

## **APPENDIX F**

### **Verification of Water-Analysis Screening Tool Results for the Brodhead Creek Watershed, Monroe and Pike Counties, Pennsylvania**



# Verification of Water-Analysis Screening Tool Results for the Brodhead Creek Watershed, Monroe and Pike Counties, Pennsylvania

This summary provides a brief description of verification of water-use data, including registered and estimated values, any mitigation efforts, and potential aquatic-resource influences for the Brodhead Creek watershed in Monroe and Pike Counties, Pennsylvania. Water-use data from 2003 were compiled and input into a Geographic Information System-based Water-Analysis Screening Tool (WAST) to identify potential aquatic-resource influences throughout the approximately 261 square mile (mi<sup>2</sup>) Brodhead Creek watershed. Results from this watershed and others will be used by the Pennsylvania Department of Environmental Protection (PaDEP) and Regional and Statewide Water Resources Committees to help identify Critical Water Planning Areas (CWPA) across the state.

The WAST uses a mouth-of-watershed or “pour-point” concept to compare net withdrawals (total withdrawals minus total discharges) to predetermined initial-screening criteria (ISC). The ISC is a percentage of the 7-day, 10-year low flow (7Q10), which is determined from regression equations (Stuckey, 2006). The results of the WAST is a Screening Indicator (SI) expressed as a rate in million gallons per day (Mgal/d), and is equal to  $ISC - (\text{total withdrawals} - \text{total discharges}) \pm \text{any impoundment evaporation or mitigating factors}$ . When the SI is presented as a percentage of the ISC, the result is a dimensionless screening indicator (SIP) useful for comparing different watersheds with varying drainage areas and natural flows. Potential aquatic-resource conflicts may occur in watersheds when the SI is negative (Stuckey, 2008).

The ISC used in the analysis for the Brodhead Creek watershed was 50 percent of the 7Q10 with the exception of one stream reach (two pour points) which is classified as Class A trout streams in carbonate areas in the watershed (Stuckey, 2008). In regions classified as Class A trout streams the ISC used for analysis was set to 30 percent of the 7Q10. Several dams or impoundments were identified in the watershed; two have withdrawals direct from storage and one of these has a conservation release. Evaporation, from State and Federally-owned impoundments with drainage areas greater than 1 mi<sup>2</sup> as listed in the 2000 National Inventory of Dams (NID) database, was determined to be significant for 57 locations and was included in the WAST analysis.

Withdrawals in the Brodhead Creek watershed, including those from registered users and estimates for unregistered users, totaled 14.16 Mgal/d (Table 1). Unregistered withdrawals were estimated, for water-use categories with water use suspected to be underreported, using water-use factors (Stuckey, 2008). There are 138 registered withdrawals, 28 discharges, and 2,740 estimated unregistered uses in the watershed. Registered ground-water withdrawals accounted for 4.06 Mgal/d (29 percent of the total), registered surface-water withdrawals accounted for 6.50 Mgal/d (46 percent of the total), and estimated unregistered uses accounted for 3.60 Mgal/d (25 percent of the total). 59 percent of the estimated unregistered use was attributable to evaporation losses (Figure 1). Discharges in the

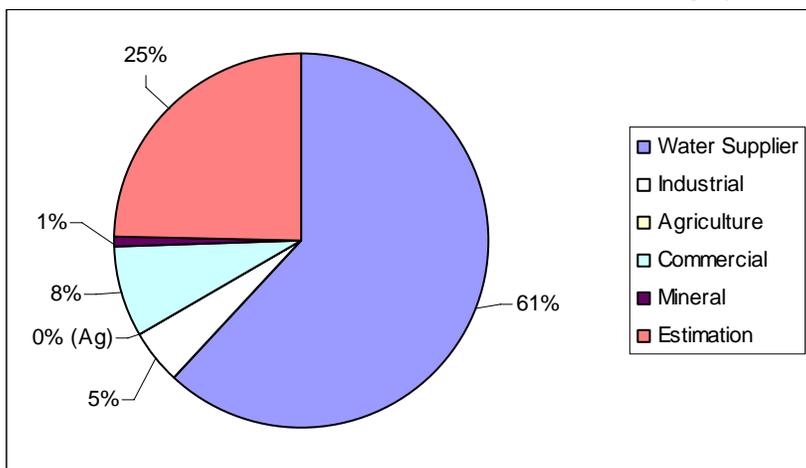
Brodhead Creek watershed totaled 4.94 Mgal/d; 20 of the 28 discharges were greater than or equal to 0.01 Mgal/d (Table 1). It should be noted that because the impacts of mitigation are not included in Table 1 the balance of withdrawals and discharges for the watershed in its entirety (i.e., at the point at the mouth of the watershed, 999902) is different from that shown in Table 1.

**Table 1.** Summary of water discharges and withdrawals in the Brodhead Creek Watershed, Monroe and Pike Counties, Pennsylvania, 2003.

[<, less than; >=, greater than or equal to; Mgal/d, million gallons per day]

Water Use	Number of water use points	Number of values >= 0.01 Mgal/d	Water use, in Mgal/d			Total	Percent of total water use
			Mean	Minimum	Maximum		
DISCHARGES							
ALL DISCHARGES	28	20	0.18	0.00	1.53	4.94	—
WITHDRAWALS							
ALL WITHDRAWALS	2,878	116	0.00	0.00	2.86	14.16	—
SUMMARY OF WITHDRAWALS BY SOURCE							
Ground water <sup>1</sup>	123	38	0.03	0.00	0.94	4.06	29
Surface water <sup>1</sup>	15	13	0.43	0.00	2.86	6.50	46
Estimation	2,740	65	0.00	0.00	0.11	3.60	25
SUMMARY OF WITHDRAWALS BY WATER-USE CATEGORY							
REGISTRATION							
Water supplier	87	35	0.10	0.00	2.86	8.77	62
Industrial	11	6	0.06	0.00	0.41	0.68	5
Commercial	33	10	0.03	0.00	0.32	1.10	8
Agriculture	0	0	0.00	0.00	0.00	0.00	0
Mineral	7	3	0.02	0.00	0.04	0.12	1
ESTIMATION							
Evaporation	57	57	0.04	0.03	0.11	2.11	15
Self-supplied residential	1,665	0	0.00	0.00	0.01	0.45	3
Industrial	34	3	0.01	0.00	0.08	0.28	2
Commercial	984	2	0.00	0.00	0.04	0.65	5
Agriculture	0	0	0.00	0.00	0.00	0.00	0
Irrigation	0	0	0.00	0.00	0.00	0.00	0
Livestock	0	0	0.00	0.00	0.00	0.00	0
<sup>1</sup> as described in registration data; does not include estimated water use							

**Figure 1.** Water withdrawn by selected categories in the Brodhead Creek Watershed, Monroe and Pike Counties, Pennsylvania, 2003. See Table 1 for further breakdown of Estimation category.



In the Brodhead Creek watershed, mitigation measures were applied at several locations to better reflect the impacts of pass-by conditions, storage, conservation releases and the timing of (seasonal) withdrawals in the WAST analysis. The most significant mitigation adjustment is related to the East Stroudsburg reservoir system, on Sambo Creek, which provides significant storage and supports a withdrawal direct from storage by the East Stroudsburg Municipal Authority. The primary method of filling the Upper Reservoir is a diversion from Michaels Creek via a man-made stone channel. The Upper Reservoir has 300 MG of storage capacity and releases water to Sambo Creek which fills the smaller Middle Reservoir (45 MG of storage) approximately 1.3 miles downstream. The East Stroudsburg Municipal Authority withdraws water direct from storage in the Middle Reservoir; the withdrawal comprises approximately 75% of the system demands, with the remainder being met by ground water wells. The reservoir system is not subject to any conservation release requirements, however the diversion from Michaels Creek is subject to a pass-by flow constraint of 0.165 Mgal/d at the diversion location, in addition the diversion is not permitted to occur between June 1 and the Labor Day holiday, regardless of flow (Russell Scott, RKR Hess Assoc., pers. comm., 2009). Based on an estimated drainage area (obtained from streamstats.usgs.gov) at this location and extrapolation from the nearest downstream pour point (212404), the pass-by criteria would not support the diversion under low flow conditions. The diversion was therefore effectively “turned off” in the WAST analysis. Similarly, as storage in the combined reservoir system is sufficient to support the associated withdrawal for in excess of 180 days, the withdrawal was also turned off in the WAST analysis on the basis of adequate storage being available.

The Mount Airy Resort includes an impoundment which is subject to a conservation release. The conservation release is 0.243 Mgal/d and adequate storage exists to support this release and the associated withdrawal. Therefore the conservation release was added to the WAST analysis and the withdrawal direct from storage was turned off.

**Table 2. Mitigation Summary for Brodhead Creek Watershed, Monroe and Pike Counties Pennsylvania, 2003**

[Mgal, million gallons; Mgal/d, million gallons per day]																
Dam/Reservoir Name	Permittee	Stream Name	Use	Dam Type	Normal Storage (Mgal)	50-yr safe yield	Associated Withdrawal (Mgal/d)	Withdrawal + ConsRelease x 180 days (Mgal)	Mitigation Type	Release/Pass-By (Mgal/d)	Relief from Release Requested	Reduced Release/Pass-By Due to Relief (Mgal/d)	ISC for Downstream Pour Point (Mgal/d)	Release/Pass-by used in Analysis (Mgal/d)	Withdrawal from Storage	Note
	Alpine Mountain Ski & Ride Center	Brodhead Creek	Snow-making				0.32		Pass-By	4			1.652		Yes	Alpine Mtn operates an intake from the Brodhead Creek which is then pumped to a pond at the foot of the ski slope. The pond is then used for snowmaking. The seasonal nature of this use and the passby requirements at the intake on Brodhead Creek indicate that this intake would not be operational during periods of low flows.
	East Stroudsburg Boro	Michael's Creek	PWS Diversion				2.86		Pass-By	Seasonal restriction (see note) and 0.165			0.01 (usgs.stream stats.gov)		No	A discharge was incorporated to negate the impact of this intake which is a diversion from Michael Creek to Sambo Creek. A seasonal restriction (Jun 1 - Labor Day) and a numerical passby would cause the intake to cease operation during a low flow period.
East Stroudsburg Middle Reservoir	East Stroudsburg Boro	Sambo Creek	PWS	Un-regulated	345 (see note)		1.36	245		n/a			0.163		Yes	345 Mgal of storage represents 300Mgal for the Upper Reservoir and 45Mgal for the Middle reservoir in this joint reservoir system. A discharge was incorporated into the tool to recognize that this facility has the capability to meet in excess of 180 days of demand from storage.
Mount Airy Lake	Mount Airy Lodge	Forest Hills Run	Golf Course Irrigation	Regulated	60 (see note)		0.039	51	Conservation Release	0.243			1.205		Yes	A discharge was added to the tool for both the conservation release and the intake at Mount Airy Lake. <i>Estimated</i> normal storage of this impoundment is adequate to supply both needs for 180 days. Sale and redevelopment of the site has made operational details difficult to obtain.
	Camelback Ski Area	Pocono Creek	Snow-making Diversion				0.78		Seasonal Use	n/a			n/a		No	Camelback operates this diversion for snowmaking use. During 2003 the intake was operated from December through March and was assumed to be representative of typical seasonal use and thus would not have been operational during a low flow condition.

For screening purposes the following actions were taken in the WAST analysis:

**Alpine Mountain Ski & Ride Center:** Discharge equal to the withdrawal of 0.32 Mgal/d was added. **East Stroudsburg Boro Diversion:** Discharge equal to the withdrawal of 2.86 Mgal/d was added. **East Stroudsburg Middle Reservoir:** Discharged equal to the withdrawal of 1.36 Mgal/d was added. **Mount Airy Lake:** Discharge equal to the withdrawal and conservation release (total = 0.282 Mgal/d) was added. **Camelback Ski Area:** Discharge equal to the seasonal use of 0.78 Mgal/d was added

The SIP was estimated at 59 pour points in the Brodhead Creek watershed, representing sub-watershed drainage areas ranging from 8 to 261 mi<sup>2</sup> (Table 2). After making the aforementioned adjustments to account for mitigation, the SIP ranged from -414 to 105 percent. An analysis using the WAST showed 12 of 59 pour points (20 percent) were colored yellow representing watersheds with an SIP value of less than -20%, 16 pour points (27 percent) were colored white, representing watersheds with an SIP balance of greater than -20 to 20 percent, and 31 of 59 pour points (53 percent) were colored green, representing watersheds with an SIP balance of greater than 20 percent (Figure 2 and Table 3).

Verification of water use showed that the largest withdrawal in the Brodhead Creek was the diversion by a water purveyor (East Stroudsburg Municipal Authority) from Michaels Creek to storage in the reservoirs on Sambo Creek; the diversion amount is 2.858 Mgal/d. As explained above, this diversion was negated in the tool as it would not occur during low-flow conditions due to a pass-by requirement. The second largest withdrawal is also related to the East Stroudsburg reservoir system and occurs directly from storage in the Middle Reservoir. The amount is 1.361 Mgal/d and is also negated in the analysis due to sufficient storage to sustain 180 days of supply. The third largest withdrawal in the watershed is also by a water purveyor at the rate of 0.942 Mgal/d and was not mitigated in the analysis. The public water supply sector is the dominant use in the watershed, accounting for 58% of all withdrawals. As noted above (and in Table 1) there is a discrepancy between withdrawals and discharges in this watershed. At the pour point at the mouth of the watershed, which includes the impact of mitigation measures, the discrepancy is 4.396 Mgal/d (the difference between 14.160 Mgal/d of withdrawals and 9.764 Mgal/d of discharges). The discrepancy is attributable to a number of causes. They include consumptive use across multiple sectors as evidenced by disparities between withdrawals and discharges for connected facilities. Estimated evaporation at impoundments amounts to 2.11 Mgal/d for the 57 locations where this was deemed significant and is added to the withdrawal side of the water balance. Estimated water withdrawals individually less than 0.01 Mgal/d, collectively total 1.238 Mgal/d. Due to the large number (2,675) of these small withdrawals they were not verified by data QA/QC or fieldwork. Another factor that can explain why withdrawals are higher than the discharge is because of the way withdrawals are calculated in the Screening Tool. Withdrawal quantities for each source used in the screening process are computed by dividing the total quantity of water withdrawn in 2003 by the number of days the source was used which results in a *daily mean withdrawal*, rather than by the number of days in a year, which results in the *annual mean withdrawal*. For withdrawals that are used 365 days a year, the daily and annual mean is the same. For withdrawals used over shorter periods throughout the year (days to weeks), the daily mean withdrawal (which may reflect a worst-case withdrawal scenario, or may simply be an over-estimation of demand) may be significantly greater than the annual mean withdrawal.

The pour point (209918) with the greatest positive SIP value (105 percent) is located on Appenzell Creek in the McMichael Creek sub-watershed. Downstream of this location is approximately 4 miles of stream classified as Class A trout streams in carbonate areas. This continuous section of stream is the only carbonate Class A trout stream in the Brodhead Creek and covers two pour points (212898 and 209988) both on Appenzell Creek. At these pour points the ISC is set to 30% of the 7Q10 value to be more protective of instream needs. Both pour points are green in the WAST analysis under these conditions.

The pour point (210028) with the most negative SIP value (-414%) is located on Lake Creek in the southern portion of the watershed with a drainage area of approximately 10 mi<sup>2</sup>. The ISC at this

location is 0.063 Mgal/d. Two ground water withdrawals by a water purveyor (Aqua PA Hamilton system) amount to 0.183 Mgal/d and comprise half of the total withdrawals for this pour point. Both wells are approximately 0.1 miles inside the Brodhead Creek watershed boundary.

Yellow pour points 212130, 212626, 212664 and 212690 are clustered in the headwaters of the Brodhead Creek watershed. The upper most pour point (212130) is located at the mouth of Buck Hill Creek where at its confluence with Brodhead Creek and has an SIP of -153% and a drainage area of <9 mi<sup>2</sup>. Water use at this location is predominantly by the water purveyor sector (Buck Hill Water Company is the only water purveyor in this sub-watershed), accounting for 84% of the withdrawals; there are no discharges at this location and discharge is to private septic systems. There is also a golf course in this sub-watershed which, although not a large withdrawal, has a consumptive water use of 90%. The three downstream pour points listed above are all located on Brodhead Creek and have SIP values of -52%, -26% and -24% respectively, the screening indicator value improves at each downstream pour point, the largest of which has a drainage area of 42 mi<sup>2</sup>.

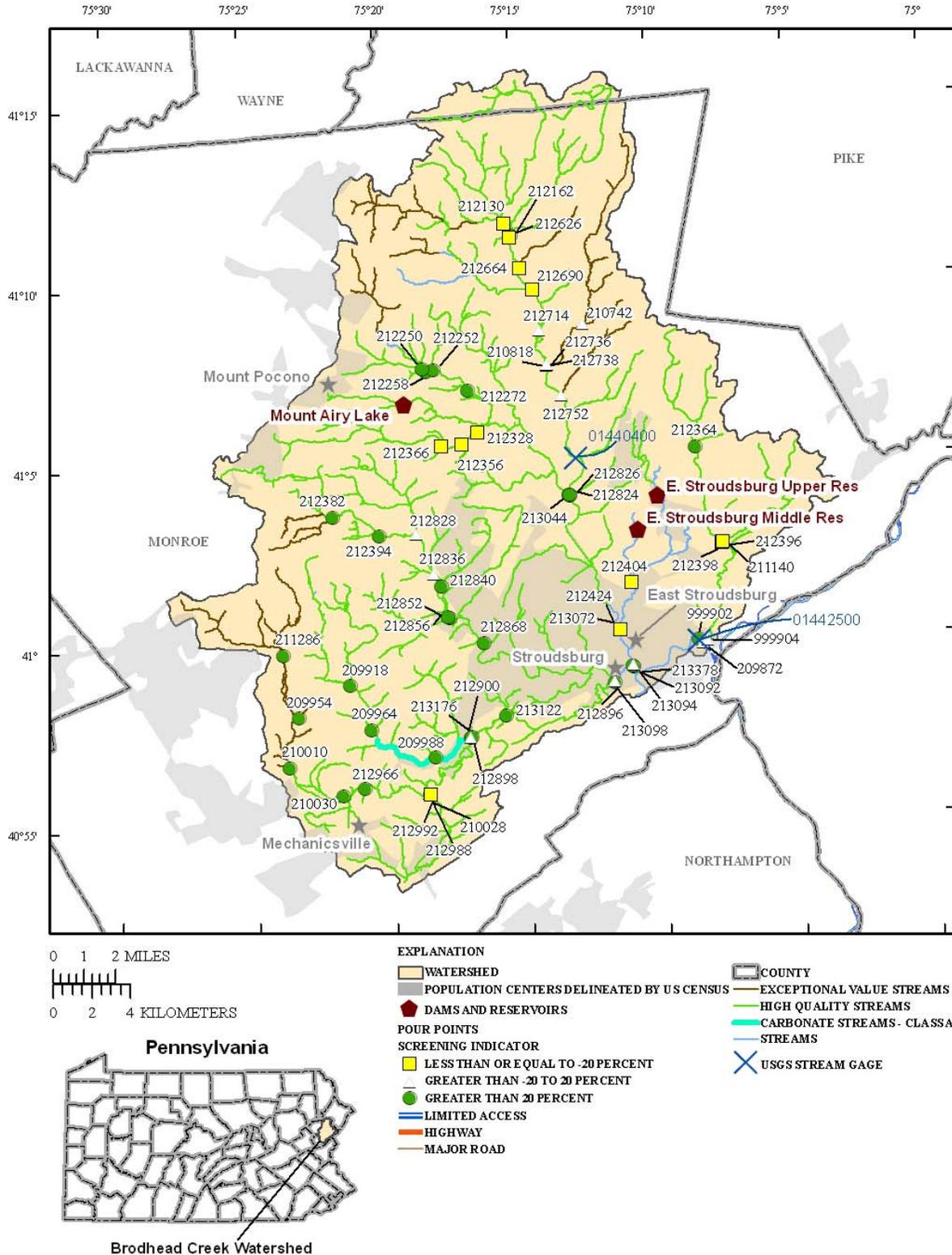
Three yellow pour points (212366, 212356 and 212328) are located on Swiftwater Creek, each has a drainage area of <10 mi<sup>2</sup> with SIP values of -247%, -191% and -165% respectively. The largest category of withdrawal is industrial water use for the Sanofi Aventis facility. Although Sanofi Aventis registered their three withdrawals and one discharge in 2003, they currently have water service provided by the Brodhead Creek Regional Authority (BCRA). The facility practices land application of treated sewage and continues to operate their own discharge but is looking to connect to a regional wastewater treatment plant when capacity becomes available. Therefore, under current (2008/09) operations in this sub-watershed, removing the withdrawals for this facility would result in SIP values of 33%, 44% and 49% respectively, thus turning each of these pour points green. The BCRA has extended its water supply infrastructure along the Route 611 corridor and this has enabled it to provide service to Sanofi Aventis. The nature of this change since 2003 reflects a rapid pace of growth in the watershed as a whole (see Figure 5).

Yellow pour point 211140 is located on Pond Creek, a tributary to Marshalls Creek, with a drainage area of <9 mi<sup>2</sup> and SIP value of -165%. The largest single component of use in this sub-watershed is estimated evaporative losses associated with State and Federally-owned impoundments with drainage areas greater than 1 mi<sup>2</sup>. There is a pour point immediately upstream and downstream of the Pond Creek on Marshalls Creek. Upstream, the pour point (212396) is white with an SIP of -3%; downstream the pour point (212398) is yellow with an SIP of -34%. Therefore it appears that the deficit on Pond Creek is impacting the downstream pour point on Marshalls Creek. Estimated evaporative losses at impoundments, including those on Pond Creek, account for nearly one third of total water use in this sub-watershed. Further downstream on Marshalls Creek, near the confluence with the Brodhead, the pour point is white with an SIP of -16%. No discharges were identified anywhere within the 27 mi<sup>2</sup> sub-watershed of Marshalls Creek.

After factoring in mitigation, the two pour points (212404 and 212424) on Sambo Creek downstream of the water supply reservoirs are yellow with SIP values of -25% and -54%. The WAST analysis is sensitive to estimated evaporative losses for impoundments at this pour point, as removing estimated evaporation changes the SIP value to 69% and 45%.

No agricultural water use records (registrations) exist for the Brodhead Creek watershed. No agricultural water use was estimated for the watershed as neither Monroe nor Pike County is included in the top ten agricultural counties, for Pennsylvania, in the U.S Agricultural Census, which provided the data for agricultural estimations. Field work in the watershed supports the assertion that agricultural activity in the Brodhead is very limited.

**Figure 2:** Location of pour points and tributaries in Brodhead Creek, Monroe and Pike Counties, Pennsylvania



**Table 3.** Summary of water use and screening indicators after verification of water use in areas draining to pour points in Brodhead Creek watershed, Berks and Lehigh Counties, Pennsylvania, 2003.

[All flows and water use in million gallons per day; ISC, initial screening criteria (50 percent of 7Q10); IND, industrial; COMM, commercial; AG, agriculture; EVAP, net evaporation loss from impoundments; SI, screening indicator [ISC-(Total Withdrawals – Total Discharges)]; SIP, screening indicator as a percent [(SI/ISC)\*100] Gray = Pour point at mouth of watershed; green = Max SIP; Yellow = Min SIP.

POINT NUMBER	STREAM NAME	DRAINAGE AREA (SQUARE MILES)	ISC	REGISTERED WITHDRAWALS					ESTIMATED WITHDRAWALS					TOTAL ESTIMATED WITHDRAWALS	TOTAL WITHDRAWALS	MINING DISCHARGES	TOTAL DISCHARGES	SI	SIP (%)
				PUBLIC WATER SUPPLY	IND	COMM	AG	MINING	EVAP	RESIDENTIAL	IND	COMM	AG						
209872	Marshalls Creek	26.86	0.59	0.17	0.00	0.18	0.00	0.01	0.19	0.05	0.01	0.08	0.00	0.33	0.69	0.00	0.00	-0.09	-15.72
209918	Appenzell Creek	9.57	0.15	0.03	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.06	0.08	0.00	0.09	0.16	105.45
209954	McMichael Creek	11.59	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.21	91.40
209964	Appenzell Creek	12.79	0.25	0.03	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.06	0.09	0.00	0.09	0.25	101.42
209988	Appenzell Creek	15.86	0.20	0.03	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.07	0.10	0.00	0.09	0.19	98.46
210010	McMichael Creek	14.08	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.23	88.79
210028	Lake Creek	9.52	0.06	0.18	0.08	0.00	0.00	0.00	0.04	0.02	0.00	0.00	0.00	0.06	0.32	0.00	0.00	-0.26	-414.47
210030	McMichael Creek	17.75	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.26	87.92
210742	Stony Run	8.76	0.12	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	-0.02	-18.54
210818	Stony Run	10.25	0.15	0.00	0.00	0.00	0.00	0.00	0.14	0.01	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.01	4.69
211140	Pond Creek	8.59	0.14	0.10	0.00	0.07	0.00	0.00	0.16	0.01	0.01	0.01	0.00	0.18	0.36	0.00	0.00	-0.22	-164.87
211286	McMichael Creek	8.34	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.19	94.44
212130		8.78	0.17	0.36	0.00	0.04	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03	0.43	0.00	0.00	-0.26	-152.53
212162	Goose Pond Run	8.24	0.11	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.05	43.26
212250	Paradise Creek	9.30	0.18	0.02	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.03	0.15	84.25
212252	Paradise Creek	11.35	0.22	0.02	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.07	0.08	0.00	0.03	0.16	73.74
212258	Paradise Creek	10.23	0.20	0.02	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.07	0.08	0.00	0.03	0.14	70.50
212272	Paradise Creek	12.73	0.25	0.02	0.00	0.00	0.00	0.00	0.09	0.01	0.00	0.00	0.00	0.10	0.12	0.00	0.03	0.16	63.79
212328	Swiftwater Creek	9.71	0.16	0.05	0.19	0.09	0.00	0.00	0.08	0.01	0.01	0.04	0.00	0.14	0.47	0.00	0.20	-0.11	-69.29
212356	Swiftwater Creek	9.09	0.15	0.05	0.19	0.09	0.00	0.00	0.08	0.01	0.01	0.04	0.00	0.14	0.47	0.00	0.20	-0.13	-85.83
212364	Marshalls Creek	9.05	0.13	0.04	0.00	0.01	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.06	0.10	0.00	0.00	0.04	28.51
212366	Swiftwater Creek	8.02	0.12	0.05	0.19	0.09	0.00	0.00	0.08	0.01	0.01	0.04	0.00	0.14	0.47	0.00	0.20	-0.15	-121.51
212382	Pocono Creek	8.59	0.13	0.01	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.04	0.05	0.00	0.00	0.09	65.64
212394	Pocono Creek	10.84	0.19	0.05	0.00	0.02	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.08	0.14	0.00	0.06	0.10	53.26
212396	Marshalls Creek	13.51	0.24	0.04	0.00	0.11	0.00	0.00	0.03	0.04	0.00	0.03	0.00	0.10	0.25	0.00	0.00	-0.01	-3.49
212398	Marshalls Creek	22.11	0.45	0.14	0.00	0.18	0.00	0.00	0.19	0.05	0.01	0.04	0.00	0.29	0.61	0.00	0.00	-0.16	-34.39
212404	Sambo Creek	8.28	0.16	1.38	0.00	0.00	0.00	0.00	0.15	0.02	0.18	0.04	0.00	0.40	1.78	1.36	1.58	-0.04	-25.33
212424	Sambo Creek	10.08	0.18	1.38	0.00	0.00	0.00	0.00	0.18	0.03	0.18	0.09	0.00	0.48	1.86	1.36	1.58	-0.10	-54.37
212626	Brodhead Creek	29.77	0.69	0.58	0.00	0.32	0.00	0.00	0.18	0.01	0.02	0.00	0.00	0.21	1.11	0.00	0.07	-0.36	-51.89
212664	Brodhead Creek	33.94	0.79	0.58	0.00	0.32	0.00	0.00	0.18	0.02	0.02	0.00	0.00	0.22	1.12	0.00	0.12	-0.21	-26.29

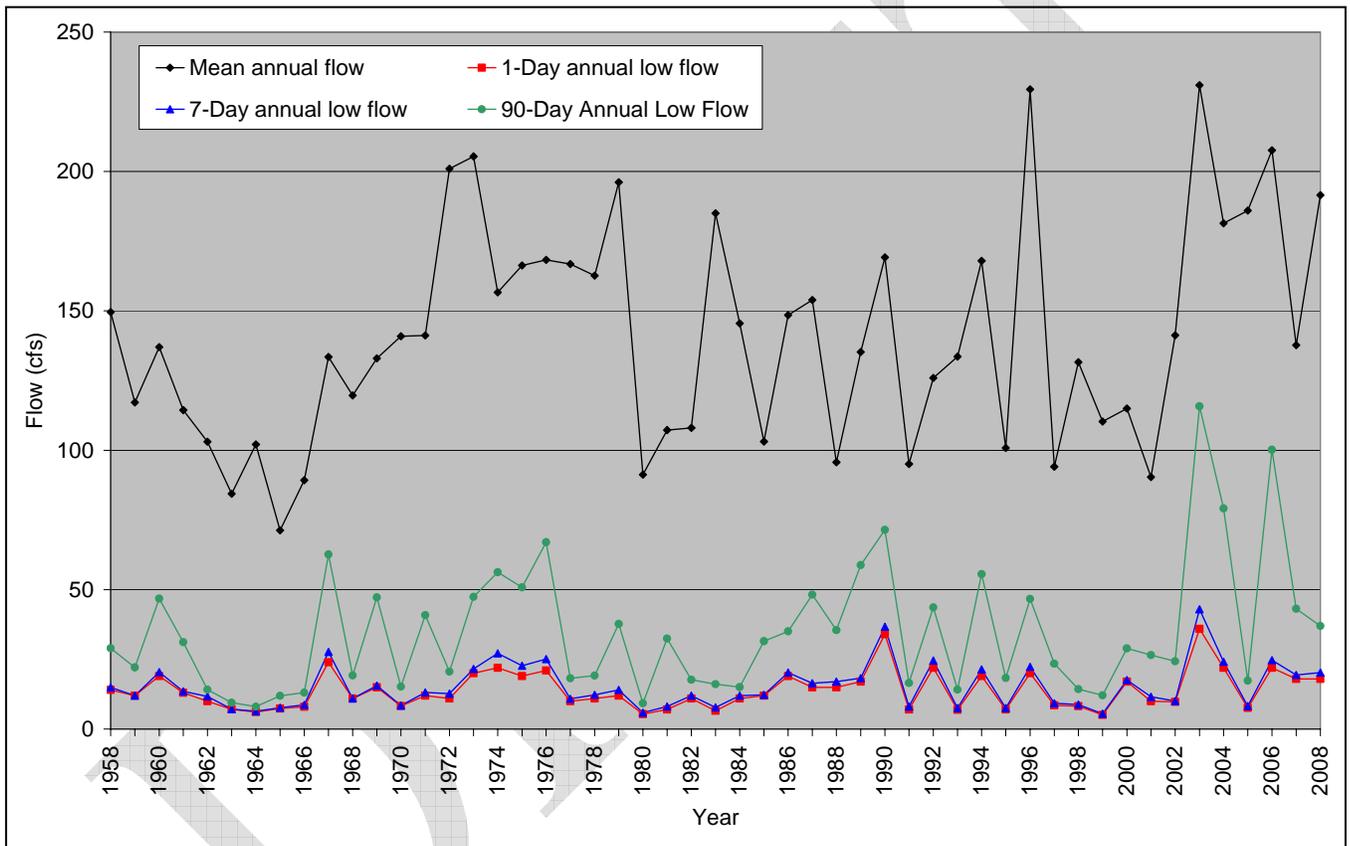
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POINT NUMBER	STREAM NAME	DRAINAGE AREA (SQUARE MILES)	ISC	REGISTERED WITHDRAWALS					ESTIMATED WITHDRAWALS					TOTAL ESTIMATED WITHDRAWALS	TOTAL WITHDRAWALS	MINING DISCHARGES	TOTAL DISCHARGES	SI	SIP (%)
				PUBLIC WATER SUPPLY	IND	COMM	AG	MINING	EVAP	RESIDENTIAL	IND	COMM	AG						
212690	Brodhead Creek	41.84	1.03	0.71	0.00	0.32	0.00	0.00	0.31	0.02	0.02	0.01	0.00	0.36	1.39	0.00	0.12	-0.25	-23.86
212714	Brodhead Creek	44.61	1.10	0.71	0.00	0.32	0.00	0.00	0.31	0.02	0.02	0.01	0.00	0.37	1.40	0.00	0.12	-0.17	-15.55
212736	Brodhead Creek	47.11	1.19	0.71	0.00	0.32	0.00	0.00	0.31	0.02	0.02	0.01	0.00	0.37	1.40	0.00	0.12	-0.09	-7.56
212738	Brodhead Creek	57.37	1.50	0.71	0.00	0.32	0.00	0.00	0.45	0.03	0.02	0.02	0.00	0.51	1.54	0.00	0.12	0.08	5.21
212752	Brodhead Creek	61.45	1.65	0.71	0.00	0.32	0.00	0.00	0.45	0.03	0.02	0.02	0.00	0.51	1.55	0.00	0.12	0.23	13.81
212824	Brodhead Creek	70.74	2.03	0.71	0.00	0.71	0.00	0.00	0.49	0.04	0.02	0.02	0.00	0.57	1.99	0.32	0.44	0.49	23.88
212826	Paradise Creek	44.44	1.21	0.08	0.19	0.13	0.00	0.00	0.36	0.04	0.01	0.08	0.00	0.51	0.90	0.28	0.92	1.22	101.19
212828	Pocono Creek	18.51	0.41	0.06	0.00	0.02	0.00	0.00	0.27	0.03	0.00	0.07	0.00	0.36	0.44	0.00	0.07	0.03	7.00
212836	Pocono Creek	22.16	0.50	0.06	0.00	0.02	0.00	0.00	0.27	0.04	0.01	0.09	0.00	0.40	0.48	0.00	0.08	0.09	18.66
212840	Pocono Creek	25.10	0.59	0.06	0.00	0.02	0.00	0.00	0.27	0.05	0.01	0.10	0.00	0.42	0.50	0.00	0.08	0.16	27.89
212852	Pocono Creek	31.43	0.80	0.06	0.00	0.02	0.00	0.00	0.37	0.05	0.01	0.11	0.00	0.53	0.62	0.00	0.08	0.25	32.03
212856	Pocono Creek	34.33	0.88	0.06	0.00	0.02	0.00	0.00	0.37	0.06	0.01	0.12	0.00	0.55	0.63	0.00	0.09	0.33	37.79
212868	Pocono Creek	37.43	0.96	0.07	0.00	0.02	0.00	0.00	0.37	0.07	0.01	0.16	0.00	0.61	0.70	0.00	0.09	0.35	36.48
212896	Pocono Creek	48.04	1.24	0.23	0.00	0.02	0.00	0.00	0.54	0.10	0.01	0.18	0.00	0.83	1.08	0.00	0.09	0.24	19.31
212898	Appenzell Creek	22.19	0.29	0.04	0.00	0.00	0.00	0.00	0.06	0.05	0.00	0.01	0.00	0.13	0.16	0.00	0.10	0.23	77.47
212900	McMichael Creek	35.72	0.54	0.23	0.08	0.00	0.00	0.11	0.08	0.07	0.01	0.04	0.00	0.21	0.63	0.00	0.05	-0.04	-7.44
212966	McMichael Creek	21.26	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.00	0.08	0.08	0.00	0.00	0.25	75.61
212988	McMichael Creek	33.39	0.50	0.18	0.08	0.00	0.00	0.00	0.04	0.07	0.01	0.04	0.00	0.17	0.43	0.00	0.00	0.07	14.02
212992	McMichael Creek	23.86	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.04	0.00	0.11	0.11	0.00	0.00	0.28	72.84
213044	Brodhead Creek	115.20	3.90	0.79	0.19	0.84	0.00	0.00	0.86	0.09	0.03	0.10	0.00	1.08	2.89	0.60	1.36	2.37	60.71
213072	Brodhead Creek	130.88	4.69	6.19	0.19	0.84	0.00	0.00	1.03	0.12	0.04	0.16	0.00	1.35	8.57	3.46	4.50	0.63	13.43
213092	Brodhead Creek	144.24	5.17	8.09	0.19	0.84	0.00	0.00	1.21	0.15	0.22	0.25	0.00	1.84	10.96	4.82	6.08	0.29	5.70
213094	McMichael Creek	113.87	3.27	0.51	0.08	0.08	0.00	0.11	0.68	0.24	0.05	0.31	0.00	1.28	2.06	0.00	1.62	2.83	86.56
213098	McMichael Creek	65.56	1.47	0.28	0.08	0.06	0.00	0.11	0.14	0.14	0.04	0.13	0.00	0.45	0.98	0.00	0.14	0.64	43.21
213122	McMichael Creek	61.78	1.35	0.28	0.08	0.00	0.00	0.11	0.14	0.13	0.04	0.13	0.00	0.45	0.91	0.00	0.14	0.58	42.86
213176	McMichael Creek	57.93	1.23	0.27	0.08	0.00	0.00	0.11	0.14	0.12	0.01	0.06	0.00	0.34	0.79	0.00	0.14	0.58	47.36
213378	Brodhead Creek	258.11	10.19	8.60	0.27	0.92	0.00	0.11	1.89	0.40	0.27	0.56	0.00	3.12	13.02	4.82	7.70	4.88	47.85
999902	Brodhead Creek	260.79	10.32	8.60	0.68	0.92	0.00	0.11	1.92	0.40	0.27	0.57	0.00	3.16	13.47	4.82	9.53	6.37	61.79
999904	Marshalls Creek	26.84	0.59	0.17	0.00	0.18	0.00	0.01	0.00	0.05	0.01	0.19	0.00	0.25	0.61	0.00	0.00	-0.02	-3.68

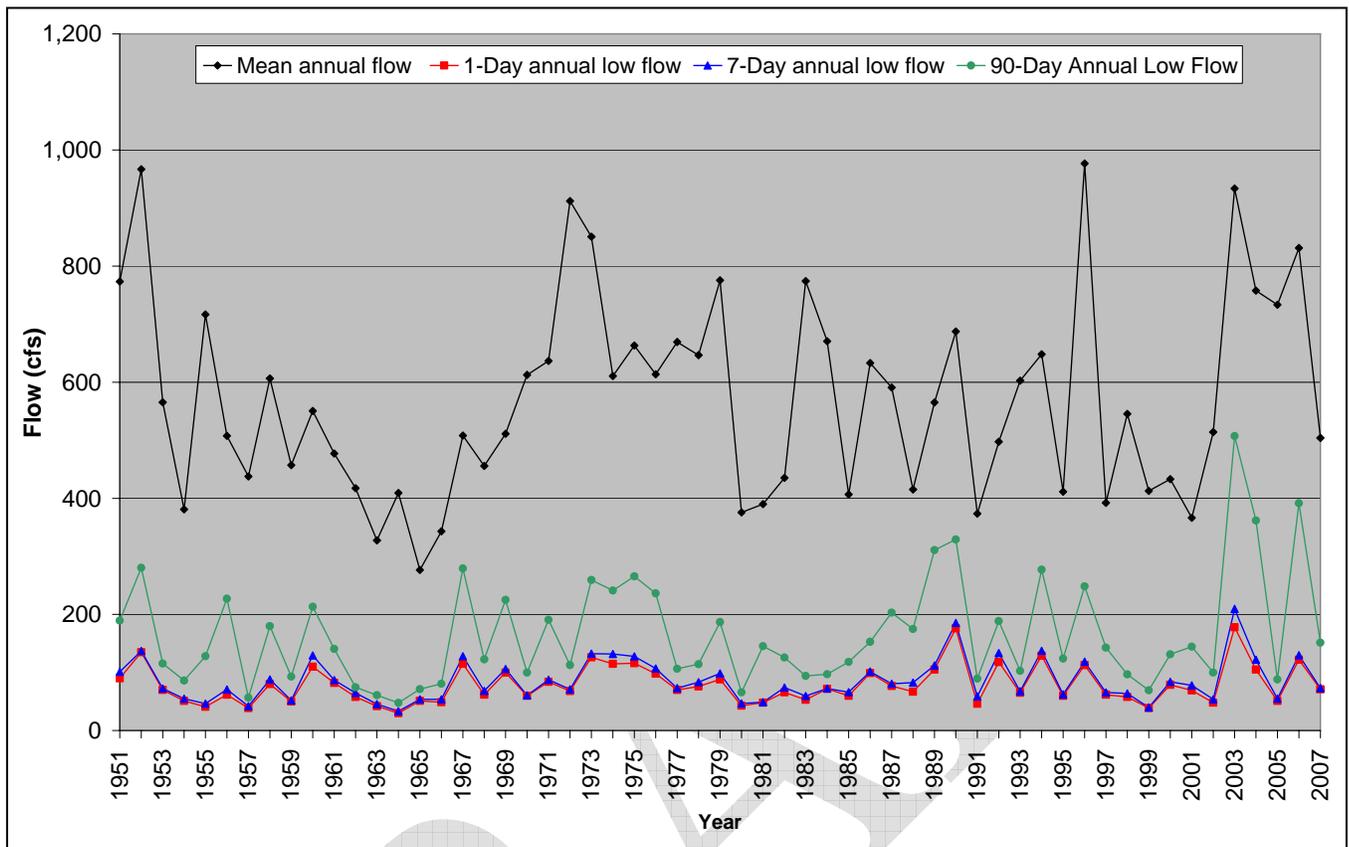
Records for eight USGS stream gages in the Brodhead Creek watershed exist in the USGS NWIS system, however only two of which (01440400 and 01442500) have a sufficient (>10 years) and current period of record to perform a useful time series analysis which may provide ground-truthing information. Gage 01440400 (Figure 3) is located on the Brodhead Creek near Analomink, slightly upstream of Leas Run; it has a drainage area of 66 mi<sup>2</sup> and provides 50 years of continuous daily streamflow data. Based on measured daily streamflow data from the gage the calculated (or observed) 7Q10 is 4.830 Mgal/d. The gage is located 1.5 miles upstream of pour point 212824 which has a drainage area of 71 mi<sup>2</sup>. The WAST data for this pour point (representing assumed natural flow conditions) indicates a 7Q10 of 4.064 Mgal/d.

**Figure 3.** USGS Gage 01440400 Brodhead Creek near Analomink, PA



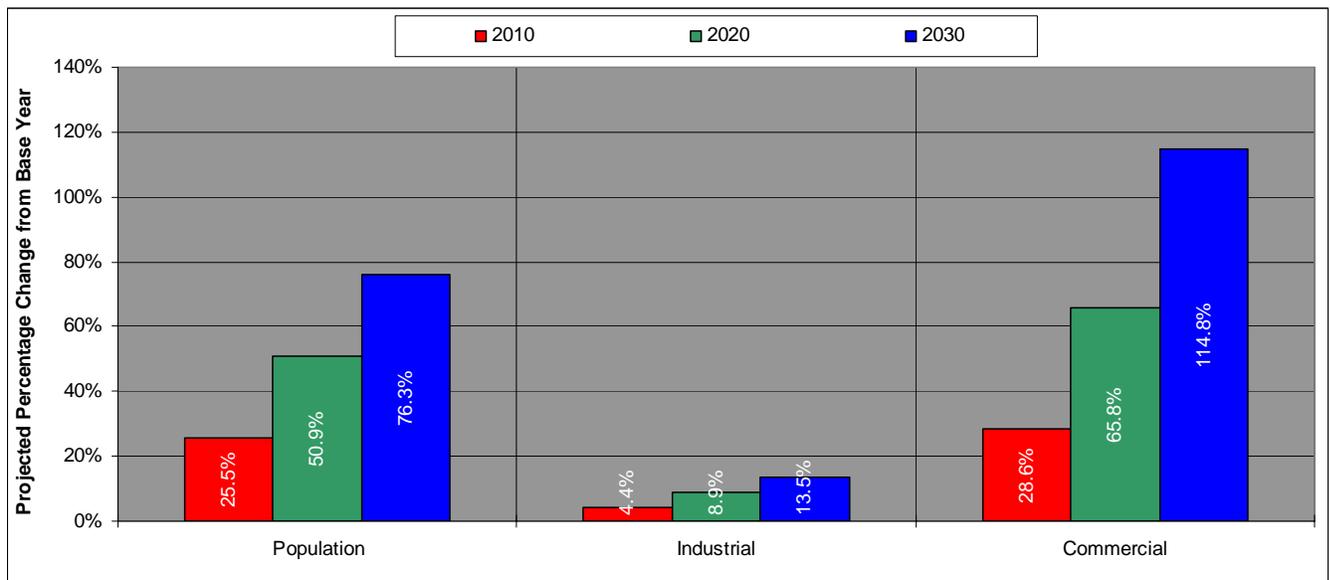
USGS Gage 01442500 (Figure 4) is also located on the Brodhead Creek at Minisink Hills, approximately 0.1 miles upstream of Marshalls Creek; it has a drainage area of 259 mi<sup>2</sup> and provides 56 years of continuous daily streamflow data. Based on an analysis of the daily streamflow data from the gage the calculated (or observed) 7Q10 is 30.129 Mgal/d. The gage is located 0.03 miles downstream of pour point 999902 which has a drainage area of 260 mi<sup>2</sup>. The WAST data for this pour point (representing assumed natural flow conditions) indicates a 7Q10 of 20.630 Mgal/d. The pour point registers withdrawals in excess of discharges in the amount of approximately 4 Mgal/d, which would typically suggest that the observed 7Q10 would be less than the estimated natural flow due to consumptive use. In this instance, the observed 7Q10 is 50% *higher* than the estimated natural flow.

**Figure 4.** USGS Gage 01442500 Brodhead Creek at Minisink Hills, PA



Population projections for the Brodhead watershed were determined by PaDEP on the basis of municipalities through 2030 (Pennsylvania Department of Environmental Protection, 2006). Population, as measured by the U.S. Census, in 2000 was 86,000 representing an average population density of 330/sq mi. Monroe County is the second-fastest growing county in the state (U.S. Census, 2000) and population in the Brodhead Creek watershed is projected to increase approximately 26 percent by 2010, approximately 51 percent by 2020, and approximately 76 percent by 2030 (figure 5). Long term industry employment projections were determined from Workforce Investment Area data (Center for Workforce Information and Analysis, 2004). The number of employees in the Industrial (Manufacturing) category is projected to increase throughout the projection period, by approximately 4 percent by 2010, approximately 9 percent by 2020, and approximately 14 percent by 2030 (figure 5). The number of employees in the commercial category is projected to increase approximately 29 percent by 2010, approximately 56 percent in 2020 and approximately 115 percent by 2030 (figure 5). Projected changes in water use by these categories may follow the same rate of growth, however further study is required to identify more precisely where the growth is likely to occur and how water resources will be developed to meet that growth. Infrastructure development enables water to be moved long distances where necessary, therefore it is possible that demand for water within the watershed could be met from sources outside, and vice versa. The population and commercial growth rates are the largest in the six watersheds studied in the Delaware River Basin portion of Pennsylvania under the Final Verification work in support of the State Water Plan.

**Figure 5.** Projected percent of change in population, number of employees in the industrial category, and number of employees in the commercial category from baseline year<sup>1</sup> to projection year within the Brodhead Creek Watershed, Monroe and Pike Counties, Pennsylvania



<sup>1</sup>Baseline year for population is 2000. Baseline year for both number of employees in the industrial category and number of employees in the commercial category is 2002.

This screening is based on 2003 data, but DRBC docket information and personal communication with other Commission staff and stakeholders in the community, verified by fieldwork, makes it clear that the Brodhead watershed is a rapidly developing area, particularly around the resort communities. The rapid pace of development is also evidenced by water infrastructure expansion such as that which has occurred along the Route 611 corridor.

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