELEMENTARY

EDUCATION FACILITIES
POCOMOKE HIGH
POCOMOKE ELEMENTARY
POCOMOKE MIDDLE

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The black circles correspond to a 2-mile buffer created around the digester location. The other elements can be checked individually on the other boards.

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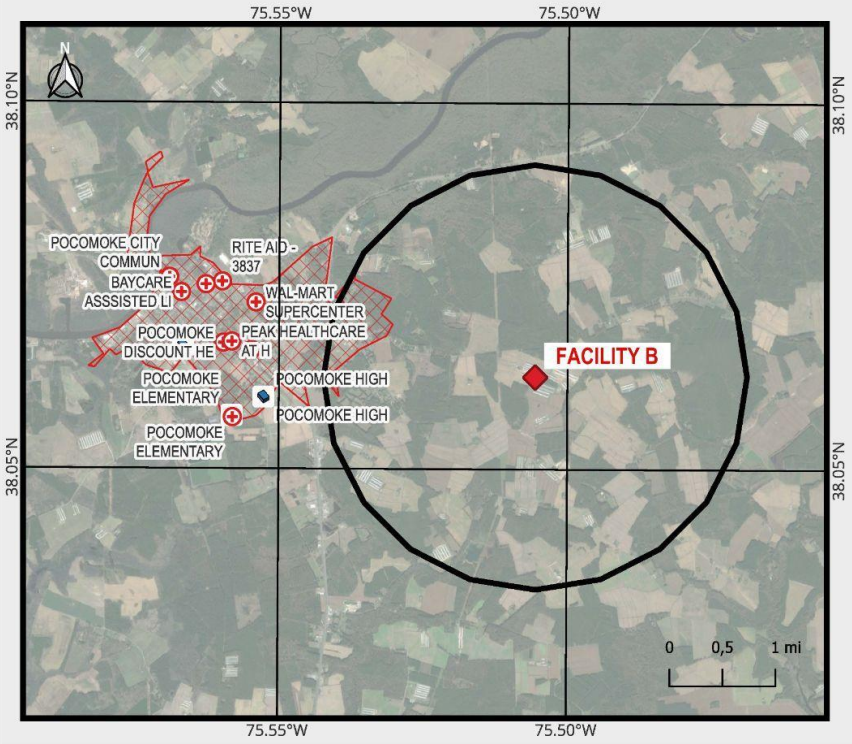
Health and education facilities



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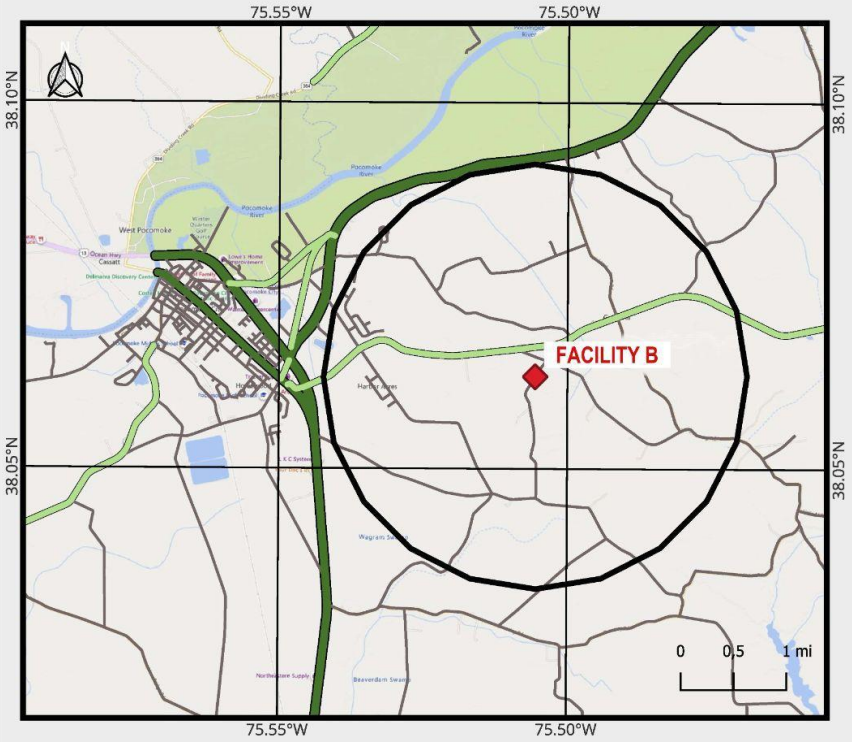
- Selected site
- Health Facilities
- Education Facilities

Roads



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- Selected site

Route type description

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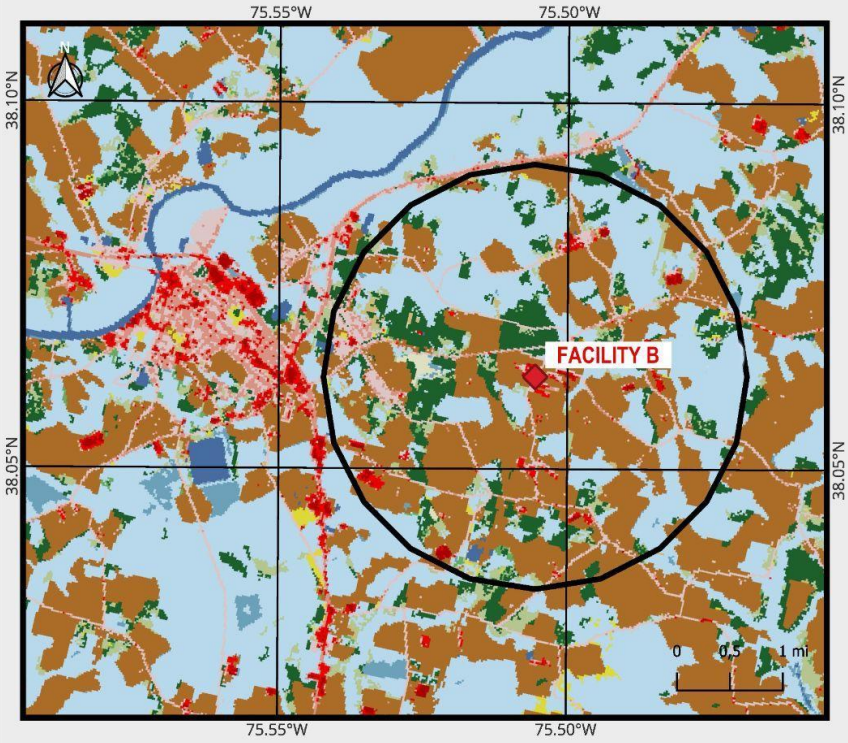
- U.S.
- State recognized
- County
- Other

Land Use/Land Cover



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- Evergreen forest
- Mixed forest
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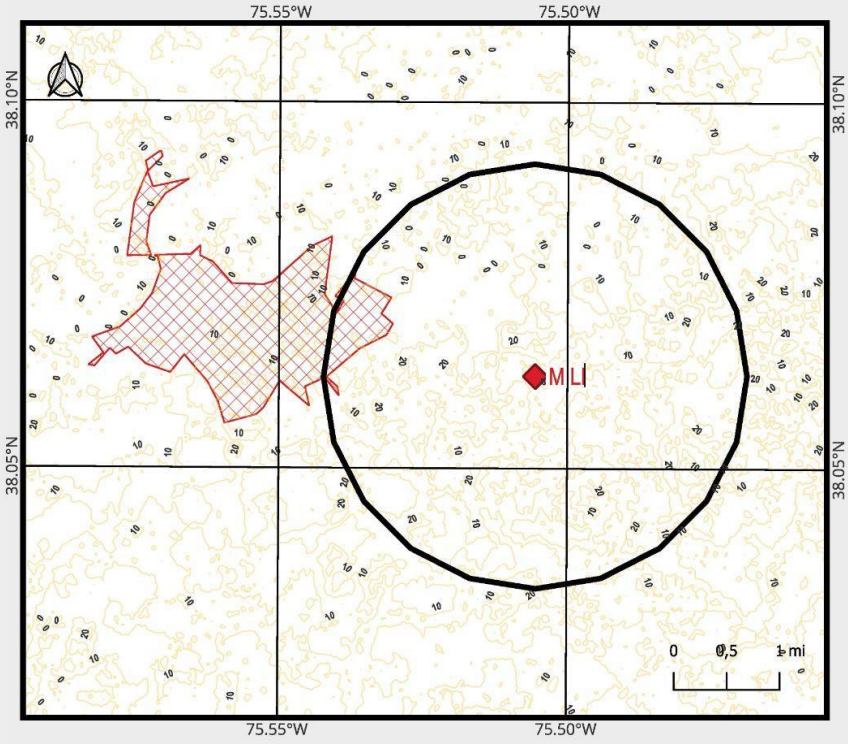
- Grassland/herbaceous
- Pasture/hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands
- Selected site

Topography and urban areas



The contour lines were generated by means of SRTM elevation. The Shuttle Radar Topography Mission (SRTM, see Farr et al. 2007) digital elevation data is an international research effort that obtained digital elevation models on a near-global scale. This SRTM V3 product (SRTM Plus) is provided by NASA JPL at a resolution of 1 arc-second (approximately 30m).

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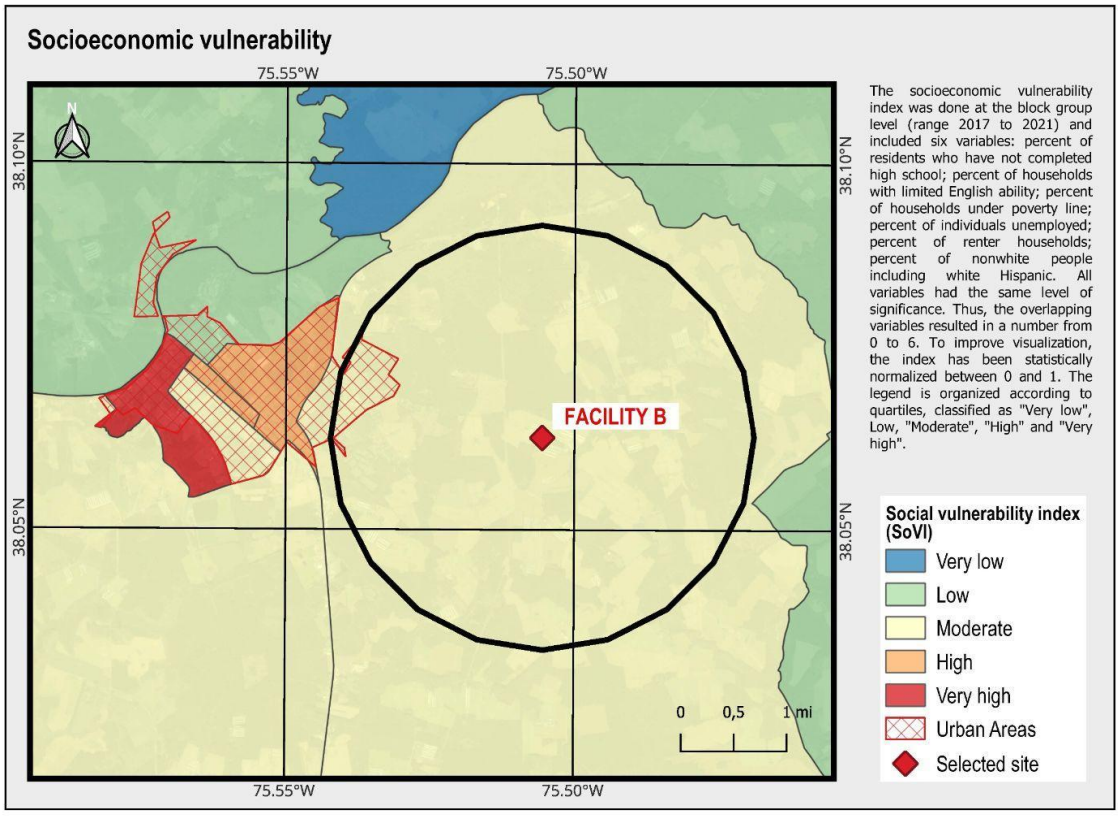
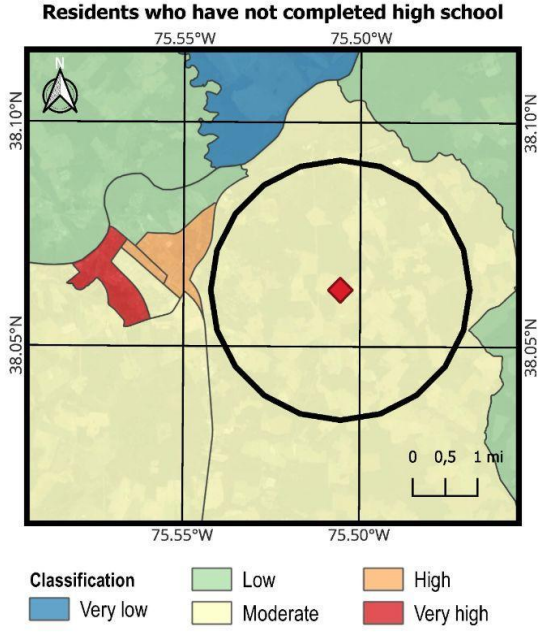
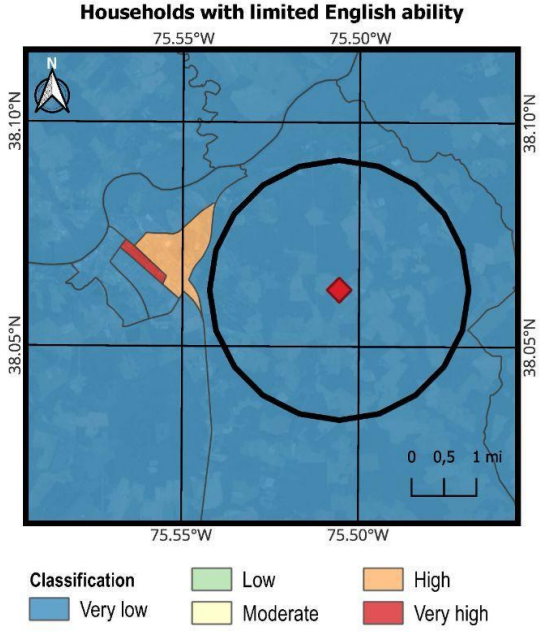
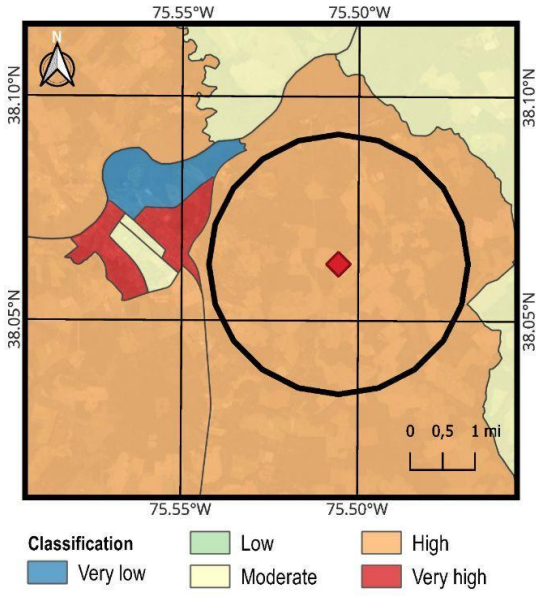
- Selected site
- Contour lines
- Urban areas


Socioeconomic vulnerability
75.55°W
75.50°W
38.10°N
38.05°N
N
FACILITY B
0 0,5 1 mi
The socioeconomic vulnerability index was done at the block group level (range 2017 to 2021) and included six variables: percent of residents who have not completed high school; percent of households with limited English ability; percent of households under poverty line; percent of individuals unemployed; percent of renter households; percent of nonwhite people including white Hispanic. All variables had the same level of significance. Thus, the overlapping variables resulted in a number from 0 to 6. To improve visualization, the index has been statistically normalized between 0 and 1. The legend is organized according to quartiles, classified as "Very low", Low, "Moderate", "High" and "Very high".
Social vulnerability index (SoVI)
Very low
Low
Moderate
High
Very high
Urban Areas
Selected site

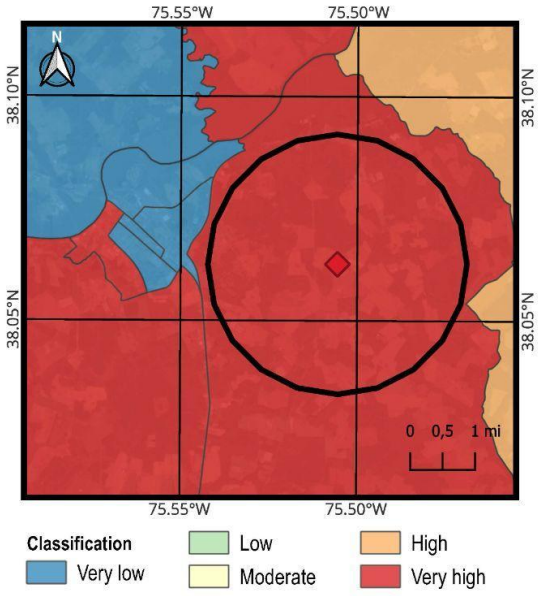

Residents who have not completed high school
75.55°W
75.50°W
38.10°N
38.05°N
N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high


Households with limited English ability
75.55°W
75.50°W
38.10°N
38.05°N
N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high

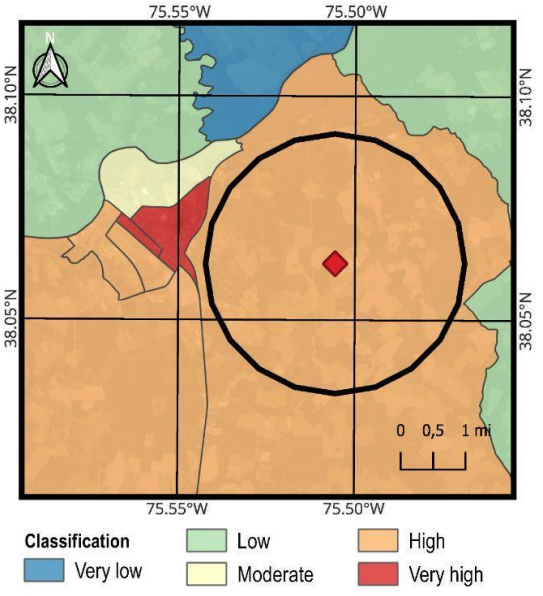
Households under poverty line



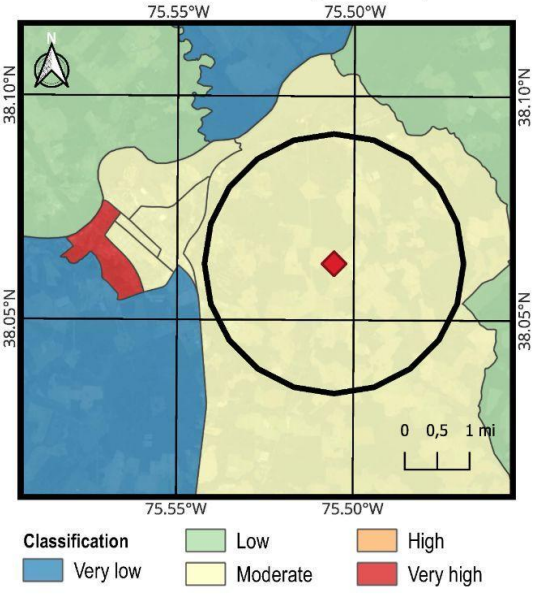
Individuals unemployed

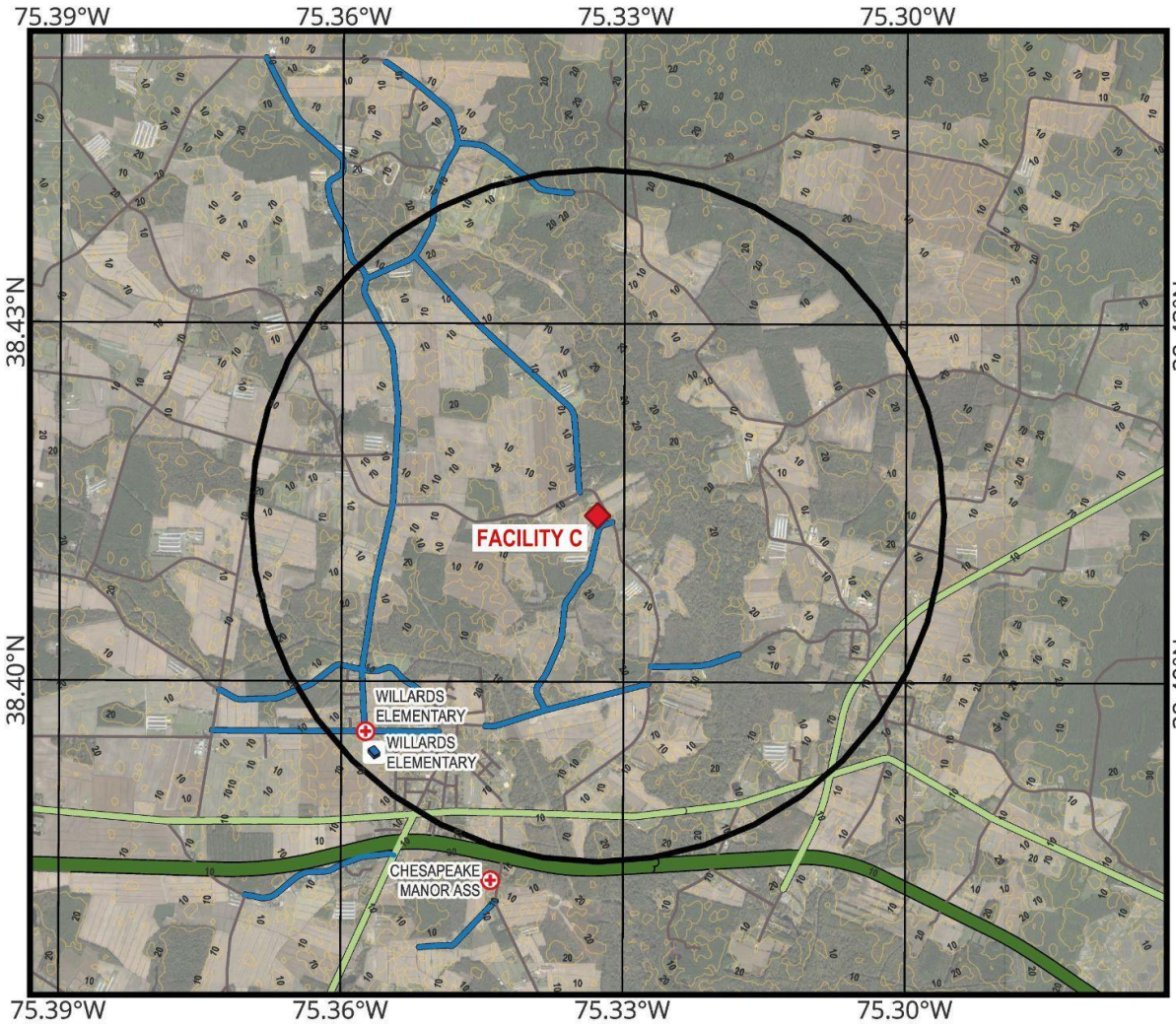


Renter households



Nonwhite people including white Hispanic





Buffer
Selected site
Health Facilities
Education Facilities
Contour Lines
Urban Areas*

Roads
Interstate
U.S.
State recognized
County
Other

*There is no record of urban areas in this region.

HEALTH FACILITIES
CHESAPEAKE MANOR ASS
WILLARDS KIDS KLUB A
WILLARDS ELEMENTARY

EDUCATION FACILITIES
WILLARDS ELEMENTARY

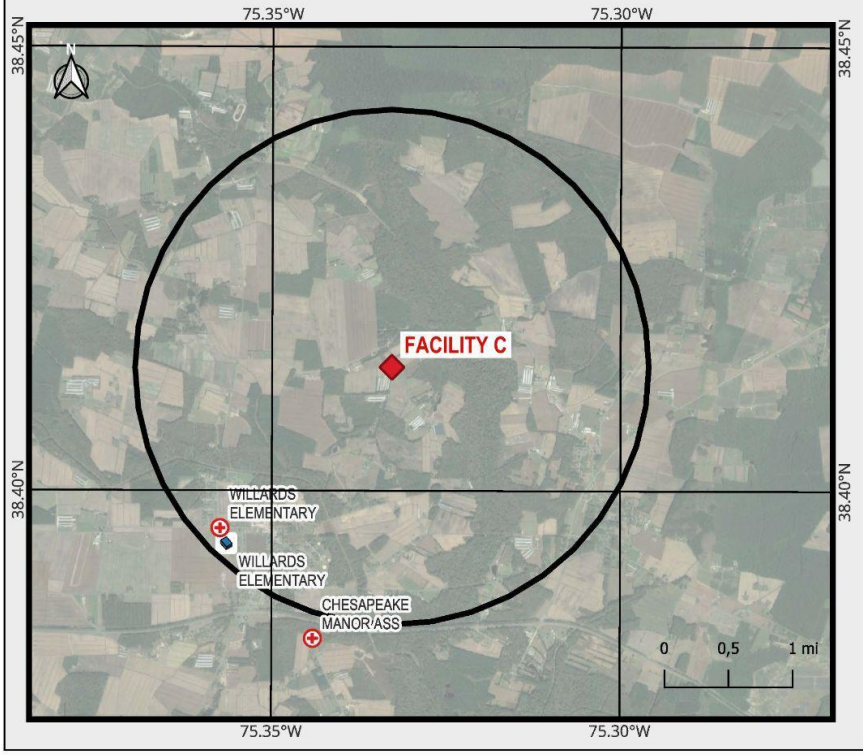
N

0,5 0 0,5 1 mi

The black circles correspond to a 2-mile buffer created around the digester location. The other elements can be checked individually on the other boards.

University of Maryland
School of Architecture, Planning and Preservation
Stormwater Infrastructure Resilience and Justice (SIRJ) Lab
3835 Campus Drive / College Park, MD 20742

Health and education facilities



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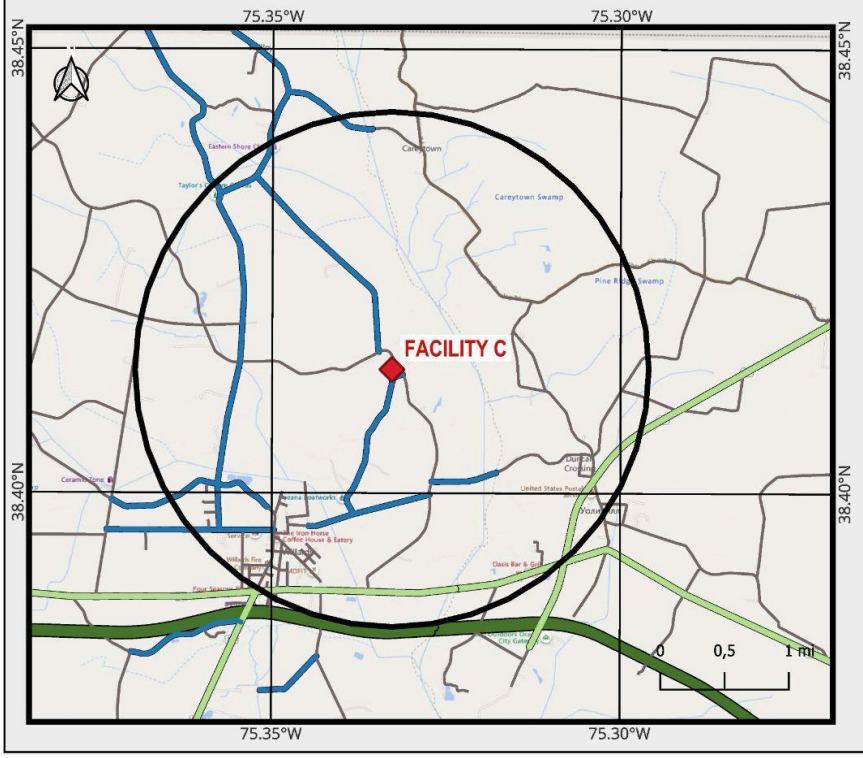
Selected site
Health Facilities
Education Facilities

Roads



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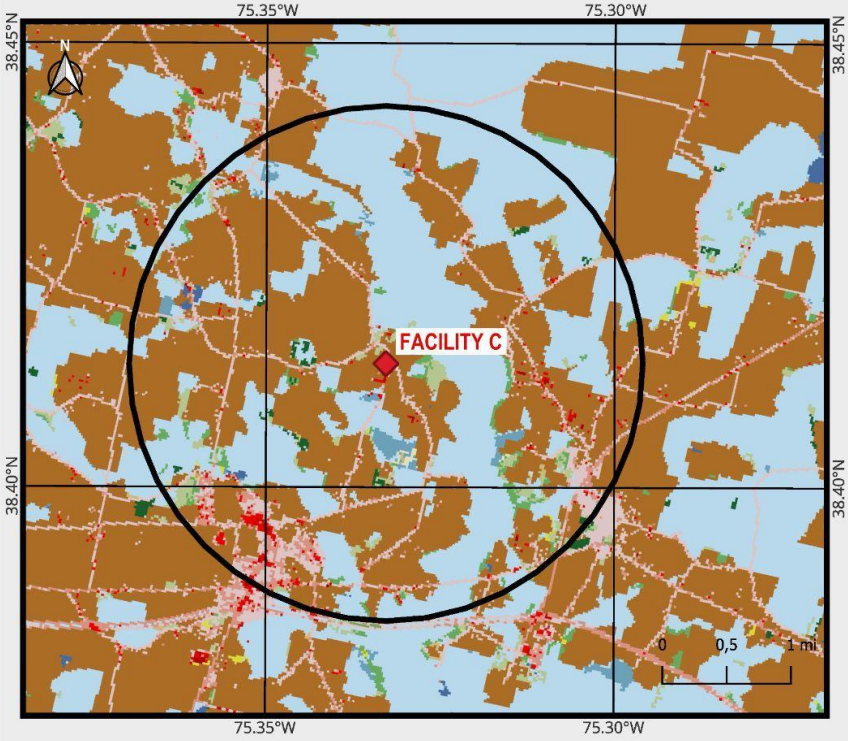
Selected site
Route type description
Interstate
U.S.
State recognized
County
Other

Land Use/Land Cover



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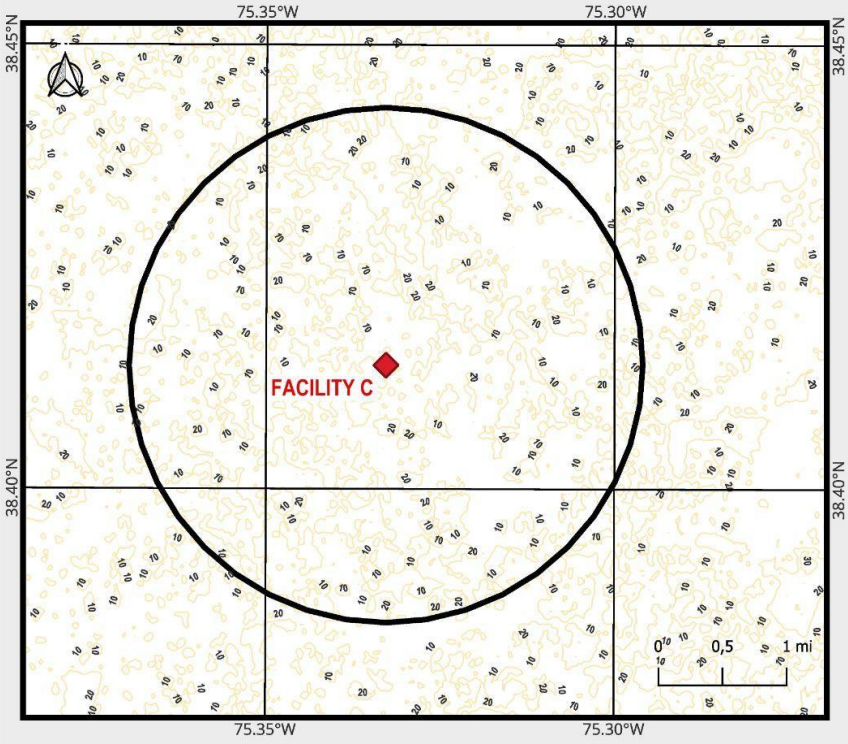
Classification

- Open water
- Perennial ice/snow
- Developed, open space
- Developed, low intensity
- Developed, medium intensity
- Developed, high intensity
- Barren land (rock/sand/clay)
- Deciduous forest
- Evergreen forest
- Mixed forest
- Shrub/scrub
- Grassland/herbaceous
- Pasture/hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands
- Selected site

Topography and urban areas



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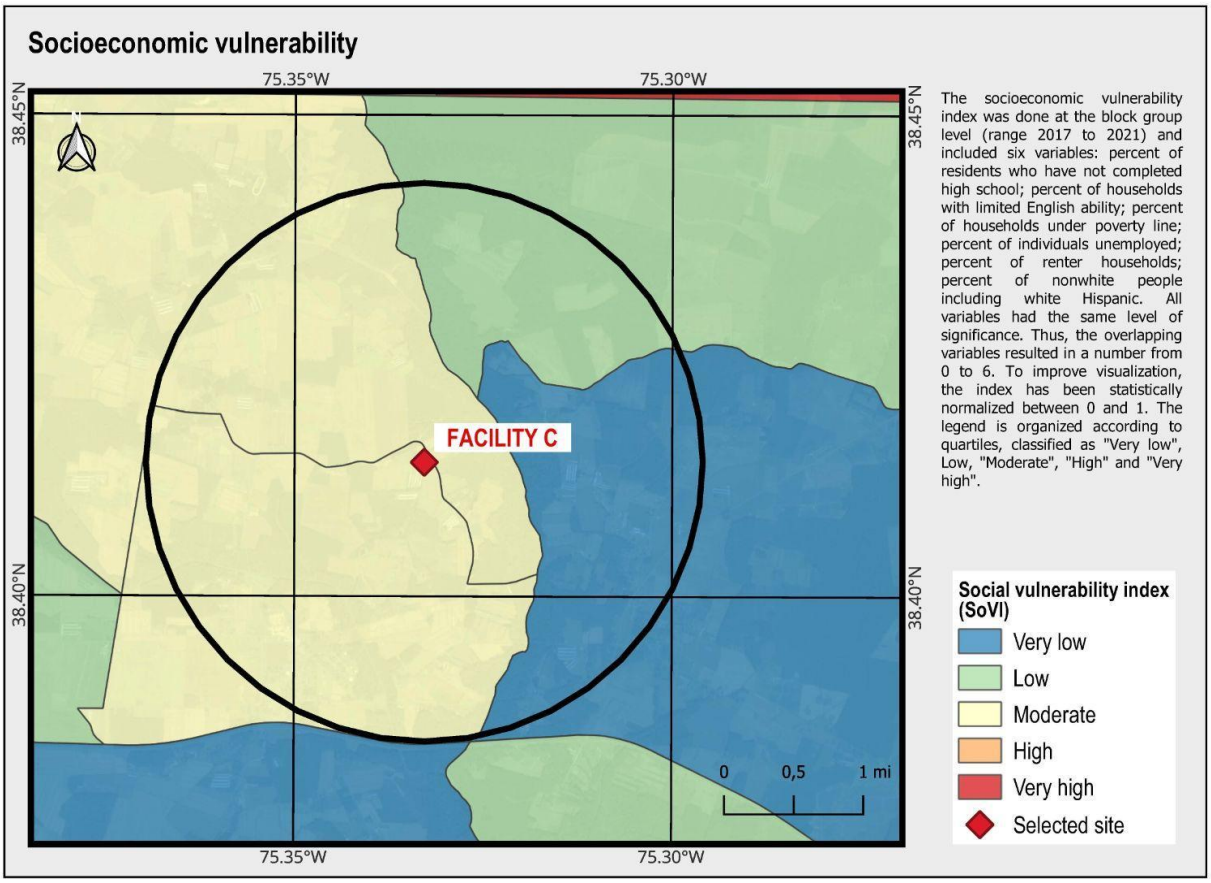
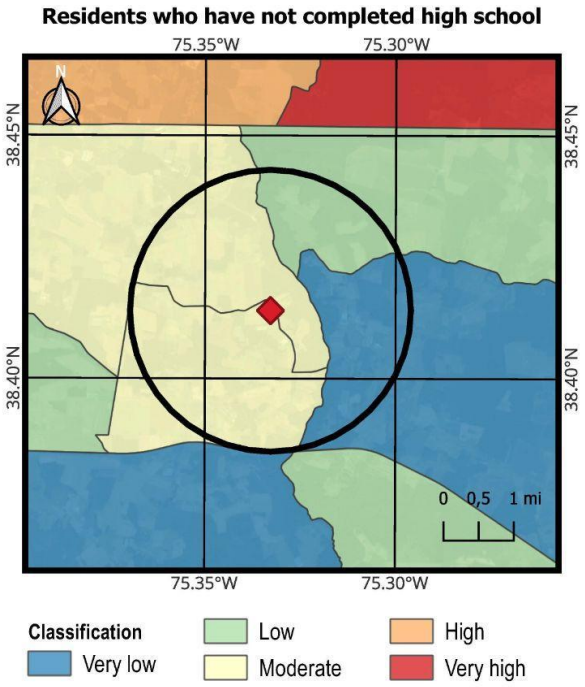
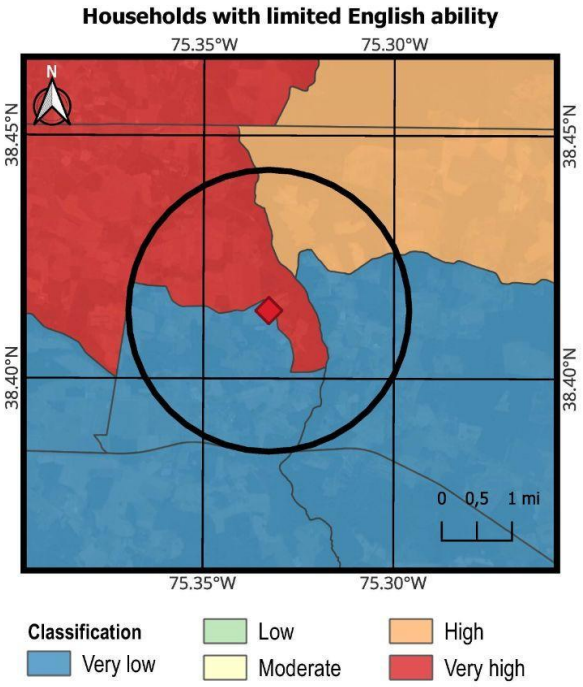
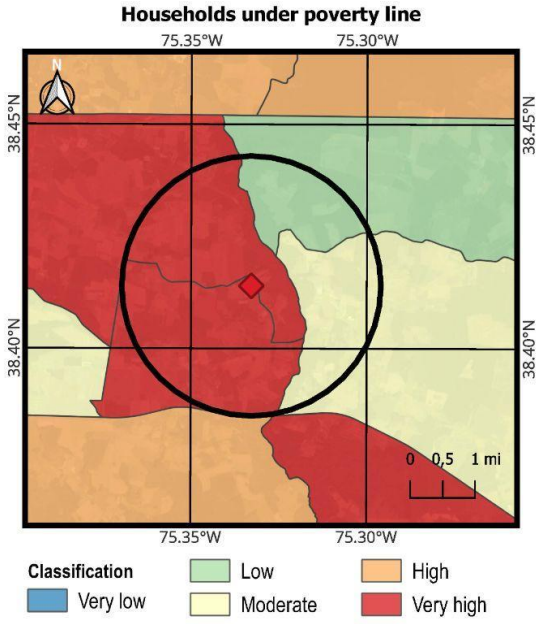
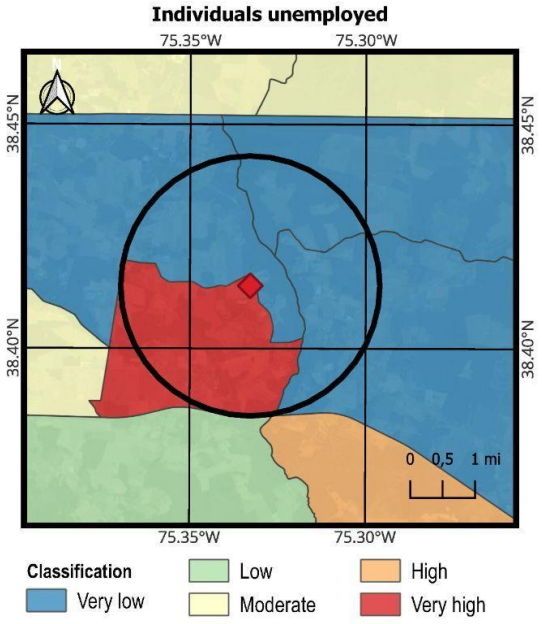
- Selected site
- Contour lines

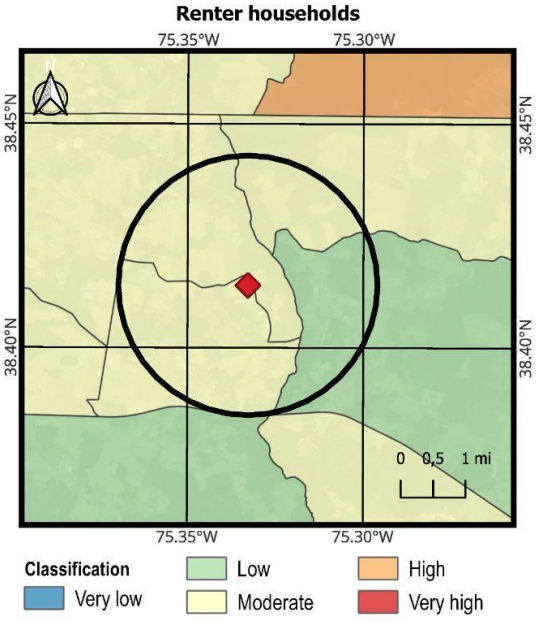

Socioeconomic vulnerability
75.35°W
75.30°W
38.45°N
38.40°N
FACILITY C
0 0,5 1 mi
The socioeconomic vulnerability index was done at the block group level (range 2017 to 2021) and included six variables: percent of residents who have not completed high school; percent of households with limited English ability; percent of households under poverty line; percent of individuals unemployed; percent of renter households; percent of nonwhite people including white Hispanic. All variables had the same level of significance. Thus, the overlapping variables resulted in a number from 0 to 6. To improve visualization, the index has been statistically normalized between 0 and 1. The legend is organized according to quartiles, classified as "Very low", Low, "Moderate", "High" and "Very high".
Social vulnerability index (SoVI)
Very low
Low
Moderate
High
Very high
Selected site

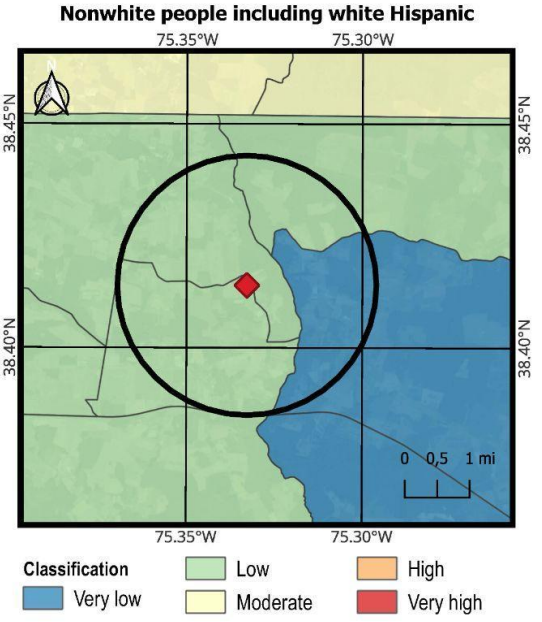

Residents who have not completed high school
75.35°W
75.30°W
38.45°N
38.40°N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high

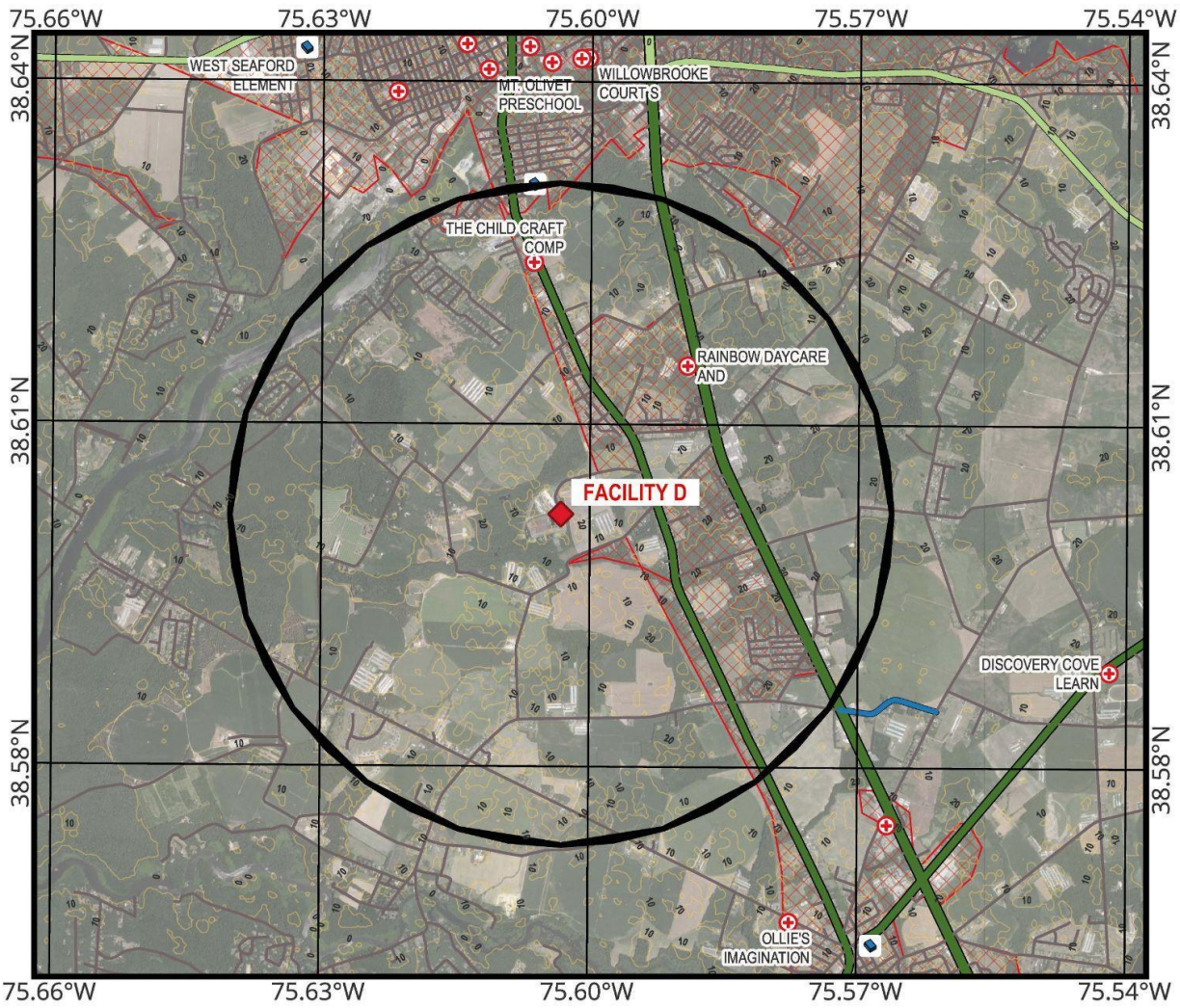

Households with limited English ability
75.35°W
75.30°W
38.45°N
38.40°N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high


Households under poverty line
75.35°W
75.30°W
38.45°N
38.40°N
0 0,5 1 mi
Classification
Low
High
Very low
Moderate
Very high


Individuals unemployed
75.35°W
75.30°W
38.45°N
38.40°N
0 0,5 1 mi
Classification
Low
High
Very low
Moderate
Very high


Renter households
75.35°W
75.30°W
38.45°N
38.40°N
0 0,5 1 mi
Classification
Low
High
Very low
Moderate
Very high


Nonwhite people including white Hispanic
75.35°W
75.30°W
38.45°N
38.40°N
0 0,5 1 mi
Classification
Low
High
Very low
Moderate
Very high



Buffer
Selected site
Health Facilities
Education Facilities
Contour Lines
Urban Areas

Roads
Interstate
U.S.
State recognized
County
Other

N

0,5 0 0,5 1 mi

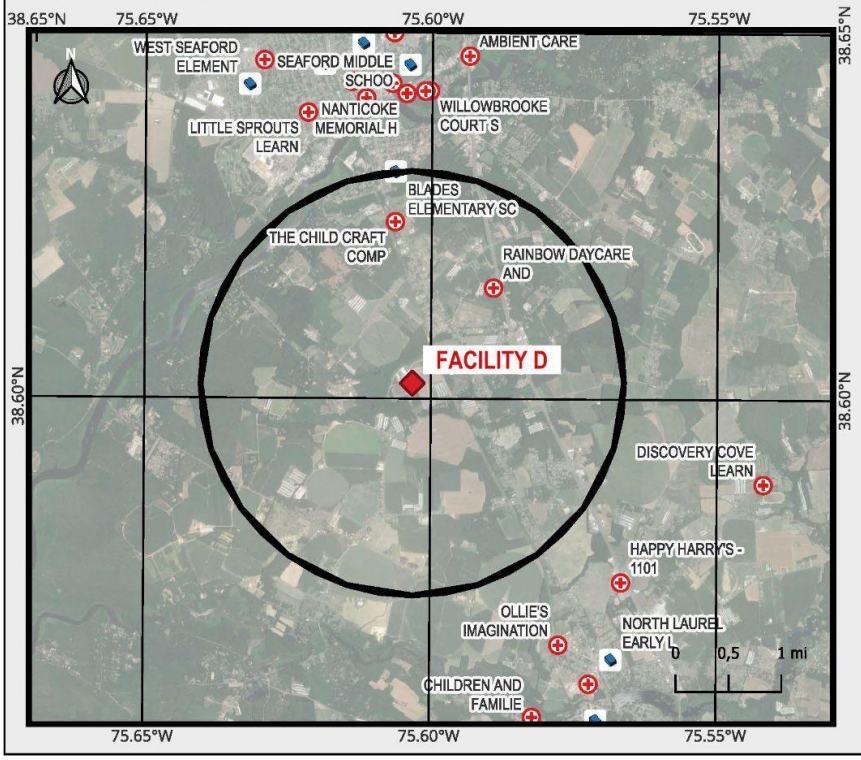
University of Maryland
School of Architecture, Planning and Preservation
Stormwater Infrastructure Resilience and Justice (SIRJ) Lab
3835 Campus Drive / College Park, MD 20742

HEALTH FACILITIES
HAPPY HARRY'S - 1101
WILLOWBROOKE COURT S
LOFLAND PARK CENTER
OAKBRIDGE TERRACE AS
NANTICOKE MEMORIAL H
THE CHILD CRAFT COMP
RAINBOW DAYCARE AND
ST. JOHN'S PRESCHOOL
MT. OLIVET PRESCHOOL
OLLIE'S IMAGINATION
LITTLE SPROUTS LEARN
DISCOVERY COVE LEARN

EDUCATION FACILITIES
BLADES ELEMENTARY SC
WEST SEAFORD ELEMENT
NORTH LAUREL EARLY L

The black circles correspond to a 2-mile buffer created around the digester location. The other elements can be checked individually on the other boards.

Health and education facilities



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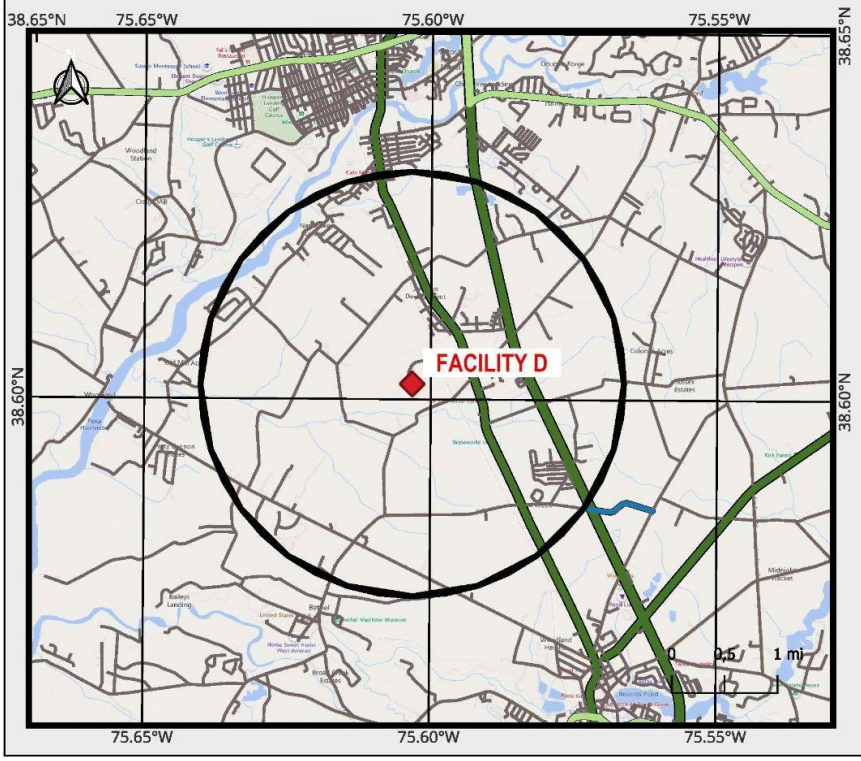
- Selected site
- Health Facilities
- Education Facilities

Roads



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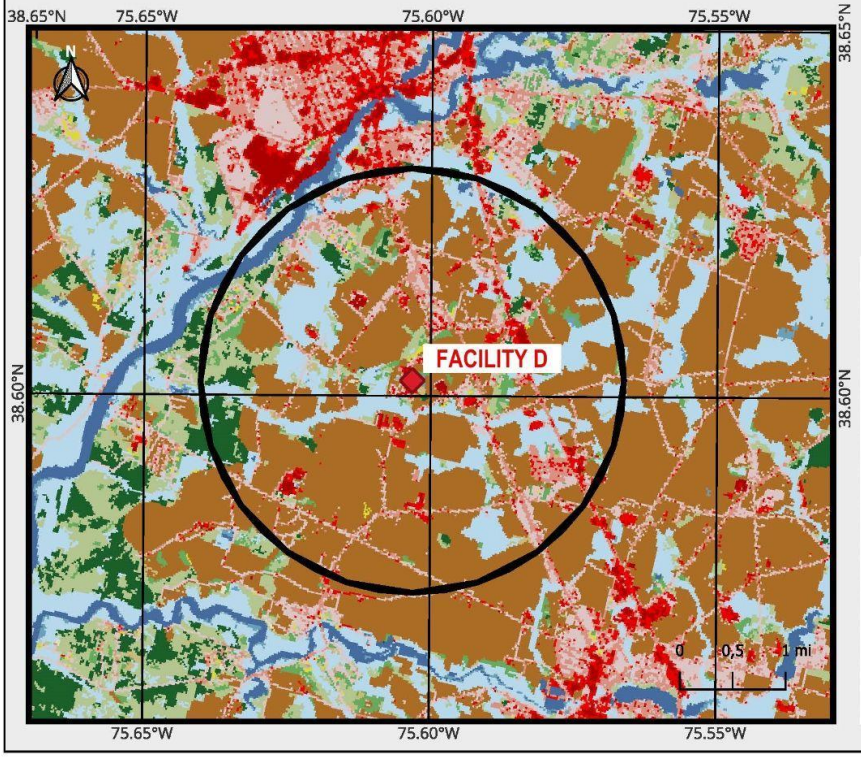
- Selected site

Route type description

- Interstate
- U.S.
- State recognized
- County
- Other

Land Use/Land Cover



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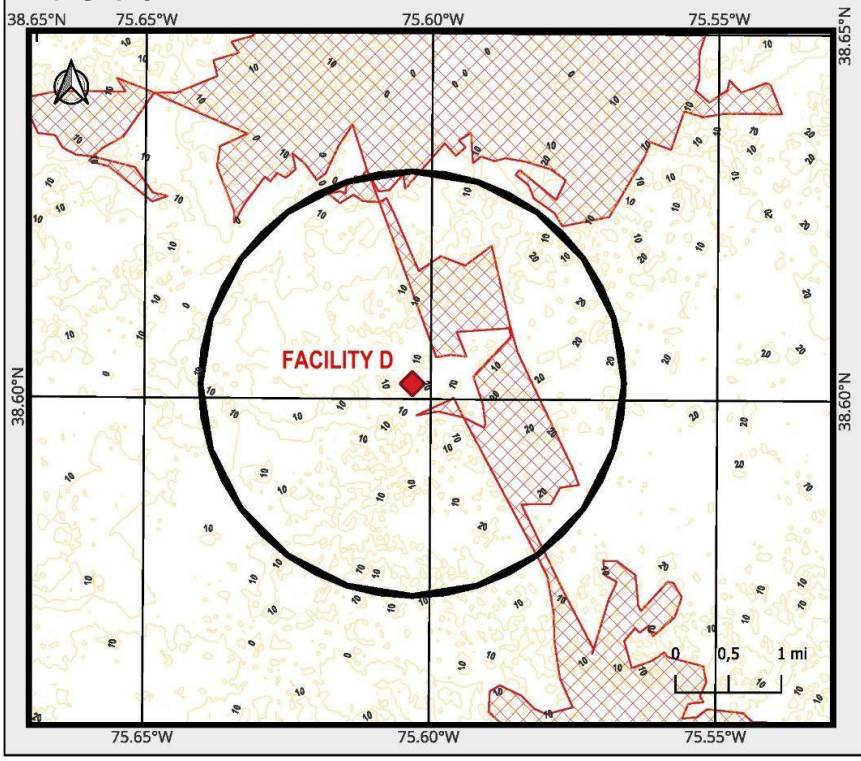
- Deciduous forest
- Evergreen forest
- Mixed forest
- Shrub/scrub
- Grassland/herbaceous
- Pasture/hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands
- Selected site

Topography and urban areas



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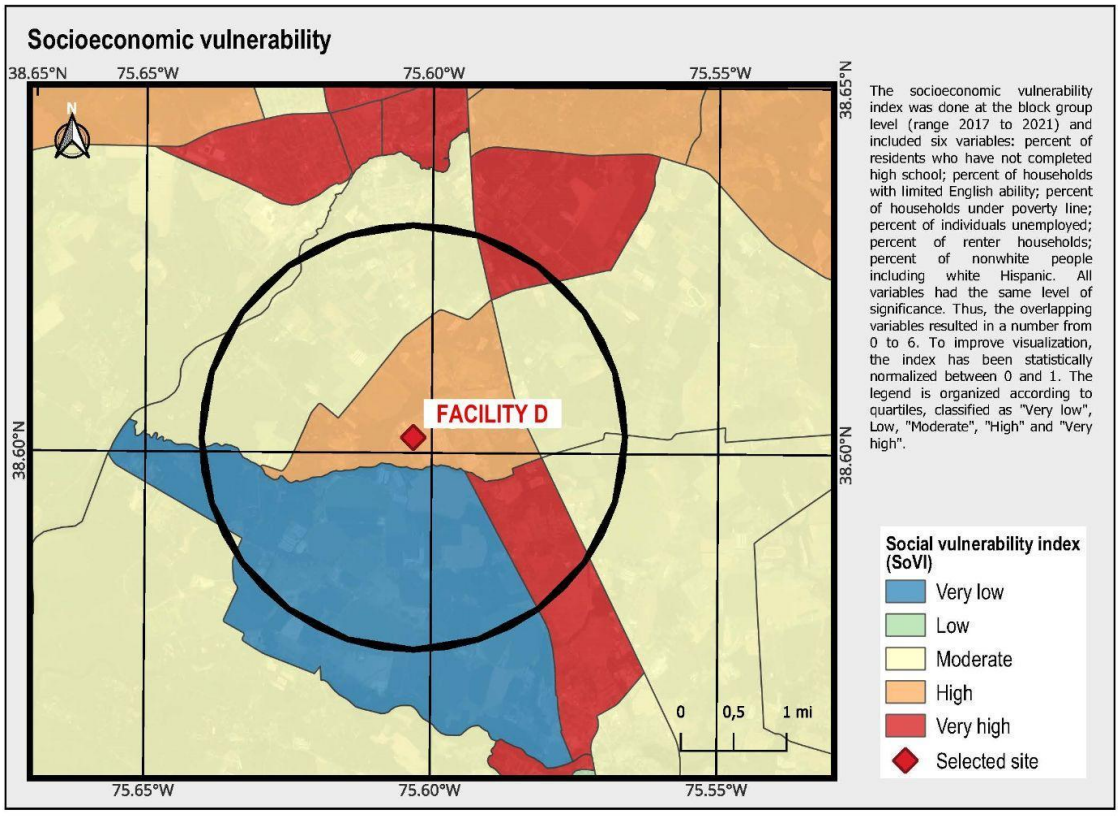
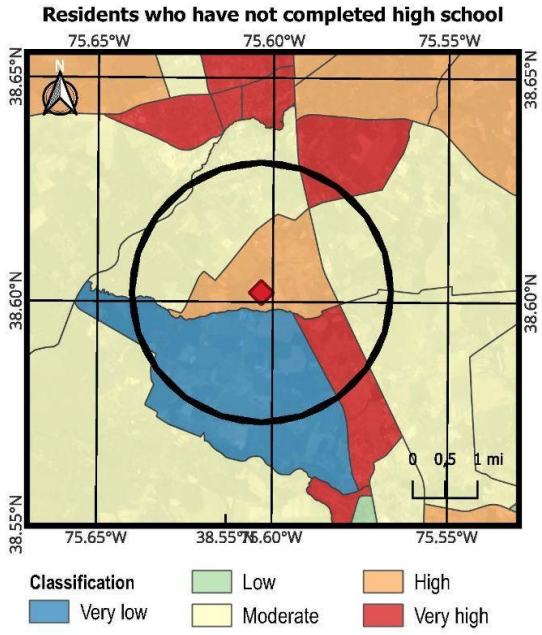
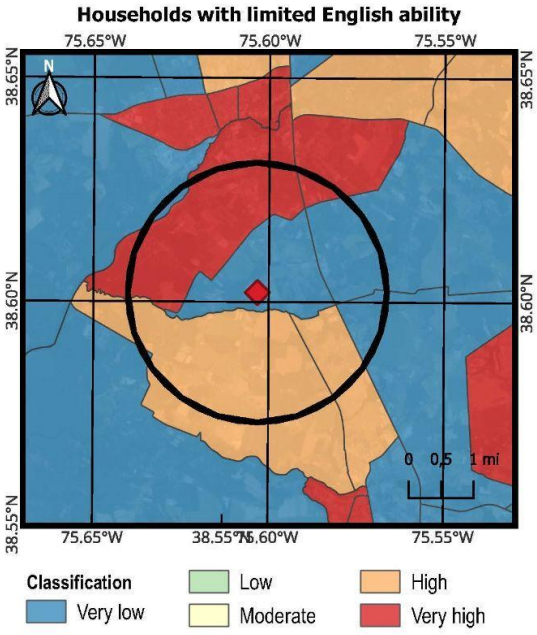
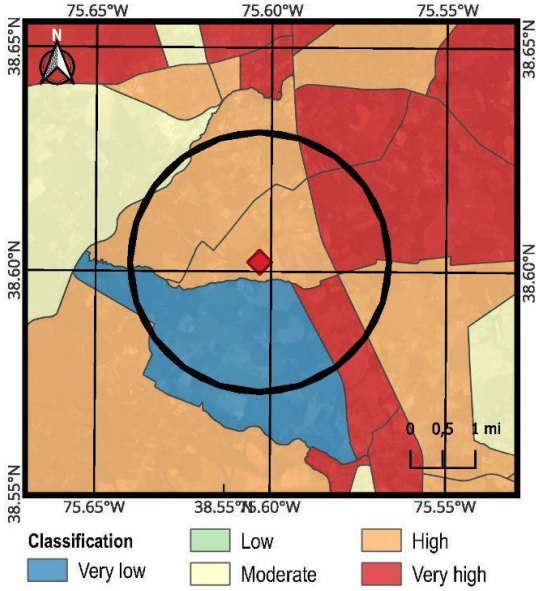
- Selected site
- Contour lines
- Urban Areas


Socioeconomic vulnerability
38.65°N
75.65°W
75.60°W
75.55°W
38.60°N
FACILITY D
0 0,5 1 mi
The socioeconomic vulnerability index was done at the block group level (range 2017 to 2021) and included six variables: percent of residents who have not completed high school; percent of households with limited English ability; percent of households under poverty line; percent of individuals unemployed; percent of renter households; percent of nonwhite people including white Hispanic. All variables had the same level of significance. Thus, the overlapping variables resulted in a number from 0 to 6. To improve visualization, the index has been statistically normalized between 0 and 1. The legend is organized according to quartiles, classified as "Very low", Low, "Moderate", "High" and "Very high".
Social vulnerability index (SoVI)
Very low
Low
Moderate
High
Very high
Selected site

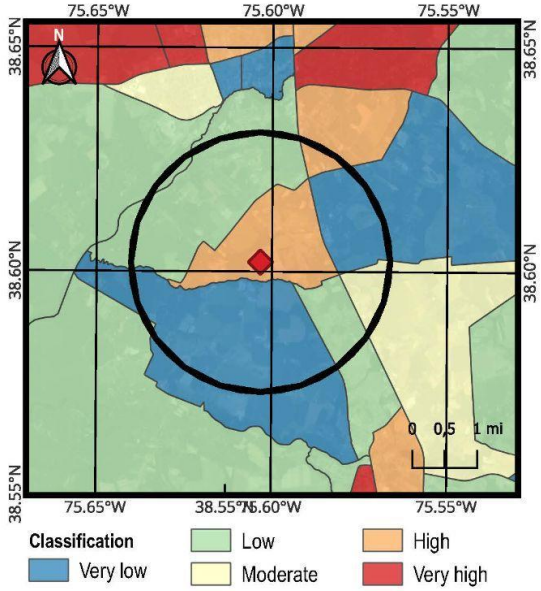

Residents who have not completed high school
75.65°W
75.60°W
75.55°W
38.65°N
38.60°N
38.55°N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high


Households with limited English ability
75.65°W
75.60°W
75.55°W
38.65°N
38.60°N
38.55°N
0 0,5 1 mi
Classification
Very low
Low
Moderate
High
Very high

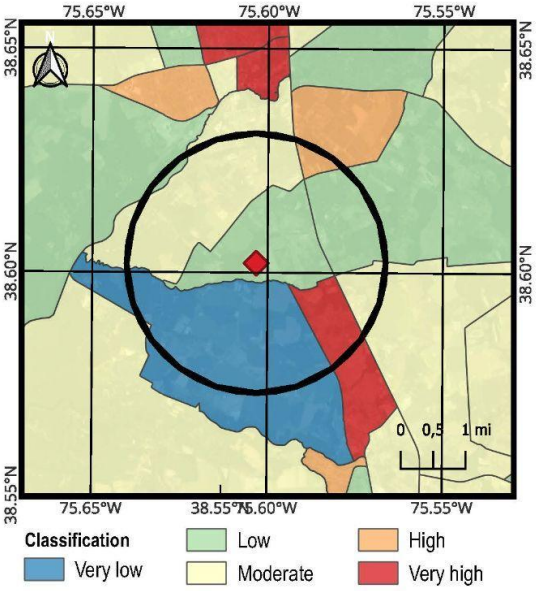
Households under poverty line



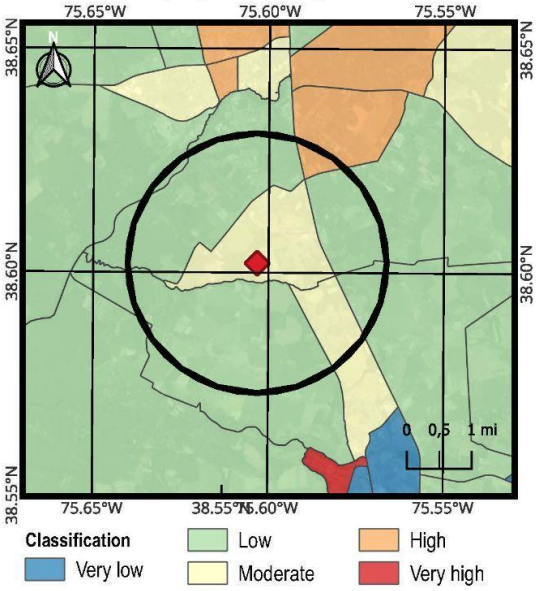
Individuals unemployed



Renter households



Nonwhite people including white Hispanic



Appendix C: Survey Results

Table 1: Research participant demographics, including gender, age, and race of 246 respondents.

Category	Raw Value	Percentage
Gender		
Female	87	36%
Male	157	64%
Other	1	0%
Age		
18-30	46	17%
31-40	48	19%
41-50	36	15%
51-60	49	20%
61-70	43	19%
Over 70	24	10%
Race		
White	230	94%
Black or African American	5	2%
American Indian or Alaska Native	0	0%
Asian	4	2%
Hispanic or Latino	1	0%
Mixed	5	2%
Other	1	0%

Table 2: County of residence and farming demographics of 249 survey respondents.

County	Raw Value	Percentage
Allegany County	6	2%
Anne Arundel County	3	1%
Baltimore City	0	0%
Baltimore County	1	0%
Calvert County	13	5%
Caroline County	5	2%
Carroll County	9	4%
Cecil County	24	10%
Charles County	11	4%
Dorchester County	6	2%
Frederick County	7	3%
Garrett County	9	4%
Harford County	22	9%
Howard County	7	3%
Kent County	4	2%
Montgomery County	3	1%
Prince George's County	12	5%
Queen Anne's County	7	3%
Saint Mary's County	19	8%
Somerset County	12	5%
Talbot County	2	1%
Washington County	0	0%
Wicomico County	17	7%
Worcester County	5	2%

County outside MD	45	18%

Table 3: Occupation demographics of 190 survey respondents

Occupation	Raw Value	Percentage
Farmer	120	63%
Commodity Group	10	5%
Extension/Academic or University	27	14%
Commodity Specialist	11	6%
Integrator	4	2%
Animal Processor	3	2%
Farm Consultant	15	8%

Table 4: Survey responses from the question "Please rank from most to least important about how the following factors drive these expected increases or decreases in animal populations on your farm (or within your commodity group)." The rankings are based on the choice that was most often selected by respondents and the percentages represent how many of the respondents put that choice as that ranking.

Ranked 1-7	Ranking Choices	Percentage of Respondents Choosing this Ranking
#1	Personal Circumstances	48%
#2	Market Forces	30%
#3	Right to Farm Issues	20%

Table 5: Survey responses from the question "Please rank from most to least important (slide up and down to move into ranked order) regarding the greatest challenges for manure management". The rankings are based on the choice that was most often selected by respondents and the percentages represent how many of the respondents put that choice as that ranking.

Ranked 1-7	Ranking Choices	Percentage of Respondents Choosing this Ranking
#1	Nutrient Management Planning	19%
#2	Moving manure off-site/hauling	19%
#3	Land limitations	20%

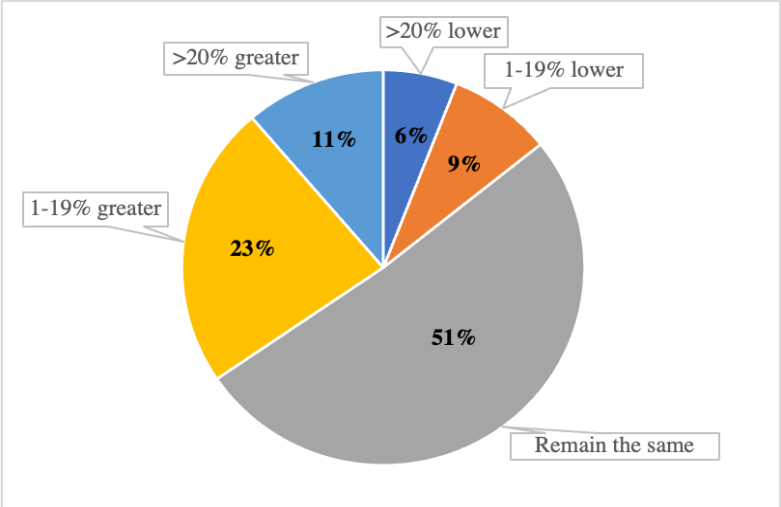


Figure 1: Survey results from the question "How do you expect your total animal population to change on your farm (or within your commodity group, if you do not have a farm) in the next five years?" from 168 respondents.

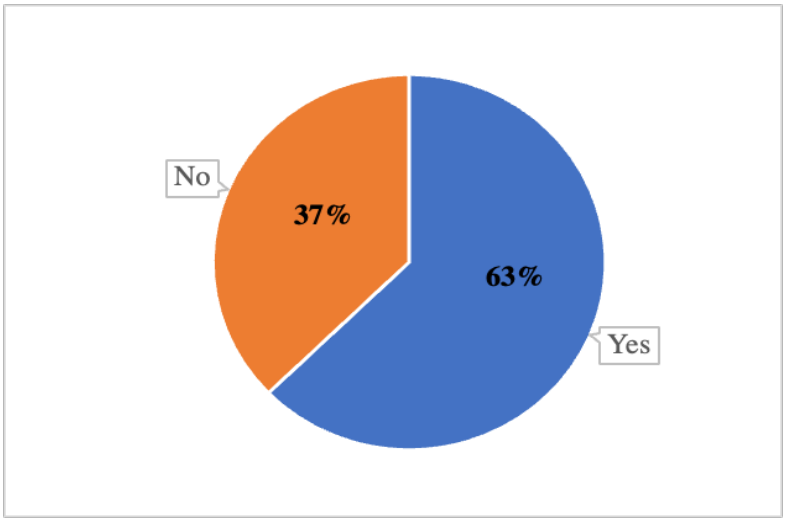


Figure 2: Survey results from the question "Do you use manure/poultry litter on your fields?" from 169 respondents.

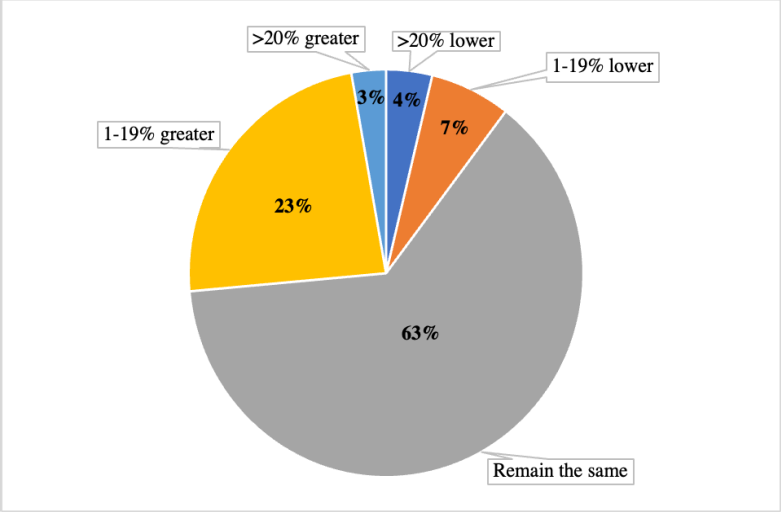


Figure 3: Survey results from the question "If manure/poultry litter is used, do you expect the quantity of manure applied to your fields in next two years (2023-2025) to:" from 106 respondents.

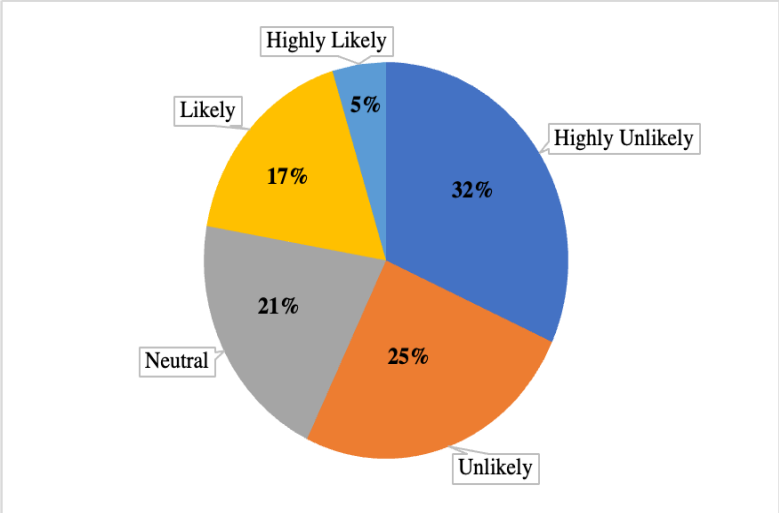


Figure 4: Survey results from the question "If manure/poultry litter is not used, how likely are you to apply manure/poultry litter to your fields in the next two years (2024-2025):" from 63 respondents.

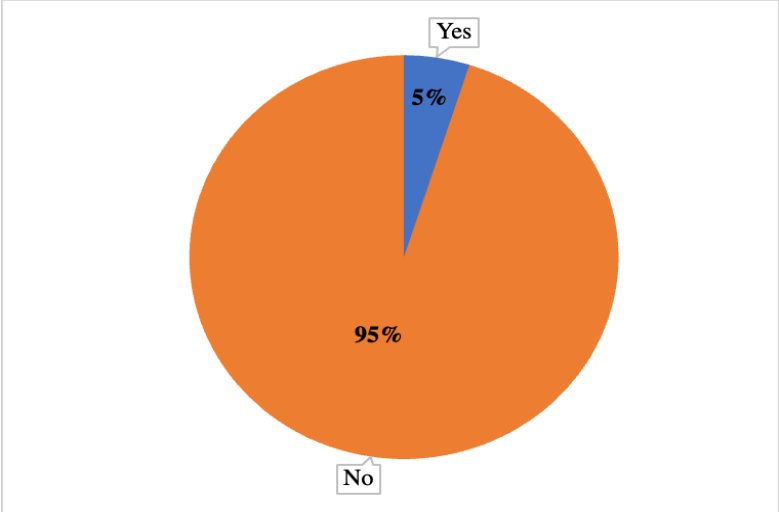


Figure 5: Survey results from the question "Do you use any 'Other Animal Waste Products,' on your fields, such as dissolved air flotation (DAF) - not manure or residential food waste?" from 162 respondents.

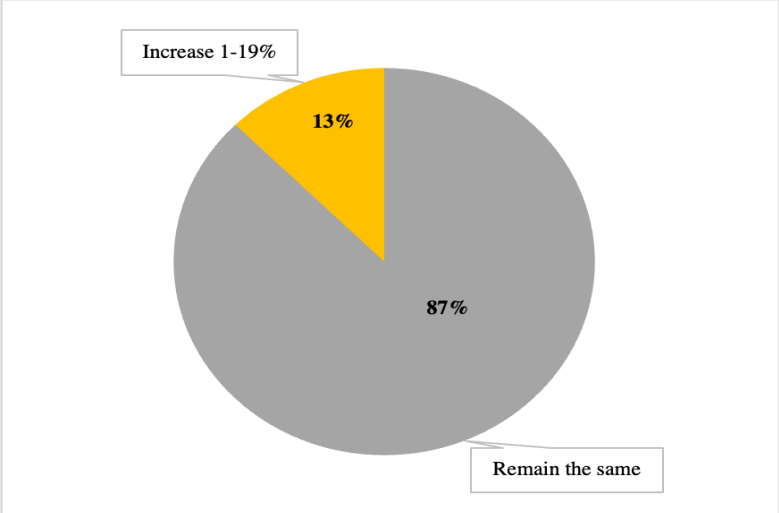


Figure 6: Survey results from the question "If any 'other animal waste products' are used on fields, do you expect the quantity of 'other animal waste products' applied to your fields in next two years (2023-2025) to:" from 8 respondents.

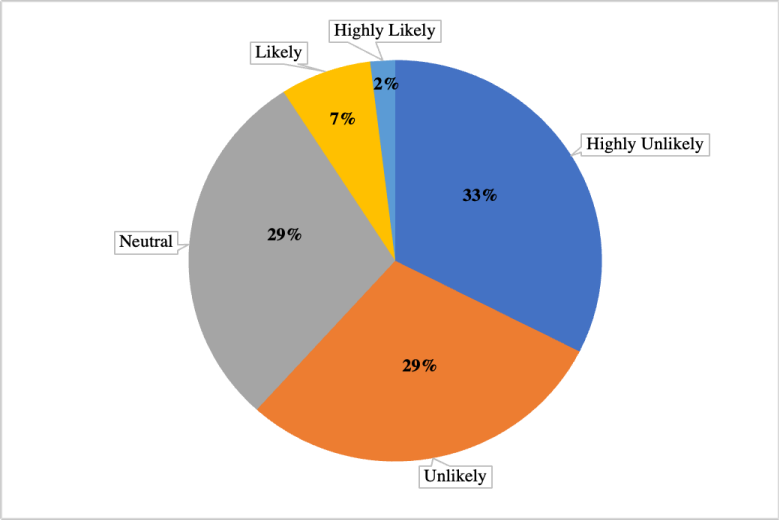


Figure 7: Survey results from the question "If any 'other animal waste products' are not used on fields, how likely are you to apply 'other animal waste products' to your fields in the next two years (2023-2025)?" from 154 respondents.

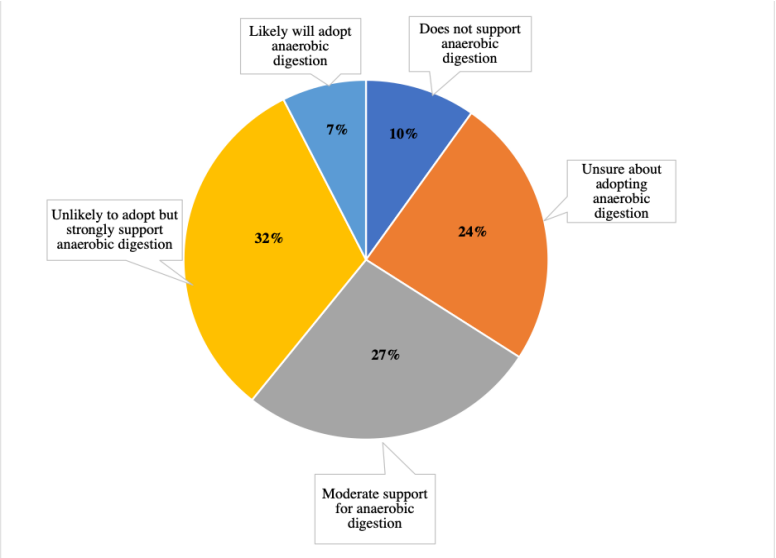


Figure 8: Survey results from the question "Which of the following best describes your outlook on anaerobic digestion in the next five years (2023-2028)?" from 214 respondents. The responses showed that 66% of the participants moderately/strongly supported anaerobic digestion while 34% were unsure or did not support anaerobic digestion.

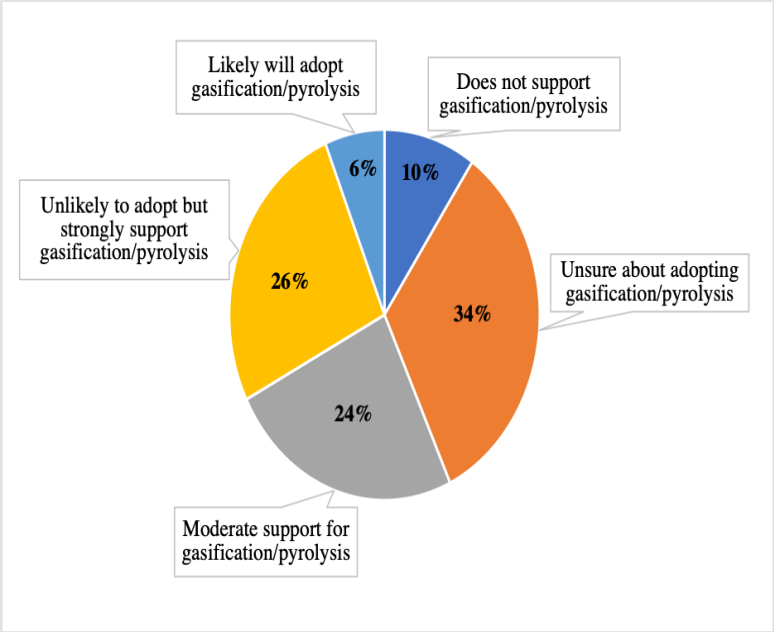


Figure 9: Survey results from the question "Which of the following best describes your outlook on gasification/pyrolysis in the next five years (2023-2028)?" from 209 respondents. The responses showed that 56% of the participants moderately/strongly supported gasification/pyrolysis while 44% were unsure or did not support gasification/pyrolysis.

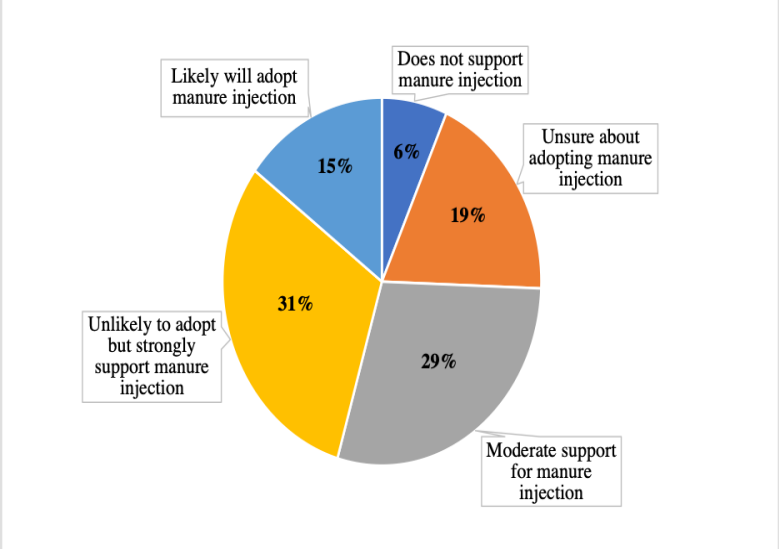


Figure 10: Survey results from the question "Which of the following best describes your outlook on manure injection in the next five years (2023-2028)?" from 211 respondents. The responses showed that 75% of the participants moderately/strongly supported manure injection while 25% were unsure or did not support manure injection.

<u>Additional Questions</u>

"What are the primary motivations for farmers to use manure, poultry litter, or other animal waste products on fields?"

- "Cost of commercial fertilizers" [34 responses]
- "Fertilizer" [32 responses]
- "Good source of nutrients" [18 responses]
- "High availability" [15 responses]

"What are the primary concerns or barriers for farmers to use manure, poultry litter, or other animal waste products on fields?"

- "Government regulations [33 responses]
- "Availability [17 responses]

- "Runoff" [14 responses]
- "Nutrient Management" [13 responses]

"Do you see opportunities for creating income from poultry, equine, and livestock products that are currently not a prime income source (i.e., not selling birds, milk, meat, etc.) but other innovative products from these industries?"
- "No, None" [45 responses]
- "Energy production from digesters" [5 responses]
- "Fertilizer" [4 responses]

"How has your farm management of livestock, poultry, manure, and waste application changed in the last five years (2019-2022)?"
- "No change" [59 responses]
- "Regulations [4 responses]

"What changes in farm management of livestock, poultry, manure, and waste application do you expect to see in the next five years (2023-2028)?"
- "None" [39 responses]
- "Regulations/restrictions" [27 responses]

"What do you think are the greatest benefits to anaerobic digestion?"
- "Renewable energy production" [43 responses]
- "Reduction of waste and waste management" [16 responses]
- "Odor management" [6 responses]

"What are your biggest concerns about anaerobic digestion implementation?"
- "Cost, too expensive, huge investment" [79 responses]
- "More regulations" [7 responses]
- "Collection and transportation of manure" [4 responses]

"What do you think are the greatest benefits to gasification or pyrolysis technologies?"
- "Renewable energy source" [46 responses]
- "Better for environmental health" [6 responses]

"What are your biggest concerns about gasification or pyrolysis implementation?"
- "Cost" [54 responses]
- "Unsure/Not enough knowledge" [24 responses]
- "Waste of nutrients [7 responses]

"What do you think are the greatest benefits to manure injection?"
- "Nutrients kept in place, maximized nutrient efficiency [48 responses]
- "Odor reduction" [30 responses]
- "Less runoff" [30 responses]

"What are your biggest concerns about manure injection?"
- "Cost" [61 responses]
- "Soil disturbances/application usage" [23 responses]

- “Regulations/restrictions” [4 responses]

Appendix D: 2023 Maryland Legislation Related to Waste Technologies

Table 1: 2023 Maryland legislation tracked regarding animal waste technologies and similar topics of interest.

Legislative Code	Legislative Title	Agency(s) Enforcing	Topic of Interest	Approved by the Governor/Progress
SB0690	Agriculture - Confinement of Egg-Laying Hens in Commercial Egg Production - Prohibitions	Maryland Department of Agriculture	Prohibiting the confinement of egg laying hens and the sale of shell eggs and egg products from confinement housing set ups	Failed in Senate
HB0847 / SB0447	Anaerobic Digestion Workgroup	N/A	Members of the MD Senate, House of Delegates, MDA, MDE, and MEA to study and explore anaerobic digestion to make State recommendations	Failed in House / Failed in Senate
HB0964 / SB0029	Baltimore City Soil Conservation District – Establishment – Requirements	Maryland Department of Agriculture	Creation of a Soil Conservation District for the geographic area for Baltimore City	Withdrew by Sponsor / Failed in House
HB0840 / SB0743	Climate, Labor, and Environmental Equity Act of 2023	Maryland Department of the Environment	Have MDE re-evaluate the process of issuing permits regarding landfills, municipalities, pollutants, and the handling of hazardous waste to understand impacts on overburdened and underserved communities	Failed in House / Failed in Senate
HB0389 / SB0034	Department of Agriculture – State Specialist for Value–Added Agriculture	Maryland Department of Agriculture	Creation of a specialist position in MDA for a point-contact & liaison for value-added agriculture in MD	Passed / Passed
HB0152	Department of Agriculture – Urban Agriculture Grant Fund	Maryland Department of Agriculture	Altering the Urban Grant fund parameters to match the definition of an "urban" area, qualifications to apply for the fund, and creation of an Urban Agriculture Advisory Committee	Passed
HB0230 / SB0224	Department of the Environment – Zero–Emission Medium– and Heavy–Duty Vehicles – Regulations (Clean Trucks Act of 2023)	Maryland Department of the Environment	Requiring the State to follow standards set by the California Air Resources Board's Advanced Clean Trucks Regulations by having regulations for the sale of zero-emission medium- and heavy-duty vehicles starting with	Passed / Passed

			vehicle model 2027; having MDE adjust grant programs and create adoption plans.	
HB0068 / SB0143	Electricity – Net Energy Metering and Virtual Net Energy Metering – Accrual of Net Excess Generation (Net Metering Flexibility Act)	Maryland Public Service Commission	Allow certain eligible customer-generators to accrue net excess generation indefinitely, alter the current methods of net-metering credit calculations to adjust for indefinite enrollment and creation of a pilot program for a community solar system	Failed in House / Passed
HB0473	Environment - Ambient Air Monitoring - Particulate and Fine Particulate Matter	Maryland Department of the Environment	Requiring MDE to deploy ambient air monitoring systems around the State to monitor air particle values to have standardized data for air quality goals and air permits	Failed in House
HB0609 / SB0768	Environment - Waste Haulers - Reporting Requirement	Maryland Department of the Environment	Having waste haulers report their activities and where they dispose of waste; includes enforcement, reporting, and penalties, with the reports to be sent to the county offices.	Unfavorable Report in House / Failed in Senate
HB0147 / SB0250	Environment – Climate Crisis Plan – Requirement	Maryland Department of the Environment	Having each county require to create a plan to address climate change	Failed in House / Failed in Senate
HB0253 / SB0262	Environment – On–Farm Composting Facilities – Permit Exemption	Maryland Department of the Environment	Exempting farms to apply to on-farm composting facility permits for 10,00 sq ft or less, with the opportunity to expand to 40,000 sq ft by 2028 after review by MDE of diversion of food and organic waste to landfills to farms; ensure the accurate tracking and record keeping of the feedstocks brought to on-farm composters	Passed / Passed
HB0030 / SB0007	Environment – On–Site Wastewater Services – Board, Fees, and Penalties	Maryland Department of the Environment	Adjusting the composition of the State Board of On-Site Wastewater professionals and adding clarifying language for fees, penalties, and licensing requirements	Passed / Passed
HB0284 / SB0222	Environment – Reducing Packaging Materials – Producer Responsibility	Maryland Department of the Environment	Having producers submit recycling plans to MDE to approve certain packaging materials OR pay to MDE a responsibility cost; conduct	Failed in Senate / Passed

			statewide recycling assessments; provide education on to consumers on how to properly dispose in an equitable manner	
HB1248 / SB0186	Green and Renewable Energy for Nonprofit Organizations Loan Program and Fund	Maryland Energy Administration	Creation of a fund, of no-interest loans, for non-profits, to create green infrastructure and help meet the state's energy goals	Failed in House / Failed in House
HB0032 / SB0124	Maryland Food System Resiliency Council	Maryland Department of Emergency Planning	Creation of a complex and holistic group to explore impacts to Maryland's food systems	Passed / Passed
HB0503 / SB0923	Natural Resources - Greenspace Equity Program - Establishment	Department of Natural Resources	Creation of grants to enhance public health of overburdened and under deserved communities to create, maintain, enhance community greenspaces	Passed / Failed in House
SB0161	NE Maryland Waste Disposal Authority - Evaluation, Termination of Bond Authority, and Assumption of Functions, Employees, and Contracts (Northeast Maryland Waste Disposal Authority Sunset Act)	Department of Legislative Services	Prevent Northeast Maryland Waste Disposal Authority from issuing bonds on projects by 2024 to begin dissolving the group and have it be absorbed by Maryland Environmental Service	Passed
HB0592 / SB0418	Property Tax - Agricultural Land and Improvements - Assessment	State Department of Assessments and Taxation	Create a subclass of agriculture tax to tax farms with value-added agriculture	Failed in House / Failed in Senate
HB0169 / SB0144	Public Utilities – Energy Efficiency and Conservation Programs – Energy Performance Targets and Low–Income Housing	Maryland Energy Administration, Department of Housing & Community Development, & Public Service Commission	Research, plan, and implement goals/policies to create energy efficiencies and conservation programs for low-income areas and explore cost effective ways to fund home upgrades	Passed / Vetoed by Governor
HB0718 / SB0590	Renewable Energy Portfolio Standard - Eligible Sources - Alterations (Reclaim Renewable Energy Act of 2023)	Maryland Energy Administration	Removing certain biomasses from energy portfolio standards, recategorizing biomass Tier qualifications, and definitions of different types of biomasses	Failed in House / Failed in Senate
HB0678	Sales and Use Tax - Electricity for	State Department of Assessments and Taxation	Exempt sales and use tax for electricity used on farms and related to farming	Failed in House

	Agricultural Purposes			
HB1139	Solid Waste Disposal and Diversion and On-Farm Composting and Compost Use	Maryland Department of Agriculture & Maryland Department of the Environment	Creation of a statewide solid waste disposal surcharge program for collection and have MDE have varying grants and funds to support waste reduction	Unfavorable Report by House
HB0586 / SB0782	State Procurement - Purchasing - Compost, Mulch, and Soil Amendments and Aggregate	Department of General Services/State or Local unit in charge of public land maintenance	Create certain specifications and standards for procuring or purchasing compost, mulch, soil amendments, or aggregate for the use on public lands	Passed / Passed
HB0109	Task Force on Recycling Policy and Recycling and Waste Systems in Maryland	Maryland Department of the Environment, Legislative Bodies, & Community Groups	Creation of a task force to review, interpret, and recommend to the Maryland Recycling Act and waste facilities	Failed in Senate
HB1004 / SB0246	Wicomico County – Sanitary District – Authorization	Governing Body of Wicomico County	Creation of a Wicomico County sanitary district	Passed / Passed

Appendix E: California Digestion Program Fund and Environmental Justice

The California Department of Food and Agriculture (CDFA) Dairy Digester Research and Development Program (DDRDP) was established in 2014 to provide financial assistance for the installation of dairy digesters in California. The DDRDP aims to support the development and deployment of dairy digester technology to help California meet its greenhouse gas reduction goals, improve air and water quality, and create new economic opportunities for dairy farmers. The program provides grants for the installation of dairy digesters and associated equipment, as well as technical assistance and research to support the development and optimization of dairy digester systems. The DDRDP has been successful in promoting the adoption of dairy digester technology in California and has helped to establish the state as a leader in the development of renewable energy from dairy waste.

The applicants must provide information on their project's scope, objectives, technical approach, timeline, budget, and expected outcomes. They may also need to provide documentation on their experience and qualifications, partnerships or collaborations with other entities, and environmental or regulatory compliance. The proposals are evaluated based on various criteria, such as their potential to reduce greenhouse gas emissions, improve manure management, promote renewable energy, and benefit the local community and economy. The California program focuses solely on dairy manure, while the AWTF in Maryland deals with various types of animal waste. However, the California program has several key factors that could be helpful for the AWTF, including:

1. Environmental Assessment:
The applicant is required to estimate the net GHG emission reductions and co-benefits associated with the proposed project using the Benefits Calculator Tool. This tool is specifically designed for use with the DDRDP and can be downloaded at: www.arb.ca.gov/cci-resources.

Benefits Calculator Tool provides applicants with a clear picture of the estimated:

- Total DDRDP GHG emission reductions (metric tons of carbon dioxide equivalent (MTCO2e);
- Total GHG emission reductions (MTCO2e);
- Total GHG emission reductions per total DDRDP GGRF funds (MTCO2e/$); and
- Total GHG emission reductions per total funds (MTCO2e/$).
- Air Pollutant Emissions ROG emission reductions (lbs) for NOx emission reductions (lbs); PM2.5 emission reductions (lbs); and Diesel PM emission reductions (lbs)
- Fossil Fuel Use Reductions (onsite reductions) over 10 years (gallons)
- Energy and fuel cost savings ($);
- Renewable Fuel Generation over 10 years (gallons);
- Renewable Energy Generation over 10 years (kWh);
- Compost production (dry tons); and
- Compost application area (acres).

The evaluation criteria for the DDRDP funded by California Dept of Food and Agriculture (see: DDRDP_Request_for_Grant_Applications):

- Technical Feasibility: The extent to which the proposed project is technically feasible, including the proposed design and use of technology, the operational plan, and the qualifications and experience of the project team.
- GHG Emissions Reductions and Co-Benefits: The extent to which the proposed project is expected to achieve significant GHG emissions reductions, as well as co-benefits, such as air pollutant emissions reductions, fossil fuel use reductions, renewable energy generation, and compost production.
- Cost-Effectiveness: The extent to which the proposed project is cost-effective, including the total cost of the project, the amount of funding requested, and the expected net GHG emissions reductions per dollar of funding requested.
- Project Readiness: The extent to which the proposed project is ready to proceed, including the level of detail provided in the project description, the demonstrated ability of the project team to manage the project, and the availability of required permits and agreements.
- Community Engagement and Outreach: The extent to which the proposed project has engaged with and received support from the local community, including community members, local government, and local community organizations. This includes documentation of outreach efforts and letters of support.
- Impact on California Dairy Industry: The extent to which the proposed project is expected to have a positive impact on the California dairy industry, including increased economic viability, enhanced environmental stewardship, and improved manure management practices.

The evaluation criteria are aimed at ensuring that only the most promising and impactful proposals are selected for funding, with a focus on reducing GHG emissions and maximizing co-benefits for the environment and local communities. The language used in the evaluation criteria for GHG Emissions Reductions and Co-Benefits category of the DDRDP is below:

Estimated Greenhouse Gas Emissions Reductions:

- Described the proposed project and explained how it will result in reduction of metric tonnes of greenhouse gas (GHG) emissions annually compared to existing practices for the dairy.
- Completed the DDRDP Benefits Calculator Tool template. Proper justification for all assumptions made in the calculation process provided.
- Applicants reported GHG emission reduction results (in MTCO2e) as:
    - Total project emission reductions over 10 years;
    - GHG reductions per unit of energy-corrected milk (ECM) produced by the dairy operation over 10 years;
    - GHG reduction per dollar of DDRDP grant money requested over 10 years;

Environmental performance:

- NOx and Criteria Pollutants
    - Described the project's impact on criteria pollutants such as NOx, toxic air contaminants, and hazardous air pollutants. Included all potential emission sources and described how emissions will change before and after implementation of project. Provided supporting information/documents to support impacts and mitigation measures.

    - Is the biogas end-use in the project one that reduces or eliminates NOx emissions, such as RCNG generation for pipeline injection or transportation fuel?
- Project Co-Benefits
    - Described project co-benefits in detail. Described benefits achieved beyond methane reduction and mitigation of NOx, criteria air pollutants, toxic air contaminants, and hazardous air pollutant impacts, supplying energy at peak grid demand, guarantee local use of transportation fuel. Provided a detailed explanation of additional co-benefits such as: water conservation, value-added products, utilization of waste heat, reduction of odor, nutrient management and removal, development of value-added products, etc. Supporting documentation must show feasibility and plan for success of any proposed co-benefits. Any assumptions must be explained in sufficient detail.

2. Public acceptance and environmental justice

The DDRDP Request for Grant Applications provided valuable insights on environmental justice (EJ), including the following lessons:

- EJ is required for every application for funding to provide comprehensive details regarding any potential negative environmental impacts, along with a clear plan for mitigation measures.
- It is imperative to demonstrate that community outreach efforts have been conducted within the local community or county where the project is proposed, no more than 12 months prior to the application deadline.
- In-person community meetings are mandatory, while additional outreach through social media is acceptable, contingent upon the provision of supplementary metrics. Examples of such metrics may include analytics data, showcasing the number of views and shares, presentation or advertisement screenshots, and information pertaining to social media platforms utilized, as well as details regarding the methods used to notify the target audience of the outreach efforts.
- As part of the application process, it is required that applicants complete and submit the "CARB Community Engagement Questionnaire" (see link), comprising pages 1 to 3. This questionnaire is sourced from the Community Engagement Co-Benefit Assessment Methodology for California Climate Investments and has been made into a fillable table for enhanced convenience. Applicants are advised to refer to Section C of the complete methodology, which can be found at www.arb.ca.gov/cci-cobenefits, for guidance on responding to each question.
- In conjunction with the Community Impact template (see link), it is required that applicants provide supplementary materials, including: 1) Up to three letters of support from community members, local government, and local community organizations to substantiate outreach efforts; and 2) Supporting Materials: Documentation justifying responses to the priority population benefits questions must also be included.

The language utilized in the Evaluation Criteria for the DDRDP is presented below:

Community Outreach Actions by Applicant:

- Described how the community was engaged. Did community-based non-profit organization(s) involved in potentially impacted communities provide assistance in engagement efforts? Did the topic of discussion include potential adverse impacts of digester projects, including a net increase in criteria pollutants, toxic air contaminants,

hazardous air pollutants, groundwater and surface water impacts, and truck traffic and odor?
- Listed the public and/or government stakeholders involved.
- Provided details of community meetings, including but not limited to the method of notification, attendance, location, date/time, translation services provided, childcare provided, meals provided.

Mitigation Measures:
- The community outreach addressed in detail specific mitigation measures that will be included in the project, including but not limited to, methods to mitigate impacts such as toxic air contaminants, hazardous air pollutants, groundwater and surface water impacts, truck traffic, and odor.

Letters of Support:
- Provided support letters from community members and/or leaders demonstrating that outreach was conducted (up to 3).

Localized Economic Benefits
- Provided jobs-related information requested in the template (see link).

Benefits Priority Populations
- Provided direct, meaningful, and assured benefits to one or more priority populations AND meaningfully addresses an important community need.

The DDRDP Frequently Asked Questions section provided a number of relevant inquiries pertaining to Community Impact.

Q: Does CA Env Quality Act (CEQA) completion satisfy requirements for Community Impact?
Answer: The Community Impact criteria must be addressed by applicants prior to submission of applications. If the above requirements were fulfilled during the process for demonstration of CEQA compliance for the project, applicants must provide supporting documentation referencing page numbers as applicable. Reference section "Community Impact" of the RGA for more info.

Q: Can there be two digesters located within a short distance of each other?
Answer: The DDRDP does not restrict projects by location, however, each grant application must represent an individual digester project at a unique project site (i.e., dairy operation). Please note that the "Community Impact" specifications/guidelines will need to be addressed for each project.

Q: Can applicants include more than three letters of support?
Answer: The Community Impact section of the RGA requests that applicants submit "up to three letters of support…" with their application. Applicants may submit more than three letters of support, but they will not receive additional points in the scoring criteria.

Q: In the Application Questionnaire, how does the question "Is the project located within boundaries of a low-income household" differs from the question "Is the project located within the boundaries of a low-income community census tract"?

Answer: The definitions for ‘low-income household’ and ‘low-income community census tract’ are provided in Assembly Bill 1550 and summarized on the CARB Priority Populations Investments webpage that lists two tools: (i) Low-income Households tool to identify low-income households, (ii) Priority Population Maps tool to identify low-income community census tracts.