VIII. WATER AVAILABILITY ISSUES

The greatest challenges for water supply issues in the Deer Creek Watershed are population growth and urbanization within and adjacent to the watershed, as well as the potential impact of such growth on the ability of the resource to meet long-term needs for agricultural operations. In the following sections, population growth and water use projections are developed for the Deer Creek Watershed.

At the current time, a primary issue of concern is the BRAC plan for APG. Harford County is undertaking significant planning steps to address potential population growth associated with this BRAC (Harford County, 2007). Surface water and groundwater resources in the Deer Creek Watershed may be appropriate resources to support this future development outside the watershed. Similarly, the towns of Bel Air and portions of Stewartstown and Shrewsbury lie outside of and adjacent to the Deer Creek Watershed. As future population growth is anticipated to nucleate around existing communities and roads, these areas are also of concern. Other demands for water use outside of the Deer Creek Watershed are not specifically addressed in this report, however.

A natural water budget for the Deer Creek Watershed was presented previously in this report. In this section, we present additional evaluations of water availability, taking into account existing and future (projected) water uses and losses. Two primary tools are used to evaluate possible conflicts related to future availability: (1) tables of water supply and demand are used to estimate the timing and locations of potential conflicts; and (2) a numerical model that simulates groundwater and surface water interactions is used to evaluate the timing of impacts on the watershed for hypothetical new appropriations.

A. Establishing Available Water Resources

To assess the availability of water resources in the Deer Creek Watershed for future allocation, water balance analyses for both average and drought years were developed. The analyses followed water allocation techniques of the SRBC and MDE Water Supply Program. These calculations are conservative and designed to assist regulators in assessing water availability rather than reflect the "natural" water budget. The assumptions used in the analyses include:

- Water use values are based upon the quantities of water permitted for each user rather than the amounts actually withdrawn. Most permit holders do not typically use their full allocation on a routine basis.
- The water use values represent the quantities of water withdrawn, not the quantity of water consumptively used (see Section I). Much of the water withdrawn is eventually returned through wastewater discharges or via on-lot septic systems. However, there is not good information available for the quantity returned, particularly for un-permitted uses, and there is little information on the quantity of Deer Creek water that is returned to watersheds outside Deer Creek, although a portion of it certainly is.
- The total available water supply is derived solely from base flow rather than total flow. Even during prolonged droughts, sporadic rainfall will temporarily boost

streamflows. That additional water is not significant and is not taken into account in this analysis.

- Because the base flow values used here are derived from the stream field measurements completed in 2006 and the historical gaged streamflow data, they are impacted by the consumptive use of water occurring in the watershed. As a result, these derived base flow values are slightly less than the natural base flow values. The quantity of consumptive use is a small percentage of the total available water (Table 13), so use of the derived base flow values should be an acceptable and conservative proxy for total natural base flow.

For the purposes of the water balance analyses, the maximum amount of water available for future use in the watershed is calculated to be the portion of base flow remaining after existing allocations and uses are taken into account. The most obvious of these are permitted users (such as industries and municipal water suppliers) and other generally un-permitted uses such as small agricultural operations and domestic wells. Estimated totals for these uses were developed previously in this report and are deducted from the base flow quantity for these water balance analyses.

There is also a less obvious use of the base flow in Deer Creek that must be considered; commonly referred to as the passby or flowby, it is the amount of water deemed necessary for preserving riparian and habitat needs. It is the policy of MDE and SRBC in approving water uses that a withdrawal cannot continue if flow conditions on the stream decline below the passby. In a sense, this policy is an allocation of water for riparian/aquatic needs; thus the passby is also deducted from the base flow when performing a water balance.

SRBC Policy No. 2003-01, dated November 8, 2002, offers guidelines on the determination of passby flows for the protection of aquatic resources and other uses, and the prevention of water quality degradation and adverse lowering of streamflow levels downstream from the point of a withdrawal. The passby determination is based on the location, drainage, state-designated stream classification, published species and habitat condition information, and state fishery management classification of the stream. In no case is the recommended passby less than the 7Q10 flow, and conditions usually dictate that a more protective level be imposed. Such was the case on Deer Creek at the site of the intake near Darlington used to service APG; local fishery needs suggested that a seasonal passby was appropriate. The passby during March, April, May, and June was determined to be the flow equal to 30 percent of the calculated average daily flow (ADF) at the site of the intake (69 cfs) and 20 percent of the ADF (46 cfs) the remainder of the year. At this particular site, 20 percent of ADF was approximately equal to the calculated 7Q10 value. It is these passby flows that were used in the water balance analysis.

Using the procedure described in the paragraphs above, Table 14 presents water balances for the watershed at a point located approximately at Darlington, subdivided by month of use. The average water balance is based upon the 30-year normal total flow at the USGS gage at Rocks, Maryland, adjusted to the Darlington gage site using techniques discussed earlier in this report. The 1-in-10-year drought flow is based upon the three lowest flow years (or tenth percentile; 1981, 2001, and 2002) for the same period. For the drought year calculation, the un-permitted water use amount was multiplied by a factor of 1.4 to account for the increase in water use typically seen during droughts.

Table 14. Monthly Comparison of Available and Allocated Water in Average and Drought Years, Using the SRBC Passby Flow at Darlington

	Total Flow at Rocks (cfs)	Base Flow at Rocks [1] (cfs)	Base Flow at Darlington [2] (cfs)	Seasonal Passby Amount [3] (cfs)	Permitted Use Upstream of Darlington (cfs)	Un-permitted Use Upstream of Darlington [4] (cfs)	Permitted Use for APG (cfs)	Undedicated Resource (cfs)
Average – 30-Year Normal (1974 to 2005)								
Jan	161.9	108.5	181.1	-46	-3.64	-3.09	-4.62	123.76
Feb	166.6	111.6	186.4	-46	-3.64	-3.09	-4.62	129.05
Mar	187.1	125.4	209.4	-69	-3.64	-3.09	-4.62	129.04
Apr	173.8	116.4	194.4	-69	-3.64	-3.09	-4.62	114.06
May	159.4	106.8	178.3	-69	-3.64	-3.09	-4.62	97.95
Jun	128.4	86.0	143.7	-69	-3.64	-3.09	-4.62	63.32
Jul	105.0	70.3	117.4	-46	-3.64	-3.09	-4.62	60.09
Aug	78.8	52.8	88.2	-46	-3.64	-3.09	-4.62	30.85
Sep	93.9	62.9	105.1	-46	-3.64	-3.09	-4.62	47.70
Oct	91.7	61.4	102.6	-46	-3.64	-3.09	-4.62	45.21
Nov	106.1	71.1	118.7	-46	-3.64	-3.09	-4.62	61.39
Dec	131.3	88.0	146.9	-46	-3.64	-3.09	-4.62	89.53
1-in-10-Year Drought of 30-Year Normal (1974 to 2005)								
Jan	57.9	38.8	64.8	-46	-3.64	-4.33	-4.62	6.21
Feb	89.5	60.0	100.2	-46	-3.64	-4.33	-4.62	41.59
Mar	92.4	61.9	103.4	-69	-3.64	-4.33	-4.62	21.80
Apr	92.1	61.7	103.1	-69	-3.64	-4.33	-4.62	21.46
May	73.9	49.5	82.7	-69	-3.64	-4.33	-4.62	1.15
Jun	62.9	42.1	70.3	-69	-3.64	-4.33	-4.62	-11.25
Jul	41.1	27.5	46.0	-46	-3.64	-4.33	-4.62	-12.63
Aug	35.0	23.5	39.2	-46	-3.64	-4.33	-4.62	-19.41
Sep	32.1	21.5	35.9	-46	-3.64	-4.33	-4.62	-22.71
Oct	45.1	30.2	50.4	-46	-3.64	-4.33	-4.62	-8.15
Nov	56.6	37.9	63.4	-46	-3.64	-4.33	-4.62	4.76
Dec	73.3	49.1	82.0	-46	-3.64	-4.33	-4.62	23.38

[1] Calculated as 67 percent of total flow.
[2] Calculated as 1.67 times the base flow at Rocks.
[3] Using the SRBC passby condition for the intake at Darlington serving APG.
[4] Based upon estimated population of 25,000 not connected to public water.

As can be seen from Table 14 and Figure 24, under existing conditions, the cumulative demand at Darlington currently exceeds the available flow during the period June through October in the 1-in-10 drought years. Under average conditions, supply exceeds demand by approximately 30 cfs during the lowest flow month of August.

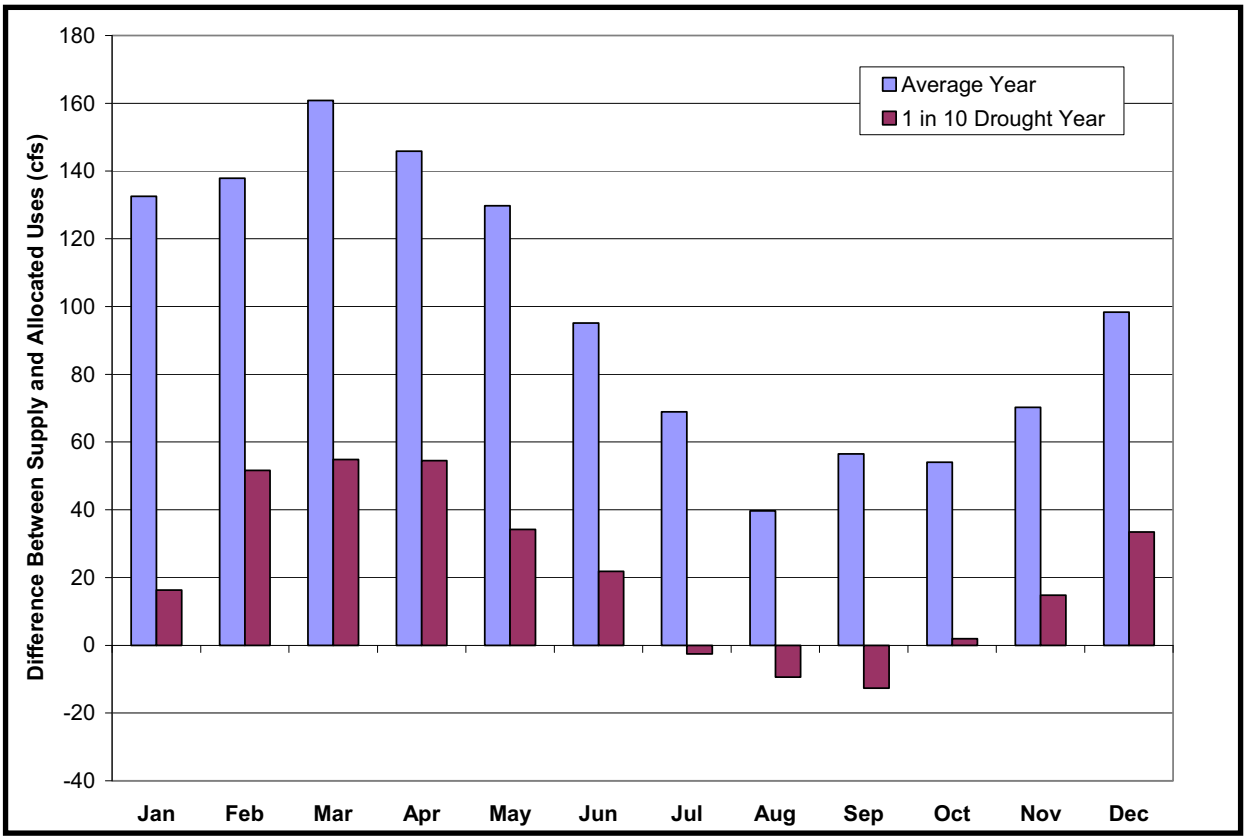

Figure 24. Monthly Comparison of Available and Allocated Water – Average and Drought Years

To demonstrate the importance of the passby flow in water allocations, the same analysis was performed using another standard, the Maryland Method. Unlike the 7Q10 calculation, which uses an analysis of annual data, the Maryland Method uses statistics based on monthly flow data, which recognizes that each month of the year has its own natural flow pattern that can differ significantly from other months. As a result, the method is more responsive to instream needs through the course of the year and is thus theoretically better at protecting aquatic habitat than the 7Q10. Also, the 7Q10 was never intended as a habitat protection measure, and actually has its origins in designs for the assimilation of wastewater discharges.

To implement an example of the Maryland Method, the monthly flow data at the Rocks gage were analyzed to extract the 85 percent exceedence value for each month over the period of record. The method then entails grouping months into seasons based on similarity of flow patterns, and deriving another exceedence value for the season. The method yielded a winter/spring passby of 89 cfs and a summer/fall passby of 57 cfs; both limits are considerably greater than the 7Q10 value at Darlington and the passby enforced by SRBC and MDE for the intake serving APG. Correspondingly, the comparison of available and allocated water in Table 15 shows greater deficits in more months.

Table 15. Monthly Comparison of Available and Allocated Water in Average and Drought Years, Using the Maryland Method for Passby Flow

	Total Flow at Rocks (cfs)	Base Flow at Rocks [1] (cfs)	Base Flow at Darlington [2] (cfs)	Seasonal Passby Amount [3] (cfs)	Permitted Use Upstream of Darlington (cfs)	Un-permitted Use Upstream of Darlington [4] (cfs)	Permitted Use for APG (cfs)	Undedicated Resource (cfs)
Average – 30-Year Normal (1974 to 2005)								
Jan	161.9	108.5	181.1	-89	-3.64	-3.09	-4.62	80.76
Feb	166.6	111.6	186.4	-89	-3.64	-3.09	-4.62	86.05
Mar	187.1	125.4	209.4	-89	-3.64	-3.09	-4.62	109.04
Apr	173.8	116.4	194.4	-89	-3.64	-3.09	-4.62	94.06
May	159.4	106.8	178.3	-89	-3.64	-3.09	-4.62	77.95
Jun	128.4	86.0	143.7	-89	-3.64	-3.09	-4.62	43.32
Jul	105.0	70.3	117.4	-57	-3.64	-3.09	-4.62	49.09
Aug	78.8	52.8	88.2	-57	-3.64	-3.09	-4.62	19.85
Sep	93.9	62.9	105.1	-57	-3.64	-3.09	-4.62	36.70
Oct	91.7	61.4	102.6	-57	-3.64	-3.09	-4.62	34.21
Nov	106.1	71.1	118.7	-57	-3.64	-3.09	-4.62	50.39
Dec	131.3	88.0	146.9	-89	-3.64	-3.09	-4.62	46.53
1-in-10-Year Drought of 30-Year Normal (1974 to 2005)								
Jan	57.9	38.8	64.8	-89	-3.64	-4.33	-4.62	-36.79
Feb	89.5	60.0	100.2	-89	-3.64	-4.33	-4.62	-1.41
Mar	92.4	61.9	103.4	-89	-3.64	-4.33	-4.62	1.80
Apr	92.1	61.7	103.1	-89	-3.64	-4.33	-4.62	1.46
May	73.9	49.5	82.7	-89	-3.64	-4.33	-4.62	-18.85
Jun	62.9	42.1	70.3	-89	-3.64	-4.33	-4.62	-31.25
Jul	41.1	27.5	46.0	-57	-3.64	-4.33	-4.62	-23.63
Aug	35.0	23.5	39.2	-57	-3.64	-4.33	-4.62	-30.41
Sep	32.1	21.5	35.9	-57	-3.64	-4.33	-4.62	-33.71
Oct	45.1	30.2	50.4	-57	-3.64	-4.33	-4.62	-19.15
Nov	56.6	37.9	63.4	-57	-3.64	-4.33	-4.62	-6.24
Dec	73.3	49.1	82.0	-89	-3.64	-4.33	-4.62	-19.62

[1] Calculated as 67 percent of total flow.
[2] Calculated as 1.67 times the base flow at Rocks.
[3] Using the Maryland Method.
[4] Based upon estimated population of 25,000 not connected to public water.

Another way to assess water availability is to perform an analysis of the frequency of occurrence of the passby flow designated for a stream reach. To illustrate this technique, the flow record developed for the Darlington gage was subjected to the seasonal passby imposed on the intake that serves APG. Tabulation was made of days exhibiting a flow below the appropriate seasonal passby, and the number of days was totaled for each year. The results are shown on Figure 25. Although the occurrence of flows less than the passby is not that frequent – in only 13 of 82 years, or 16 percent – the implication is that the source is unavailable on average about once every 6 years. The duration of the unavailability is also worth noting; in 4 years, it is

for a month or more, and in 2 additional years, it is for a period of 2 to 3 weeks. An interruption of that frequency and/or duration is sufficient to render a water supply unreliable.

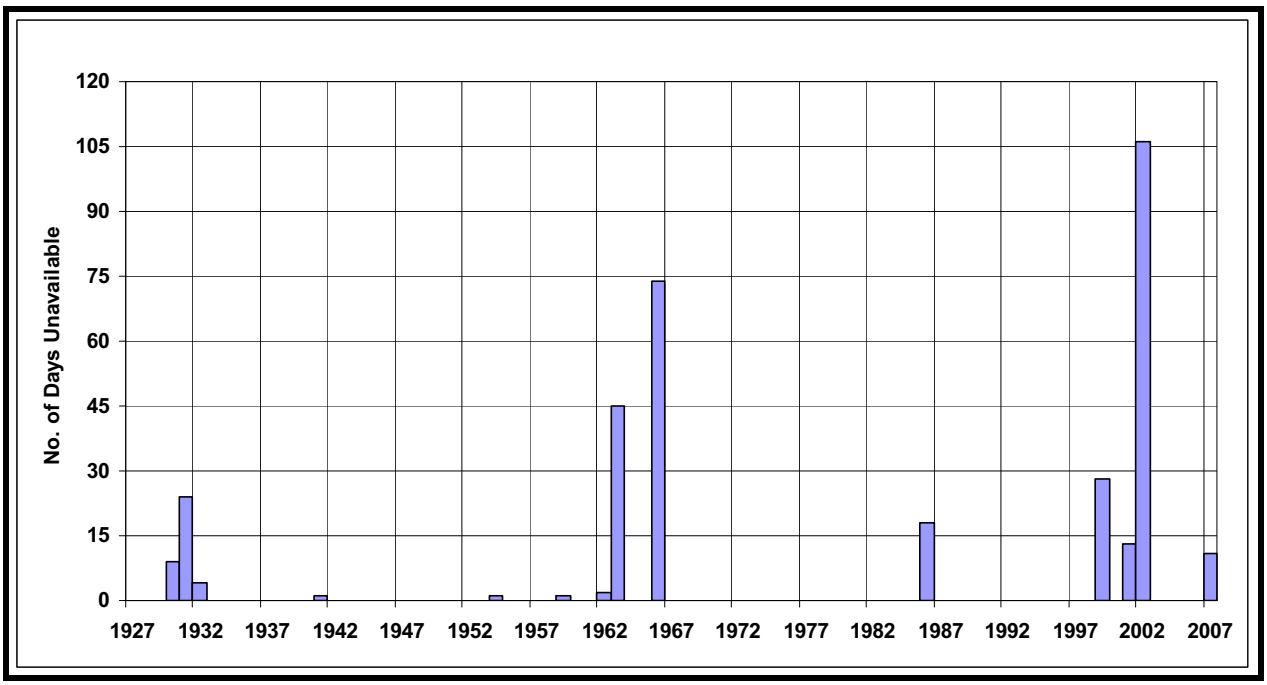

Figure 25. Occurrences of Passby Flow at Darlington

To better consider the geographic impact of water demands across the watershed, the availability of water for allocation was also evaluated by subwatersheds. Table 16 lists water availability for average year conditions, and Table 17 lists water availability for drought year conditions. Existing permitted user demands were allocated to the subwatershed in which the permitted source is located. Un-permitted residential use was incorporated using a general population density of 0.27 persons per acre (173 persons per square mile), applied evenly across the watershed. This population density is estimated from the watershed population, excluding those York County residents assumed to be receiving public water supply. Public water systems in these areas provide a substantial portion of the supply and are already accounted for under the permitted amounts. Therefore, no additional un-permitted demand was incorporated for the Deer Creek Headwaters or Ebaugh's Creek subwatersheds. The total available water for each subwatershed was estimated as base flow originating as recharge within the subwatershed. This is, of course, not an entirely accurate assumption, as water available for use within a subwatershed may originate from upstream in the main stem of Deer Creek. Nonetheless, this approach provides some insight into the impact of permitting for groundwater use and surface water use from Deer Creek tributaries.

Table 16. Average Year Allocation of Water Resources

	Sub-watershed	Basin Area (mi^2)	Base Flow [2] (cfs/mi^2)	Base Flow in Watershed [2] (cfs)	Permitted Water Use [3] (cfs)	Un-permitted Residential Use (cfs @ 0.27 person/acre)	7Q10 Passby Allowance (cfs)	Undedicated Base Flow (cfs)	Percentage of Base Flow Undedicated
Cool Branch Run	1	2.47	0.77	1.91	-0.01	-0.05	-0.65	1.19	63%
Stout Bottle Branch - Cabbage Run	2	7.25	1.02	7.39	-0.12	-0.16	-1.90	5.21	71%
Thomas Run	3	8.13	0.77	6.26	-0.05	-0.17	-2.14	3.90	62%
Mill Brook	4	4.67	0.77	3.60	-0.03	-0.10	-1.23	2.24	62%
Hollands Branch	5	3.38	0.77	2.60	-0.03	-0.07	-0.89	1.61	62%
UNT at Thomas Bridge Rd	6	4.36	1.02	4.45	-0.28	-0.09	-1.15	2.93	66%
Saint Omer Branch [1]	7	11.25	0.90	10.07	-0.06	-0.24	-2.95	6.81	68%
Deer Creek – Mid	8	5.29	1.02	5.40	-0.01	-0.11	-1.39	3.89	72%
South Stirrup - North Stirrup Run	9	6.55	1.02	6.68	-0.01	-0.14	-1.72	4.81	72%
Rock Hollow - Kellogg - Gladden Branches	10	12.50	1.02	12.75	-0.23	-0.27	-3.28	8.97	70%
UNT south of Falling Branch	11	0.63	1.02	0.64	-0.01	-0.01	-0.16	0.45	71%
UNT west of Falling Branch	12	0.38	1.02	0.39	0.00	-0.01	-0.10	0.28	72%
Little Deer Creek	13	14.36	1.02	14.64	-0.02	-0.31	-3.77	10.54	72%
Falling Branch	14	6.47	1.02	6.60	-0.01	-0.14	-1.70	4.75	72%
Big Branch	15	7.99	1.02	8.15	-0.00	-0.17	-2.10	5.88	72%
Island - Jackson - Plumtree Branches	16	29.01	1.02	29.59	-0.18	-0.62	-7.62	21.17	72%
Ebaugh's Creek	17	6.91	1.02	7.05	-0.65	0	-1.81	4.58	65%
Deer Creek Headwaters	18	17.33	1.02	17.68	-0.55	0	-4.55	12.58	71%
Graveyard Creek	19	1.62	0.77	1.24	-0.01	-0.03	-0.42	0.78	62%
Hopkins Branch	20	2.28	0.77	1.76	-0.01	-0.05	-0.60	1.10	63%
Tobacco Run	21	7.99	0.77	6.15	-0.16	-0.17	-2.10	3.72	61%
Buck Branch - Elbow Branch [3]	22	10.26	0.77	7.90	-0.01	-0.22	-2.69	4.98	63%
UNT east of Hollands Branch	23	0.05	0.77	0.04	0.00	-0.00	-0.01	0.03	63%
Entire Watershed		**171.13**		**162.93**	**-2.44**	**-3.14**	**-44.93**	**112.42**	**69%**

[1] Half of this watershed subject to 1.02 cfs/mi^2 recharge, and half subject to 0.77 cfs/mi^2 recharge.
[2] Value includes current consumptive use.
[3] Excluding APG permitted amount of 4.6 cfs.

Table 17. Drought Year Allocation of Water Resources

	Sub-watershed	Base Flow in Watershed [2] (cfs)	Drought Year Base Flow [3] (cfs)	Permitted Water Use (cfs)	Un-permitted Residential Use [4] (@ 0.27 person/acre)	Permitted and Un-permitted Water Use - Drought Year	7Q10 Passby Allowance (cfs)	Undedicated Base Flow (cfs)	Percentage of Base Flow Undedicated
Cool Branch Run	1	1.91	0.94	-0.01	-0.07	-0.08	-0.65	0.21	22%
Stout Bottle Branch - Cabbage Run	2	7.39	3.66	-0.12	-0.22	-0.34	-1.90	1.42	39%
Thomas Run	3	6.26	3.10	-0.05	-0.24	-0.29	-2.14	0.68	22%
Mill Brook	4	3.60	1.78	-0.03	-0.14	-0.17	-1.23	0.39	22%
Hollands Branch	5	2.60	1.29	-0.03	-0.10	-0.13	-0.89	0.27	21%
UNT at Thomas Bridge Rd	6	4.45	2.21	-0.28	-0.13	-0.41	-1.15	0.65	29%
Saint Omer Branch [1]	7	10.07	4.99	-0.06	-0.34	-0.40	-2.95	1.64	33%
Deer Creek – Mid	8	5.40	2.68	-0.01	-0.16	-0.17	-1.39	1.12	42%
South Stirrup - North Stirrup Run	9	6.68	3.31	-0.01	-0.20	-0.21	-1.72	1.38	42%
Rock Hollow - Kellogg - Gladden Branches	10	12.75	6.32	-0.23	-0.37	-0.61	-3.28	2.43	38%
UNT south of Falling Branch	11	0.64	0.32	-0.01	-0.02	-0.03	-0.16	0.13	40%
UNT west of Falling Branch	12	0.39	0.19	0.00	-0.01	-0.01	-0.10	0.08	42%
Little Deer Creek	13	14.64	7.26	-0.02	-0.43	-0.45	-3.77	3.04	42%
Falling Branch	14	6.60	3.27	-0.01	-0.19	-0.20	-1.70	1.37	42%
Big Branch	15	8.15	4.04	-0.00	-0.24	-0.24	-2.10	1.70	42%
Island - Jackson - Plumtree Branches	16	29.59	14.67	-0.18	-0.87	-1.04	-7.62	6.01	41%
Ebaugh's Creek	17	7.05	3.49	-0.65	0	-0.65	-1.81	1.03	29%
Deer Creek Headwaters	18	17.68	8.76	-0.55	0	-0.55	-4.55	3.66	42%
Graveyard Creek	19	1.24	0.62	-0.01	-0.05	-0.06	-0.42	0.13	22%
Hopkins Branch	20	1.76	0.87	-0.01	-0.07	-0.08	-0.60	0.19	22%
Tobacco Run	21	6.15	3.05	-0.16	-0.24	-0.40	-2.10	0.55	18%
Buck Branch - Elbow Branch [3]	22	7.90	3.91	-0.01	-0.31	-0.32	-2.69	0.91	23%
UNT east of Hollands Branch	23	0.042	0.021	0.00	-0.002	-0.002	-0.01	0.005	23%
Entire Watershed		**163**	**80.76**	**-2.44**	**-4.40**	**-6.84**	**-44.93**	**29.00**	**36%**

[1] Half of this watershed subject to 1.02 cfs/mi^2 recharge, and half subject to 0.77 cfs/mi^2 recharge.
[2] Value includes current consumptive use.
[3] Excluding APG permitted amount of 4.6 cfs.
[4] Residential use increased by 40 percent in drought year.

Comparison of Tables 16 and 17 indicates that during average and drought years, the total amount of allocated water on an *annual* basis is less than the total available resource on an *annual* basis. To further investigate the geographic and temporal impact of water demands across the watershed, the availability of water for allocation was evaluated at three subwatersheds, subdivided by month of use. The three watersheds selected for analysis were Ebaugh's Creek, Deer Creek Headwaters, and Hopkins Branch subwatersheds. Tables 18, 19, and 20 list water availability for average 30-year normal and 1-in-10-year drought conditions at the selected subwatersheds. Figures 26, 27, and 28 depict cumulative demand compared to available flow, on a monthly basis, under average and drought year conditions at the selected subwatersheds.

As can be seen from Tables 18, 19, and 20 and Figures 26, 27, and 28, under existing conditions, the cumulative demand at each of the selected subwatersheds currently exceeds the available flow during August and September in the 1-in-10 drought years. In addition, cumulative demand also currently exceeds the available flow during July at Ebaugh's Creek subwatershed, and during June, July, and October at Hopkins Branch subwatershed, in drought years. Under average conditions for each of the selected subwatersheds, supply exceeds demand by an approximate minimum of 46 percent during the lowest flow month of September.

Table 18. Monthly Comparison of Available and Allocated Water at Ebaugh's Creek Subwatershed – Average and Drought Years

	Base Flow at Ebaugh's Creek (cfs)	Permitted Water Use (cfs)	Un-permitted Residential Use (cfs @ 0.27 person/acre)	Transferred Passby Allowance (cfs)	Undedicated Base Flow (cfs)	Percentage of Base Flow Undedicated
Average – 30-Year Normal (1974 to 2005)						
Jan	8.64	-0.65	0.00	-1.86	6.13	71%
Feb	8.89	-0.65	0.00	-1.86	6.39	72%
Mar	9.99	-0.65	0.00	-2.78	6.55	66%
Apr	9.27	-0.65	0.00	-2.78	5.84	63%
May	8.51	-0..65	0.00	-2.78	5.07	60%
Jun	6.85	-0.65	0.00	-2.78	3.42	50%
Jul	5.60	-0.65	0.00	-1.86	3.10	55%
Aug	4.21	-0.65	0.00	-1.86	1.70	40%
Sep	5.01	-0.65	0.00	-1.86	2.51	50%
Oct	4.89	-0.65	0.00	-1.86	2.39	49%
Nov	5.66	-0.65	0.00	-1.86	3.16	56%
Dec	7.01	-0.65	0.00	-1.86	4.50	64%
1-in-10-Year Drought of 30-Year Normal (1974 to 2005)						
Jan	3.23	-0.65	0.00	-1.86	0.72	22%
Feb	4.99	-0.65	0.00	-1.86	2.48	50%
Mar	5.15	-0.65	0.00	-2.78	1.72	33%
Apr	5.13	-0.65	0.00	-2.78	1.70	33%
May	4.12	-0..65	0.00	-2.78	0.69	17%
Jun	3.50	-0.65	0.00	-2.78	0.07	2%
Jul	2.29	-0.65	0.00	-1.86	-0.22	-9%
Aug	1.95	-0.65	0.00	-1.86	-0.55	-28%
Sep	1.79	-0.65	0.00	-1.86	-0.72	-40%
Oct	2.51	-0.65	0.00	-1.86	0.01	0%
Nov	3.16	-0.65	0.00	-1.86	0.65	21%
Dec	4.08	-0.65	0.00	-1.86	1.58	39%

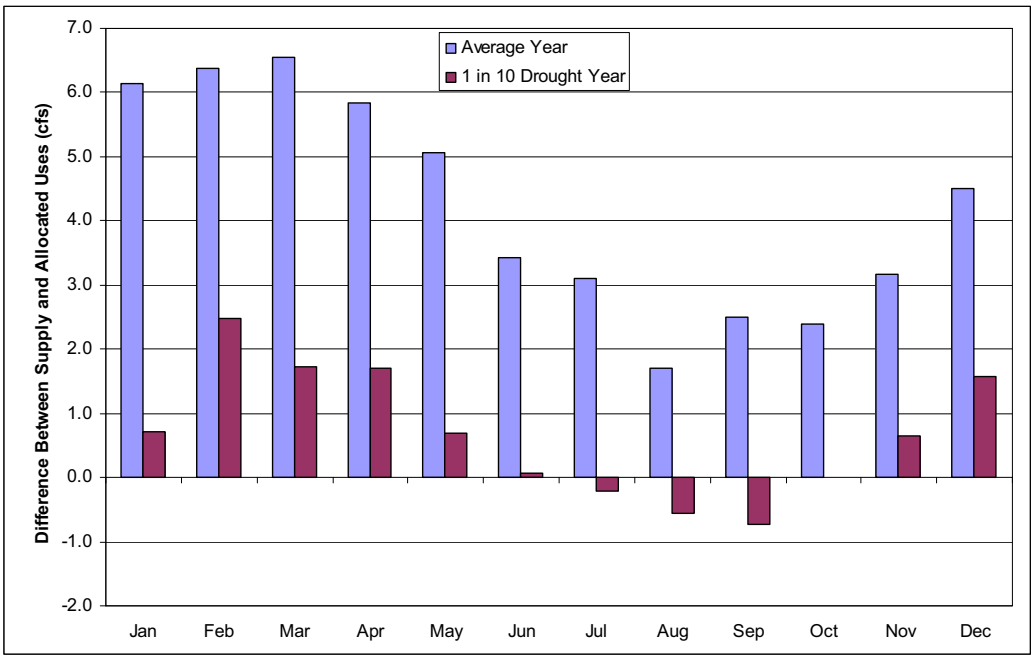

Figure 26. Monthly Comparison of Available and Allocated Water at Ebaugh's Creek Subwatershed – Average and Drought Years

Table 19. Monthly Comparison of Available and Allocated Water at Deer Creek Headwaters Subwatershed – Average and Drought Years

	Base Flow at Deer Creek Headwaters (cfs)	Permitted Water Use (cfs)	Un-permitted Residential Use (cfs @ 0.27 person/acre)	Transferred Passby Allowance (cfs)	Undedicated Base Flow (cfs)	Percentage of Base Flow Undedicated
Average – 30-Year Normal (1974 to 2005)						
Jan	21.68	-0.55	0.00	-4.66	16.47	76%
Feb	22.32	-0.55	0.00	-4.66	17.11	77%
Mar	25.07	-0.55	0.00	-6.99	17.53	70%
Apr	23.28	-0.55	0.00	-6.99	15.74	68%
May	21.35	-0.55	0.00	-6.99	13.81	65%
Jun	17.20	-0.55	0.00	-6.99	9.66	56%
Jul	14.06	-0.55	0.00	-4.66	8.85	63%
Aug	10.56	-0.55	0.00	-4.66	5.35	51%
Sep	12.58	-0.55	0.00	-4.66	7.37	59%
Oct	12.28	-0.55	0.00	-4.66	7.07	58%
Nov	14.22	-0.55	0.00	-4.66	9.01	63%
Dec	17.58	-0.55	0.00	-4.66	12.38	70%
1-in-10-Year Drought of 30-Year Normal (1974 to 2005)						
Jan	8.10	-0.55	0.00	-4.66	2.89	36%
Feb	12.52	-0.55	0.00	-4.66	7.31	58%
Mar	12.93	-0.55	0.00	-6.99	5.39	42%
Apr	12.88	-0.55	0.00	-6.99	5.34	41%
May	10.34	-0.55	0.00	-6.99	2.80	27%
Jun	8.79	-0.55	0.00	-6.99	1.25	14%
Jul	5.75	-0.55	0.00	-4.66	0.54	9%
Aug	4.90	-0.55	0.00	-4.66	-0.31	-6%
Sep	4.49	-0.55	0.00	-4.66	-0.72	-16%
Oct	6.31	-0.55	0.00	-4.66	1.10	17%
Nov	7.92	-0.55	0.00	-4.66	2.71	34%
Dec	10.25	-0.55	0.00	-4.66	5.04	49%

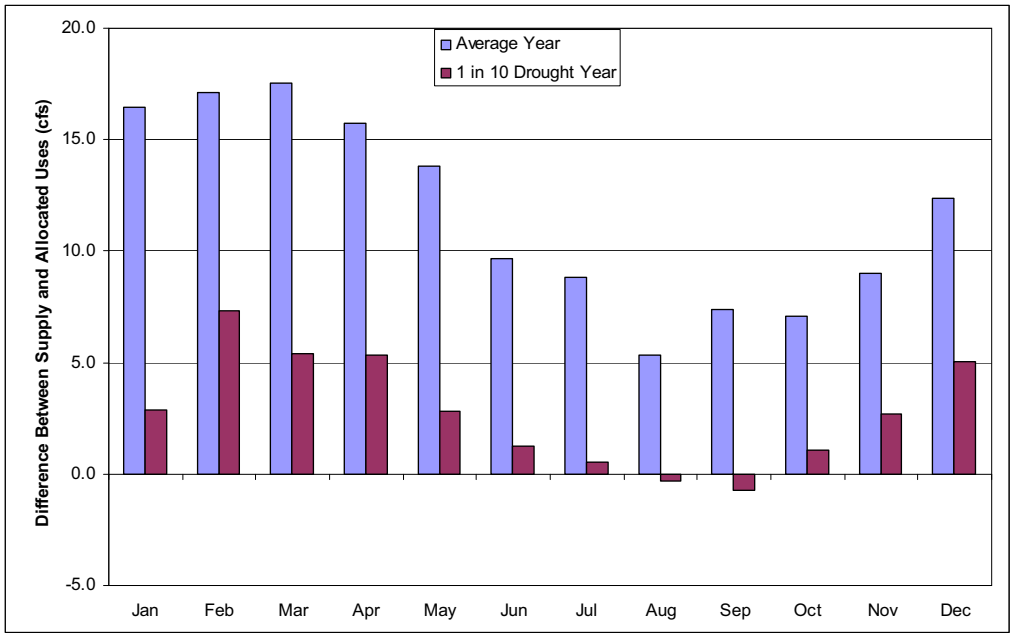

Figure 27. Monthly Comparison of Available and Allocated Water at Deer Creek Headwaters Subwatershed – Average and Drought Years

Table 20. Monthly Comparison of Available and Allocated Water at Hopkins Branch Subwatershed – Average and Drought Years

	Base Flow at Hopkins Branch (cfs)	Permitted Water Use (cfs)	Un-permitted Residential Use (cfs @ 0.27 person/acre)	Transferred Passby Allowance (cfs)	Undedicated Base Flow (cfs)	Percentage of Base Flow Undedicated
Average – 30-Year Normal (1974 to 2005)						
Jan	2.16	-0.01	-0.05	-0.61	1.48	69%
Feb	2.22	-0.01	-0.05	-0.61	1.55	70%
Mar	2.49	-0.01	-0.05	-0.61	1.51	61%
Apr	2.31	-0.01	-0.05	-0.61	1.34	58%
May	2.12	-0.01	-0.05	-0.61	1.14	54%
Jun	1.71	-0.01	-0.05	-0.61	0.73	43%
Jul	1.40	-0.01	-0.05	-0.61	0.73	52%
Aug	1.05	-0.01	-0.05	-0.61	0.38	36%
Sep	1.25	-0.01	-0.05	-0.61	0.58	46%
Oct	1.22	-0.01	-0.05	-0.61	0.55	45%
Nov	1.41	-0.01	-0.05	-0.61	0.74	52%
Dec	1.75	-0.01	-0.05	-0.61	1.08	62%
1-in-10-Year Drought of 30-Year Normal (1974 to 2005)						
Jan	0.81	-0.01	-0.07	-0.61	0.11	14%
Feb	1.24	-0.01	-0.07	-0.61	0.55	44%
Mar	1.28	-0.01	-0.07	-0.61	0.29	22%
Apr	1.28	-0.01	-0.07	-0.61	0.28	22%
May	1.03	-0.01	-0.07	-0.61	0.03	3%
Jun	0.87	-0.01	-0.07	-0.61	-0.12	-14%
Jul	0.57	-0.01	-0.07	-0.61	-0.12	-21%
Aug	0.49	-0.01	-0.07	-0.61	-0.20	-42%
Sep	0.45	-0.01	-0.07	-0.61	-0.25	-55%
Oct	0.63	-0.01	-0.07	-0.61	-0.06	-10%
Nov	0.79	-0.01	-0.07	-0.61	0.10	12%
Dec	1.02	-0.01	-0.07	-0.61	0.33	32%

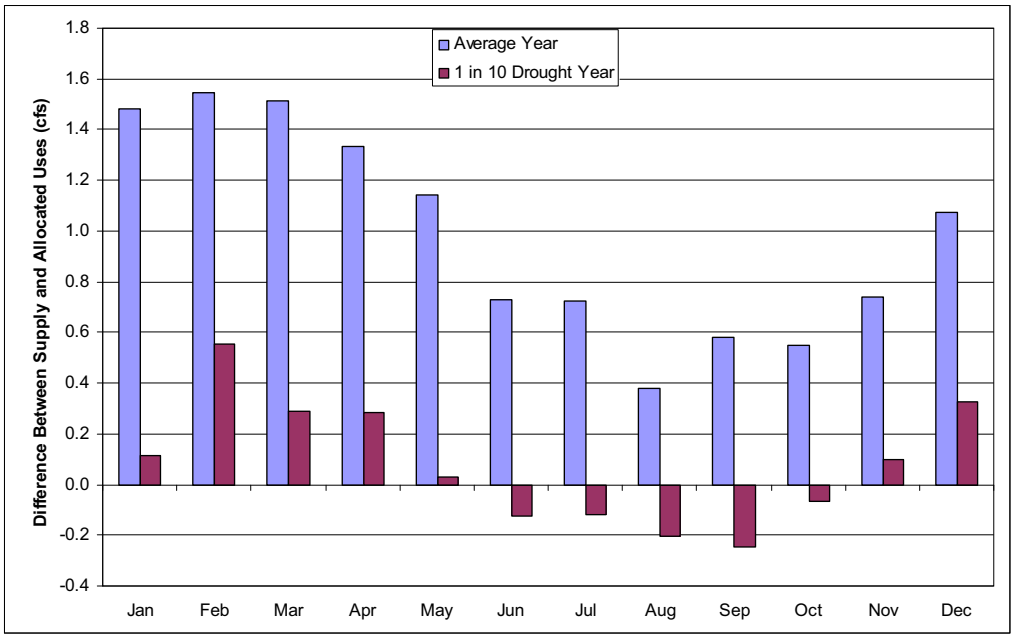

Figure 28. Monthly Comparison of Available and Allocated Water at Hopkins Branch Subwatershed – Average and Drought Years

Table 21 summarizes base flow, water uses, and available water for the entire watershed for an average year, a drought year, and a month within the drought year that is subject to the maximum groundwater use (typically August, September, or October). For consistency with the tables that follow, Table 21 is presented in terms of total gallons of use per year (or month), rather than cfs, and is expressed in billion-gallons. The available (or unavailable) gallons are then used to estimate the population that the water can serve. The yearly flow required to meet Aberdeen's permit conditions reflects 8 months at 46 cfs and 4 months at 69 cfs.

Table 21. Average Year, Drought Year, and Maximum Month Allocation of Water Resources

	Average Year		**1-in-10 Drought Year**		**Maximum Month Aug, Sept, or Oct**	
Available Base Flow						
Average Base Flow Infiltration to the Watershed	38.44	BGallons	19.05	BGallons	0.72	BGallons
Current Use						
Permitted Groundwater Withdrawals	-0.58	BGallons	-0.58	BGallons	-0.05	BGallons
Estimated Un-permitted Groundwater Withdrawals	-0.74	BGallons	-1.04	BGallons	-0.09	BGallons
Total Groundwater Consumption	-1.32	BGallons	-1.61	BGallons	-0.14	BGallons
Currently Available Base Flow						
	37.12	BGallons	17.44	BGallons	0.58	BGallons
Required Flow Passby						
Aberdeen Permit Conditions	-12.66	BGallons	-12.66	BGallons	-0.90	BGallons
Residual Groundwater Resources						
	24.46	BGallons	4.78	BGallons	-0.32	BGallons
Surplus/Deficit Population Supported						
(Represented as Residential Users @ 80, 112, and 134 gpd)	837,671	People	116,927	People	-69,879	People

B. Ten- and Twenty-Five-Year Population Projections

To assess the future demand for water within the Deer Creek Watershed, population and water demand estimates were developed. The primary sources of information were Year 2000 U.S. Census Bureau data, and population data and projections provided by Harford, Baltimore, and York Counties. All three counties provided tabulated and graphic population projections organized by Transportation Zone (TZ). Using GIS methods, the subwatershed delineation was overlain onto the TZ data. Where TZ data overlapped multiple subwatersheds or the periphery of the Deer Creek Watershed, the TZ was subdivided on the basis of area falling within each subwatershed.

The most densely populated portion of the Deer Creek Watershed is in York County, Pennsylvania. The York County Planning Commission provided current and projected population estimates for the Boroughs of Shrewsbury and Stewartstown and the Townships of Hopewell and Shrewsbury. This dataset was presented based on the County's methodology, which integrates a population trend analysis, 1930-forward, using standard projection techniques.

For comparison purposes, the GIS-compatible 2000 TZ data for York County were obtained and adjusted based on the watershed boundary to account for TZ populations within the watershed. A comparison with the tabular municipality data provided by the county showed that the GIS methodology produced population estimates for York County that were approximately 50 percent lower than data produced using standard projection techniques. The cause for the discrepancy is the assumption that the populations in the TZs are evenly distributed throughout, instead of clustered in and near the Boroughs of Shrewsbury and Stewartstown. Further, clipping the data to the limits of the watershed immediately discounted those people who utilize municipal water from the watershed but reside outside of the watershed boundary. To be conservative, the higher population projections from the County's method were incorporated instead of using the results generated from the GIS data method.

Harford County, in conjunction with MDE, has recently developed population and demand projections for its portion of the Deer Creek Watershed (Deer Creek Watershed Characterization, March 2006). The Harford County Planning Department provided the TZ data that was used for its study. The data was then divided by subwatershed to calculate populations. The Harford County Planning Department estimated that 24,750 persons resided in the Harford County portion of the watershed. The method of breaking the TZ data into percentages by subwatershed calculated a total population for the same Harford County area equaling 24,331. The difference of 1.7 percent suggests that the subwatershed breakdown is reasonably accurate.

Population projections in 5-year increments for each subwatershed can be seen in Table 22. The total 25-year projected population increase for the Deer Creek Watershed (2000 to 2025) is approximately 24 percent, as can be seen on Figure 29 and Table 22. Projected increases for individual subwatersheds range from about 5 percent to 35 percent. Population growth is generally tied to the existing road network. The lowest projected growth value corresponds to a subwatershed (Little Deer Creek), with no major roads within the watershed boundaries. The greatest projected growth is in the Deer Creek Headwaters, near Shrewsbury.

The report entitled *Aberdeen Proving Ground BRAC Impacts on Seven Jurisdictions*, prepared by the Sage Policy Group, Inc. (Sage Policy Group, 2007), was also consulted during the development of population projections. The APG-BRAC document presents estimated phasing of BRAC-related population impacts, including baseline conditions and three BRAC projection scenarios, for seven area jurisdictions. Appendix B1 provides a discussion of how the information presented in the APG BRAC plan was incorporated into the population projections and includes supporting tables and figures. Interpretation of the report suggests that BRAC will increase population growth through the study period by an additional 4 percent.

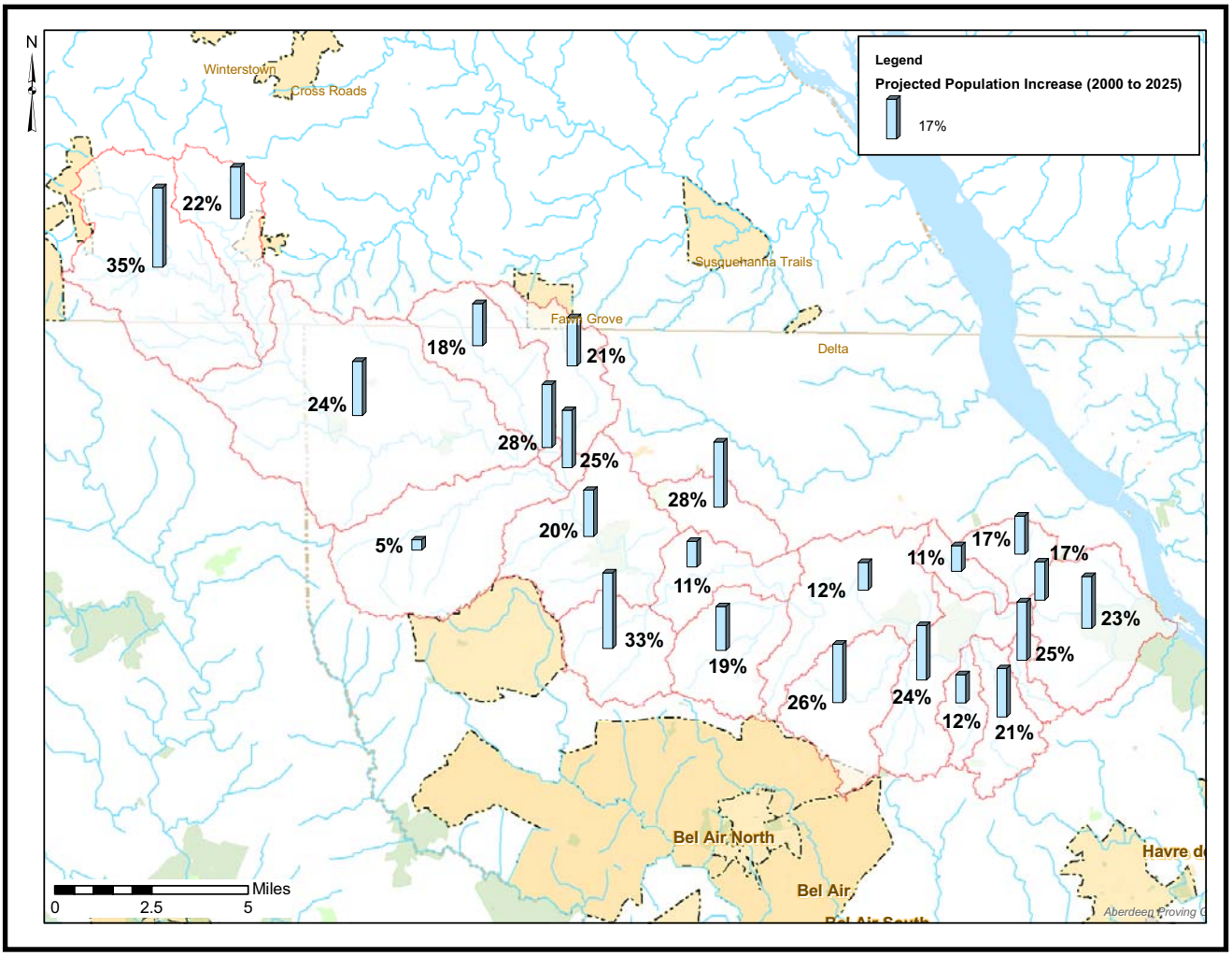

Figure 29. Twenty-Five-Year Population Projections by Subwatershed

Table 22. Population Projections

ID	Location	2000*	2005	2010	2015	2020	2025	10-Year Growth*	25-Year Growth*	2000 to 2025 Percentage Growth
	By County									
	Harford County	24,332	25,421	27,130	28,160	28,729	29,129	2,799	4,798	19.7%
	York County	16,139	17,476	17,225	18,240	19,147	20,947	1,086	4,808	29.8%
	Baltimore County	1,170	1,323	1,394	1,407	1,416	1,428	224	258	22.1%
	By Subwatershed									
1	Cool Branch Run	472	477	501	516	523	530	29	58	12.3%
2	Stout Bottle Branch - Cabbage Run	1980	2102	2260	2321	2383	2358	280	378	19.1%
3	Thomas Run	3113	3407	3668	3817	3877	3907	555	794	25.5%
4	Mill Brook	736	749	801	839	865	891	65	155	21.0%
5	Hollands Branch	397	421	441	453	459	464	44	66	16.7%
6	UNT at Thomas Bridge Rd	588	620	675	712	735	755	87	167	28.4%
7	Saint Omer Branch	2238	2304	2408	2465	2487	2507	171	269	12.0%
8	Deer Creek - Mid	772	790	827	847	850	858	54	86	11.2%
9	South Stirrup - North Stirrup Run	1808	1931	2122	2253	2336	2405	314	597	33.0%
10	Rock Hollow - Kellogg - Gladden Branches	2306	2373	2543	2653	2716	2770	237	464	20.1%
11	UNT south of Falling Branch	76	80	86	90	93	95	10	19	24.7%
12	UNT west of Falling Branch	40	42	46	48	50	51	6	11	26.8%
13	Little Deer Creek	2531	2500	2583	2624	2632	2644	52	113	4.5%
14	Falling Branch	547	572	611	636	649	662	64	115	21.0%
15	Big Branch	648	676	717	742	755	767	68	119	18.3%
16	Island - Jackson - Plumtree Branches	2821	3021	3233	3351	3423	3485	412	665	23.6%
17	Ebaugh's Creek	6859	7566	6890	7300	7666	8397	32	1539	22.4%
18	Deer Creek Headwaters	9708	10394	10845	11455	11999	13072	1137	3364	34.6%
19	Graveyard Creek	177	187	201	211	216	221	25	45	25.3%
20	Hopkins Branch	413	424	441	451	455	459	29	46	11.2%
21	Tobacco Run	2276	2378	2563	2685	2757	2816	287	540	23.7%
22	Buck Branch - Elbow Branch	1130	1199	1280	1331	1360	1385	150	255	22.6%
23	UNT east of Hollands Branch	6	6	7	7	7	7	1	1	17.9%
	Deer Creek Watershed Total	41,640	44,220	45,750	47,807	49,292	51,504	4,109	9,864	23.7%

* From 2000 Census Data.

C. Water Demand Projections

The final step in completing of the groundwater balance was to forecast the projected demand for new permits and increased use in each subwatershed. Projections for three main uses were developed for future average and drought conditions:

- Commercial/Industrial Permit Demand
- Municipal Permit Demand
- Subdivision/Residential (un-permitted) Demand

Commercial/Industrial demand was estimated using zoning information provided by the counties and counting the number of commercially zoned areas within each subwatershed. The 10-year normal projections are based on an assumed development scenario requiring 50,000 gpd per commercially zoned area. The assumption is based on one retail space (e.g., 5,000 gpd for a retail convenience store), one small commercial/institutional facility (e.g., 10,000 gpd for a school, care facility, or small commercial agribusiness,) and one larger industrial facility (e.g., 35,000 gpd for food processing or industrial/building materials preparation plant). The 25-year scenario assumption is based on additional build-out of the zoned areas, resulting in the demand doubling to 100,000 gpd use. Any acreage zoned commercial/industrial, but also identified as under permanent agricultural easement in Harford County, was excluded from this estimate based on the assumption that the land will remain devoted to agriculture.

Municipal demand was based on government agency reports, and is confined to subwatersheds where the Pennsylvania municipalities of Forest Lakes, Shrewsbury, and Stewartstown have developed well fields. Subdivision/Residential demand was estimated using 10- and 25-year population projections based on the population projections described in a previous section. A demand of 80 gpd per person, based on historical records maintained for average households by MDE, was used for the normal year projections. A drought demand of 112 gpd (1.4 times normal) was assumed for drought conditions to account for the increase in water use typically seen during times of drought. The same factor was also applied to drought demands for the other two categories.

Agricultural water demand increase is not projected. Acreage of land dedicated to agricultural operations is not likely to increase, but there is potential for existing agricultural land to become more water-use intensive over the next 20 years. There is no reliable methodology for predicting such increases. However, it is important to note that the assumptions made in this study are conservatively skewed regarding agricultural water use. Permitted operations are included in current use totals, and all uses are incorporated by default due to their impacts on actual flows in the Deer Creek Watershed, which are the basis for the water balances performed. The flow measurements reflect the actual consumptive use of operations, which is often lower than the full permitted quantity. By also including the permitted use, the estimates do a better job of capturing potential increases, as well as current use. Nevertheless, approximate potential agricultural water use estimates were made for conversion to more water-intensive uses; the results are shown in Appendix B2.

The 2010 and 2025 water resource values were also adjusted for changes in impervious area for the 2010 and 2025 periods. Future impervious conditions were based on the future land

use layer derived for the Watershed Restoration Action Strategy (KCI, 2007). The method involved applying a full build-out condition to the land use layers based on their current zoning classifications. The impervious factors were applied to the future land use layer to derive future imperviousness following the same methods used to generate existing imperviousness.

The future imperviousness estimate for the entire Deer Creek Watershed is 5.3 percent, an increase in 1,120 acres. The results for each subwatershed are listed in Tables 23, 24, 25, and 26 as the change in percent future impervious area. The majority of the subwatersheds are estimated to remain under 5 percent impervious. The two subwatersheds that increased to more than 5 percent are Big Branch and Falling Branch. These subwatersheds also experienced the highest percent acreage increases as a result of existing agricultural areas that are zoned in York County for residential use. The largest increases in impervious acres are estimated to be in the Deer Creek Headwaters subwatershed, with the potential for 354.72 additional acres of impervious surface and a future imperviousness of 16.70 percent. Although local and state stormwater management policies require that post-development recharge rates mimic predevelopment conditions, there are exemptions and inefficiencies in management practices; thus the conservative approach is to assume that development will result in impacts to groundwater recharge. As with agricultural water demand, the effect of permanent easements in Harford County was employed for estimates of impervious cover by excluding those acres zoned for development but conserved under easements.

Tables 23, 24, 25, and 26 are groundwater balances for average year conditions and drought year conditions for the years 2010 and 2025. These results are illustrated graphically on Figure 30. As expected, the number of subwatersheds with an allocation deficit is greater for drought years than for average years. The number also increases from 2010 to 2025, reflecting increases in demand. Under average conditions, the allocated water resources do not indicate any deficits during 2010 and a deficit only for the Hopkins Branch subwatershed in 2025.

More significantly, under 2010 and 2025 drought conditions, several of the subwatersheds show an allocation deficit. The allocation deficits are concentrated in the lower portion of the watershed and in the headwaters. This primarily reflects: (1) growth in an area having aquifers with relatively low recharge rates; and (2) growth in an area having minimal upgradient contributing recharge area. Under drought conditions in 2010, it is expected that five subwatersheds will show allocation deficits of as much as 150 million gallons over the year (0.63 cfs), which equates to the quantity of water used by more than 3,600 people. Although presented as an annual analysis, the deficits are likely to manifest during the summer months, as they did over the watershed as a whole (Table 14, Figure 24) and for the three subwatersheds selected for additional analyses (Tables 18, 19, and 20; Figures 26, 27, and 28). Under drought conditions in 2025, eight subwatersheds show deficits in the range of 18 to 314 million gallons over the year (0.08 cfs to 1.33 cfs).

The BRAC-related population projections included in the APG-BRAC document (Sage Policy Group, 2007) mentioned previously also were incorporated into the water demand projection analyses. Appendix B1 provides a discussion of how the information presented in the APG BRAC plan was incorporated into the water demand projections and includes supporting tables and figures.

Table 23. Water Allocation, 2010 Population, Average Precipitation

ID	Subwatershed	Average Base Flow (cfs)	Existing Permitted Ground-water Withdrawals (cfs)	Existing Un-permitted Ground-water Withdrawals (cfs)	Aberdeen Permit Passby (cfs)	Change in Percent Future Impervious Area (%)	Reduction for Future Impervious Area (cfs)	Reduction for Municipal/ Commercial (cfs)	Additional Residential Population[1] (cfs)	Residual Ground-water Resources (cfs)	Surplus/ Deficit Population Supported (people)
1	Cool Branch Run	1.91	-0.01	-0.05	-0.78	1.08	-0.02	-0.31	0.00	0.73	5,918
2	Stout Bottle Branch - Cabbage Run	7.39	-0.12	-0.16	-2.27	1.73	-0.13	-0.39	-0.03	4.29	34,692
3	Thomas Run	6.26	-0.05	-0.17	-2.55	0.47	-0.03	-0.39	-0.07	3.00	24,274
4	Mill Brook	3.60	-0.03	-0.10	-1.47	0.47	-0.02	-0.31	-0.01	1.67	13,495
5	Hollands Branch	2.60	-0.03	-0.07	-1.06	0.47	-0.01	-0.08	-0.01	1.35	10,872
6	UNT at Thomas Bridge Rd	4.45	-0.28	-0.09	-1.37	0.33	-0.01	-0.08	-0.01	2.61	21,046
7	Saint Omer Branch	10.07	-0.06	-0.24	-3.53	0.74	-0.07	-0.39	-0.02	5.75	46,491
8	Deer Creek – Mid	5.40	-0.01	-0.11	-1.66	0.33	-0.02	0.00	-0.01	3.59	29,014
9	South Stirrup - North Stirrup Run	6.68	-0.01	-0.14	-2.05	0.54	-0.04	-0.15	-0.04	4.25	34,302
10	Rock Hollow - Kellogg - Gladden Branches	12.75	-0.23	-0.27	-3.92	0.21	-0.03	-0.31	-0.03	7.97	64,346
11	UNT south of Falling Branch	0.64	-0.01	-0.01	-0.20	2.80	-0.02	0.00	0.00	0.40	3,254
12	UNT west of Falling Branch	0.39	0.00	-0.01	-0.12	2.80	-0.01	0.00	0.00	0.25	2,006
13	Little Deer Creek	14.65	-0.02	-0.31	-4.50	0.20	-0.03	-0.23	-0.01	9.54	77,103
14	Falling Branch	6.60	-0.01	-0.14	-2.03	2.80	-0.18	-0.39	-0.01	3.84	31,035
15	Big Branch	8.15	0.00	-0.17	-2.51	2.62	-0.21	-0.23	-0.01	5.02	40,559
16	Island - Jackson - Plumtree Branches	29.59	-0.18	-0.62	-9.10	0.22	-0.07	-0.23	-0.05	19.35	156,286
17	Ebaugh's Creek	7.05	-0.65	0.00	-2.17	2.42	-0.17	-0.39	0.00	3.67	29,633
18	Deer Creek Headwaters	17.68	-0.55	0.00	-5.44	4.06	-0.72	-0.77	-0.14	10.06	81,294
19	Graveyard Creek	1.24	-0.01	-0.03	-0.51	0.47	-0.01	0.00	0.00	0.68	5,532
20	Hopkins Branch	1.76	-0.01	-0.05	-0.72	0.47	-0.01	-0.70	0.00	0.28	2,226
21	Tobacco Run	6.15	-0.16	-0.17	-2.51	1.08	-0.07	-0.08	-0.04	3.14	25,337
22	Buck Branch - Elbow Branch	7.90	-0.01	-0.22	-3.22	0.05	0.00	0.00	-0.02	4.43	35,795
23	UNT east of Hollands Branch	0.04	0.00	0.00	-0.02	0.47	0.00	0.00	0.00	0.02	188
	Entire Watershed	**162.94**	**-2.44**	**-3.14**	**-53.67**	**1.00**	**-1.63**	**-5.42**	**-0.51**	**95.90**	**774,699**

[1] Calculated at 80 gpd per person.

Table 24. Water Allocation, 2010 Population, Drought Conditions

ID	Subwatershed	Average Base Flow (cfs)	Existing Permitted Ground-water Withdrawals (cfs)	Existing Un-permitted Ground-water Withdrawals (cfs)	Aberdeen Permit Passby (cfs)	Change in Percent Future Impervious Area (%)	Reduction for Future Impervious Area (cfs)	Reduction for Municipal/ Commercial (cfs)	Additional Residential Population[1] (cfs)	Residual Ground-water Resources (cfs)	Surplus/ Deficit Population Supported (people)
1	Cool Branch Run	0.94	-0.01	-0.07	-0.78	1.08	-0.02	-0.31	-0.01	-0.25	-1,448
2	Stout Bottle Branch - Cabbage Run	3.67	-0.12	-0.22	-2.27	1.73	-0.13	-0.39	-0.05	0.49	2,827
3	Thomas Run	3.10	-0.05	-0.24	-2.55	0.47	-0.03	-0.39	-0.10	-0.25	-1,442
4	Mill Brook	1.78	-0.03	-0.14	-1.47	0.47	-0.02	-0.31	-0.01	-0.19	-1,081
5	Hollands Branch	1.29	-0.03	-0.10	-1.06	0.47	-0.01	-0.08	-0.01	0.00	22
6	UNT at Thomas Bridge Rd	2.21	-0.28	-0.13	-1.37	0.33	-0.01	-0.08	-0.02	0.32	1,845
7	Saint Omer Branch	4.99	-0.06	-0.34	-3.53	0.74	-0.07	-0.39	-0.03	0.57	3,299
8	Deer Creek - Mid	2.68	-0.01	-0.16	-1.66	0.33	-0.02	0.00	-0.01	0.82	4,735
9	South Stirrup - North Stirrup Run	3.31	-0.01	-0.20	-2.05	0.54	-0.04	-0.15	-0.05	0.81	4,646
10	Rock Hollow - Kellogg - Gladden Branches	6.32	-0.23	-0.37	-3.92	0.21	-0.03	-0.31	-0.04	1.42	8,171
11	UNT south of Falling Branch	0.32	-0.01	-0.02	-0.20	2.80	-0.02	0.00	0.00	0.07	431
12	UNT west of Falling Branch	0.19	0.00	-0.01	-0.12	2.80	-0.01	0.00	0.00	0.05	287
13	Little Deer Creek	7.26	-0.02	-0.43	-4.50	0.20	-0.03	-0.23	-0.01	2.03	11,732
14	Falling Branch	3.27	-0.01	-0.19	-2.03	2.80	-0.18	-0.39	-0.01	0.46	2,633
15	Big Branch	4.04	0.00	-0.24	-2.51	2.62	-0.21	-0.23	-0.01	0.84	4,829
16	Island - Jackson - Plumtree Branches	14.67	-0.18	-0.87	-9.10	0.22	-0.07	-0.23	-0.07	4.16	23,985
17	Ebaugh's Creek	3.49	-0.65	0.00	-2.17	2.42	-0.17	-0.39	-0.01	0.11	655
18	Deer Creek Headwaters	8.76	-0.55	0.00	-5.44	4.06	-0.72	-0.77	-0.20	1.09	6,290
19	Graveyard Creek	0.62	-0.01	-0.05	-0.51	0.47	-0.01	0.00	0.00	0.04	245
20	Hopkins Branch	0.87	-0.01	-0.07	-0.72	0.47	-0.01	-0.70	0.00	-0.63	-3,646
21	Tobacco Run	3.05	-0.16	-0.24	-2.51	1.08	-0.07	-0.08	-0.05	-0.05	-283
22	Buck Branch - Elbow Branch	3.91	-0.01	-0.31	-3.22	0.05	0.00	0.00	-0.03	0.35	2,037
23	UNT east of Hollands Branch	0.02	0.00	0.00	-0.02	0.47	0.00	0.00	0.00	0.00	11
	Entire Watershed	**80.77**	**-2.44**	**-4.40**	**-53.67**	**1.00**	**-1.63**	**-5.42**	**-0.71**	**12.27**	**70,782**

[1] Calculated at 112 gpd per person.

Table 25. Water Allocation, 2025 Population, Average Precipitation

ID	Subwatershed	Average Base Flow (cfs)	Existing Permitted Ground-water Withdrawals (cfs)	Existing Un-permitted Ground-water Withdrawals (cfs)	Aberdeen Permit Passby (cfs)	Change in Percent Future Impervious Area (%)	Reduction for Future Impervious Area (cfs)	Reduction for Municipal/ Commercial (cfs)	Additional Residential Population[1] (cfs)	Residual Ground-water Resources (cfs)	Surplus/ Deficit Population Supported (people)
1	Cool Branch Run	1.91	-0.01	-0.05	-0.78	1.08	-0.02	-0.62	-0.01	0.42	3,390
2	Stout Bottle Branch - Cabbage Run	7.39	-0.12	-0.16	-2.27	1.73	-0.13	-0.77	-0.05	3.90	31,470
3	Thomas Run	6.26	-0.05	-0.17	-2.55	0.47	-0.03	-0.77	-0.10	2.59	20,910
4	Mill Brook	3.60	-0.03	-0.10	-1.47	0.47	-0.02	-0.62	-0.02	1.35	10,906
5	Hollands Branch	2.60	-0.03	-0.07	-1.06	0.47	-0.01	-0.15	-0.01	1.27	10,224
6	UNT at Thomas Bridge Rd	4.45	-0.28	-0.09	-1.37	0.33	-0.01	-0.15	-0.02	2.52	20,342
7	Saint Omer Branch	10.07	-0.06	-0.24	-3.53	0.74	-0.07	-0.77	-0.03	5.36	43,267
8	Deer Creek – Mid	5.40	-0.01	-0.11	-1.66	0.33	-0.02	0.00	-0.01	3.59	28,982
9	South Stirrup - North Stirrup Run	6.68	-0.01	-0.14	-2.05	0.54	-0.04	-0.31	-0.07	4.06	32,769
10	Rock Hollow - Kellogg - Gladden Branches	12.75	-0.23	-0.27	-3.92	0.21	-0.03	-0.62	-0.06	7.63	61,618
11	UNT south of Falling Branch	0.64	-0.01	-0.01	-0.20	2.80	-0.02	0.00	0.00	0.40	3,246
12	UNT west of Falling Branch	0.39	0.00	-0.01	-0.12	2.80	-0.01	0.00	0.00	0.25	2,001
13	Little Deer Creek	14.65	-0.02	-0.31	-4.50	0.20	-0.03	-0.46	-0.01	9.30	75,168
14	Falling Branch	6.60	-0.01	-0.14	-2.03	2.80	-0.18	-0.77	-0.01	3.45	27,860
15	Big Branch	8.15	0.00	-0.17	-2.51	2.62	-0.21	-0.46	-0.01	4.78	38,634
16	Island - Jackson - Plumtree Branches	29.59	-0.18	-0.62	-9.10	0.22	-0.07	-0.46	-0.08	19.08	154,159
17	Ebaugh's Creek	7.05	-0.65	0.00	-2.17	2.42	-0.17	-0.77	-0.19	3.09	25,001
18	Deer Creek Headwaters	17.68	-0.55	0.00	-5.44	4.06	-0.72	-1.55	-0.42	9.01	72,817
19	Graveyard Creek	1.24	-0.01	-0.03	-0.51	0.47	-0.01	0.00	-0.01	0.68	5,512
20	Hopkins Branch	1.76	-0.01	-0.05	-0.72	0.47	-0.01	-1.39	-0.01	-0.42	-3,417
21	Tobacco Run	6.15	-0.16	-0.17	-2.51	1.08	-0.07	-0.15	-0.07	3.03	24,459
22	Buck Branch - Elbow Branch	7.90	-0.01	-0.22	-3.22	0.05	0.00	0.00	-0.03	4.42	35,689
23	UNT east of Hollands Branch	0.04	0.00	0.00	-0.02	0.47	0.00	0.00	0.00	0.02	187
	Entire Watershed	**162.94**	**-2.44**	**-3.14**	**-53.67**	**1.00**	**-1.63**	**-10.83**	**-1.22**	**89.77**	**725,195**

[1] Calculated at 80 gpd per person.

Table 26. Water Allocation, 2025 Population, Drought Precipitation

ID	Subwatershed	Average Base Flow (cfs)	Existing Permitted Ground-water Withdrawals (cfs)	Existing Un-permitted Ground-water Withdrawals (cfs)	Aberdeen Permit Passby (cfs)	Change in Percent Future Impervious Area (%)	Reduction for Future Impervious Area (cfs)	Reduction for Municipal/ Commercial (cfs)	Additional Residential Population[1] (cfs)	Residual Ground-water Resources (cfs)	Surplus/ Deficit Population Supported (people)
1	Cool Branch Run	0.94	-0.01	-0.07	-0.78	1.08	-0.02	-0.62	-0.01	-0.57	-3,261
2	Stout Bottle Branch - Cabbage Run	3.67	-0.12	-0.22	-2.27	1.73	-0.13	-0.77	-0.07	0.09	498
3	Thomas Run	3.10	-0.05	-0.24	-2.55	0.47	-0.03	-0.77	-0.14	-0.68	-3,913
4	Mill Brook	1.78	-0.03	-0.14	-1.47	0.47	-0.02	-0.62	-0.03	-0.51	-2,955
5	Hollands Branch	1.29	-0.03	-0.10	-1.06	0.47	-0.01	-0.15	-0.01	-0.08	-447
6	UNT at Thomas Bridge Rd	2.21	-0.28	-0.13	-1.37	0.33	-0.01	-0.15	-0.03	0.23	1,320
7	Saint Omer Branch	4.99	-0.06	-0.34	-3.53	0.74	-0.07	-0.77	-0.05	0.17	968
8	Deer Creek - Mid	2.68	-0.01	-0.16	-1.66	0.33	-0.02	0.00	-0.01	0.82	4,703
9	South Stirrup - North Stirrup Run	3.31	-0.01	-0.20	-2.05	0.54	-0.04	-0.31	-0.10	0.60	3,470
10	Rock Hollow - Kellogg - Gladden Branches	6.32	-0.23	-0.37	-3.92	0.21	-0.03	-0.62	-0.08	1.07	6,157
11	UNT south of Falling Branch	0.32	-0.01	-0.02	-0.20	2.80	-0.02	0.00	0.00	0.07	423
12	UNT west of Falling Branch	0.19	0.00	-0.01	-0.12	2.80	-0.01	0.00	0.00	0.05	282
13	Little Deer Creek	7.26	-0.02	-0.43	-4.50	0.20	-0.03	-0.46	-0.02	1.79	10,333
14	Falling Branch	3.27	-0.01	-0.19	-2.03	2.80	-0.18	-0.77	-0.02	0.06	351
15	Big Branch	4.04	0.00	-0.24	-2.51	2.62	-0.21	-0.46	-0.02	0.60	3,439
16	Island - Jackson - Plumtree Branches	14.67	-0.18	-0.87	-9.10	0.22	-0.07	-0.46	-0.12	3.88	22,393
17	Ebaugh's Creek	3.49	-0.65	0.00	-2.17	2.42	-0.17	-0.77	-0.27	-0.53	-3,084
18	Deer Creek Headwaters	8.76	-0.55	0.00	-5.44	4.06	-0.72	-1.55	-0.58	-0.07	-401
19	Graveyard Creek	0.62	-0.01	-0.05	-0.51	0.47	-0.01	0.00	-0.01	0.04	225
20	Hopkins Branch	0.87	-0.01	-0.07	-0.72	0.47	-0.01	-1.39	-0.01	-1.33	-7,681
21	Tobacco Run	3.05	-0.16	-0.24	-2.51	1.08	-0.07	-0.15	-0.09	-0.17	-983
22	Buck Branch - Elbow Branch	3.91	-0.01	-0.31	-3.22	0.05	0.00	0.00	-0.04	0.33	1,931
23	UNT east of Hollands Branch	0.02	0.00	0.00	-0.02	0.47	0.00	0.00	0.00	0.00	10
	Entire Watershed	**80.77**	**-2.44**	**-4.40**	**-53.67**	**1.00**	**-1.63**	**-10.83**	**-1.71**	**5.85**	**33,778**

[1] Calculated at 112 gpd per person.

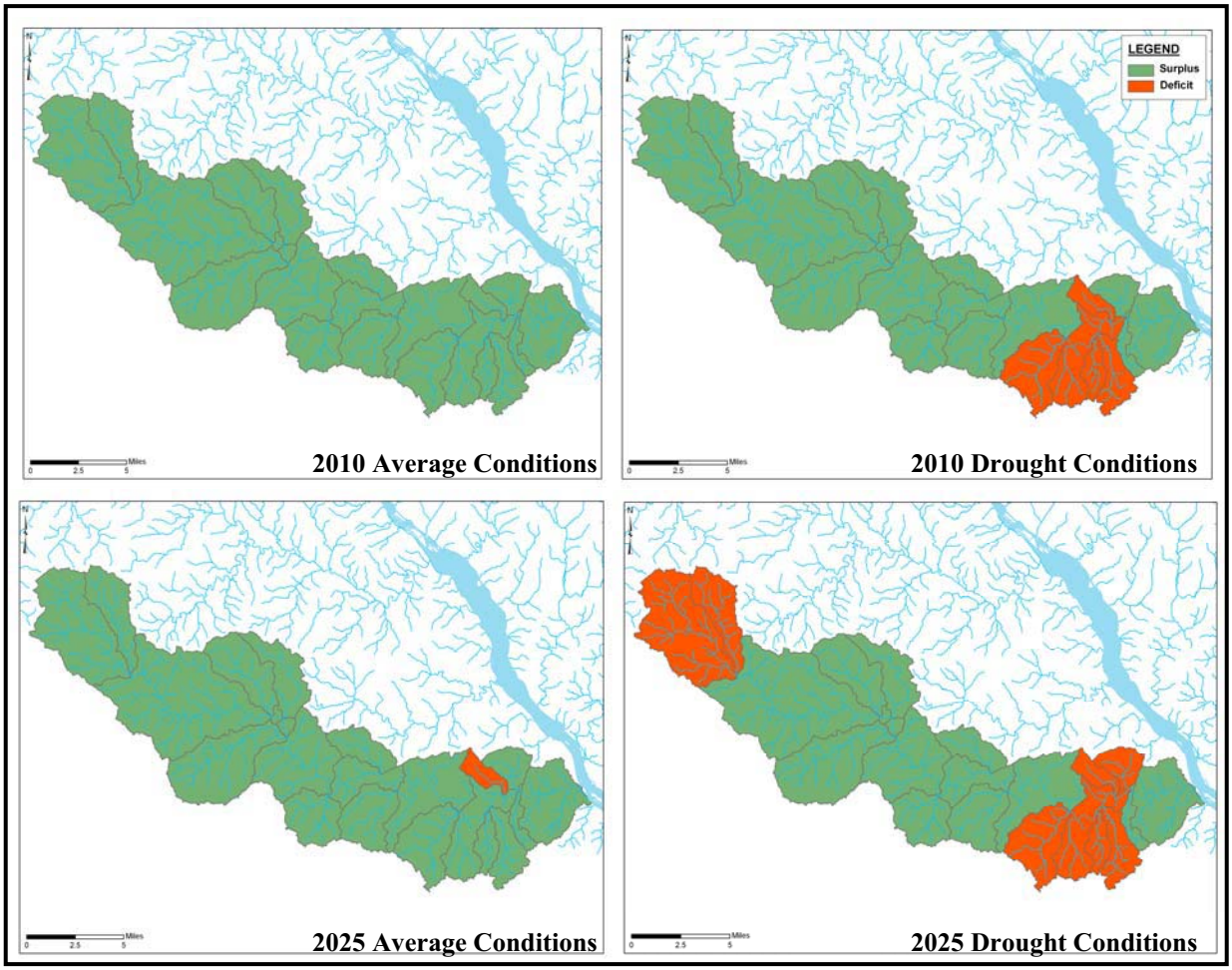

Figure 30. Twenty-Five-Year Projected Water Allocation Surplus/Deficit by Subwatershed

To assess the effect of future water demand in terms of the availability of water from Deer Creek during a drought, the number of days below the passby flow threshold at Darlington was examined using the 2002 as a reference point. In that drought, the flow at Darlington was below the passby threshold for a duration of 130 days in the time period March 1 through October 10. If the projected increase in water demand is assumed to directly reduce the flow in Deer Creek on a gallon-for-gallon basis, the impacted flow at Darlington during a repeat of the 2002 drought in the year 2025 would result in the creek being below the passby threshold for an additional 43 days, and extend the time period 1 week sooner and 2 weeks later. A graphical depiction of the change to streamflow at Darlington is shown on Figures 31 and 32. Of the projected 14.2 cfs increase in water demand during future droughts, three-quarters are attributable to commercial and municipal demand, and the remainder is about even attributable to self-supplied residential use and loss of base flow due to increase in impervious cover.

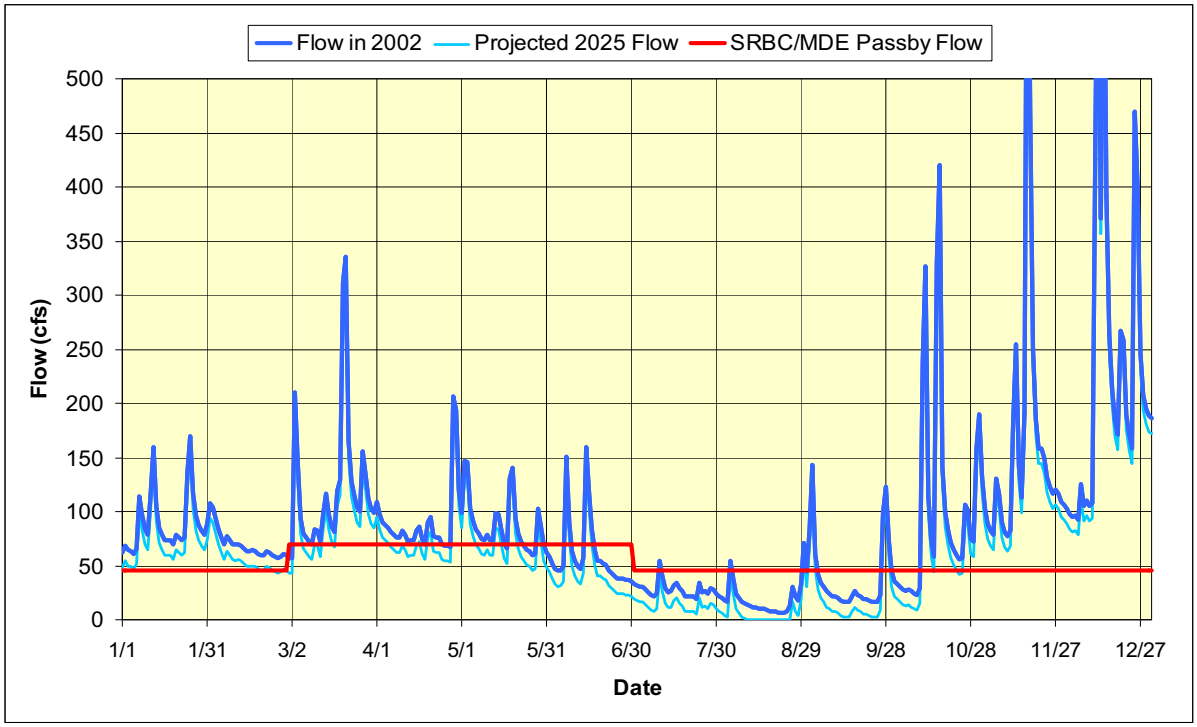

Figure 31. Actual and Reduced 2002 Drought Flow at Darlington Compared to Passby Threshold

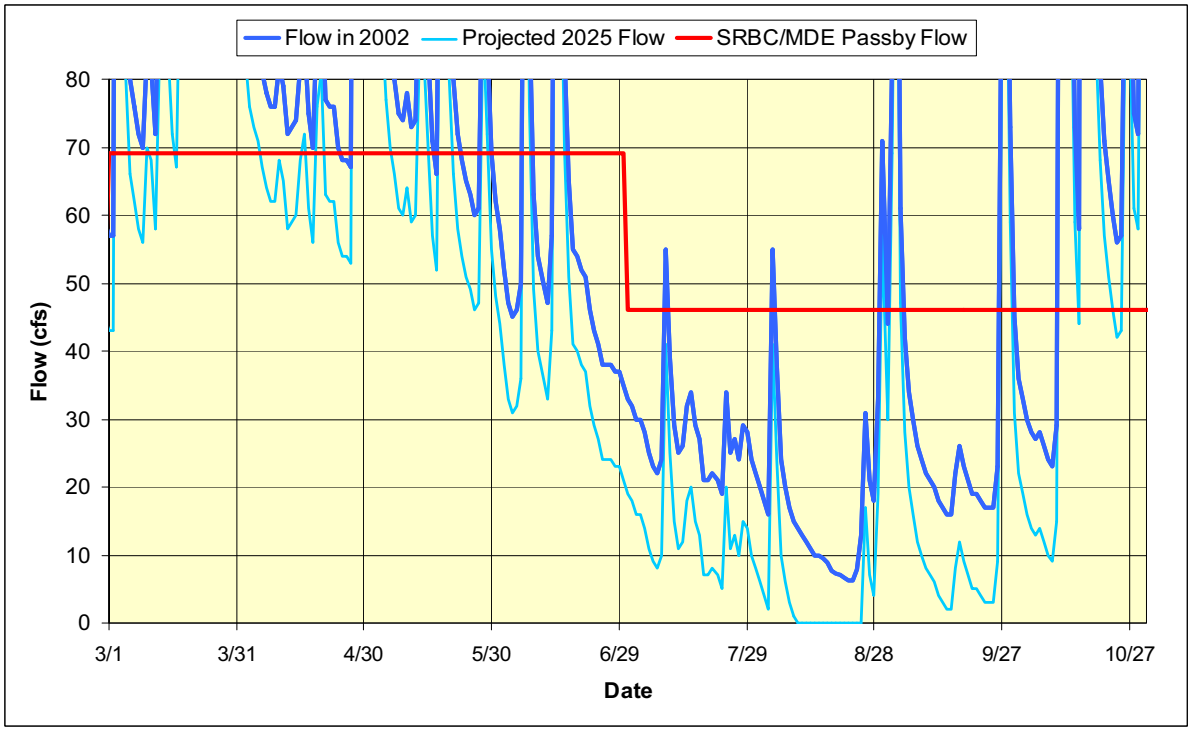

Figure 32. Close View; Actual and Reduced 2002 Drought Flow at Darlington Compared to Passby Threshold