Surface Water Withdrawals and Consumption

Electric power plants in Maryland use several types of generating technologies, including steam-driven turbines, combustion turbines, combined cycle facilities (a combination of steam and combustion turbine units) and renewable energy facilities (hydroelectric, solar, wind). Power plants utilizing steam have significant water withdrawals because of the need to cool and condense the recirculating steam.[1] The majority of all surface water withdrawn in the state is used for cooling water at steam electric facilities. Power plant cooling accounted for about 75 percent of the total surface water appropriations in the state in 2022. Combined water withdrawal for all steam generating power plants in Maryland during 2022 was reported at approximately 3.9 billion gallons per day as an annual average. By comparison, the Potomac River has an average discharge of roughly 7 billion gallons per day, and the Susquehanna River discharges an average of more than 20 billion gallons per day (actual daily flows in both the Susquehanna and the Potomac fluctuate greatly, both seasonally and from year to year).

Table 1 lists all major steam-generating power plants in Maryland (excluding self-generators) and quantifies their water withdrawals and consumption for 2021 and 2022. The plants are grouped into two categories: those that use once-through cooling, and those with closed-cycle cooling systems.

Table 1 Surface Water Appropriations and Use at Maryland Power Plants with Steam Cycles, 2021-2022

Power Plant	Surface Water Appropriation (average, mgd)	2021 Actual Surface Withdrawal (average, mgd)	2022 Actual Surface Withdrawal (average, mgd)	Estimated Consumption (mgd)	Water Source
Once-Through Cooling					
Calvert Cliffs	3,500	3,386	3,375	18.4	Chesapeake Bay
H.A. Wagner	600	124	95	0.63	Patapsco River
Morgantown See Note (a)	1,500	766	343	1.18	Potomac River
Wheelabrator	50	38.5	31.1	0.18	Gwynns Falls
SUBTOTAL	**5,650**	**4,315**	**3,844**	**20.4**	
Closed-Cycle Cooling					
AES Warrior Run See Note (b)	0.021	1.36	1.35	0.88	City of Cumberland (freshwater)

[1] Combustion turbines have minimal water needs in comparison; however, they do consume water to control emissions and improve efficiency. This water must be high quality because it comes in direct contact with turbine surfaces. Therefore, it is generally sourced from groundwater or purchased water supply.

Power Plant	Surface Water Appropriation (average, mgd)	2021 Actual Surface Withdrawal (average, mgd)	2022 Actual Surface Withdrawal (average, mgd)	Estimated Consumption (mgd)	Water Source
Brandon Shores	35	1.10	0.85	0.63	Patapsco River (Wagner discharge)
Chalk Point	20	0.06	2.08	0.70	Patuxent River
CPV St. Charles	N/A	2.28	2.23	1.47	Mattawoman WWTP
Montgomery Co. Resource Recovery Facility	1.549	1.01	1.13	0.70	Potomac River (nontidal)
KMC Thermo - Brandywine	N/A	0.54	0.36	0.29	Mattawoman WWTP
Vienna	2.0	0.010	0.011	0.01	Nanticoke River
SUBTOTAL	**58.6**	**6.36**	**8.01**	**4.68**	
TOTAL	**5,709**	**4,321**	**3,852**	**25.1**	

Source: MDE Water & Science Administration
mgd = million gallons per day
N/A = not applicable
(a) Morgantown's appropriation was deactivated in July 2023 following decommissioning of the coal-fired units.
(b) AES Warrior Run purchases its water from the City of Cumberland. The surface water appropriation of 0.021 mgd is for backup surface water withdrawals only.

Closed-cycle systems recycle cooling water and withdraw less than one-tenth of the water required for once-through cooling; however, depending on plant design and operating parameters, 50 to 80 percent of the water evaporates from the cooling tower and does not return to the source, thus representing a consumptive use. Consumptive use is water that is withdrawn but not returned directly to the surface or groundwater source and is unavailable to other users. In water-limited or highly regulated systems (rivers with multiple dams and reservoirs), consumptive use is a critical factor in determining the allocation and under what conditions competing uses have to be curtailed or prioritized.

Seven steam power plants in Maryland—AES Warrior Run, Brandon Shores, Chalk Point, CPV St. Charles, Montgomery Co. Resource Recovery Facility, KMC Thermo and Vienna—currently use closed-cycle cooling (cooling towers) exclusively instead of once-through cooling. In Table 1, the estimated consumption values for closed-cycle systems are calculated assuming 65 percent of the surface water withdrawals are lost to evaporation. One more recently constructed steam power plant—Wildcat Point in Cecil County—also uses closed-cycle cooling, but it obtains water via direct withdrawal from the Susquehanna River in Pennsylvania and thus is not subject to Maryland appropriations permitting.

For power plants with once-through cooling systems, water losses within the cooling system itself are negligible, but the water discharged is at a higher temperature and this results in elevated evaporative losses in the receiving waters. These losses are not easily measured. PPRP's estimate of consumptive use from once-through cooling is based on work conducted in the 1980s by the Interstate Commission on the Potomac River Basin (ICPRB), which calculated instream evaporative losses caused by heated discharges from 14 Maryland power plants. The ICPRB found that, on average, instream losses were equivalent to about 0.6 percent of a plant's total discharge volume during the summer and 0.5 percent during the winter.

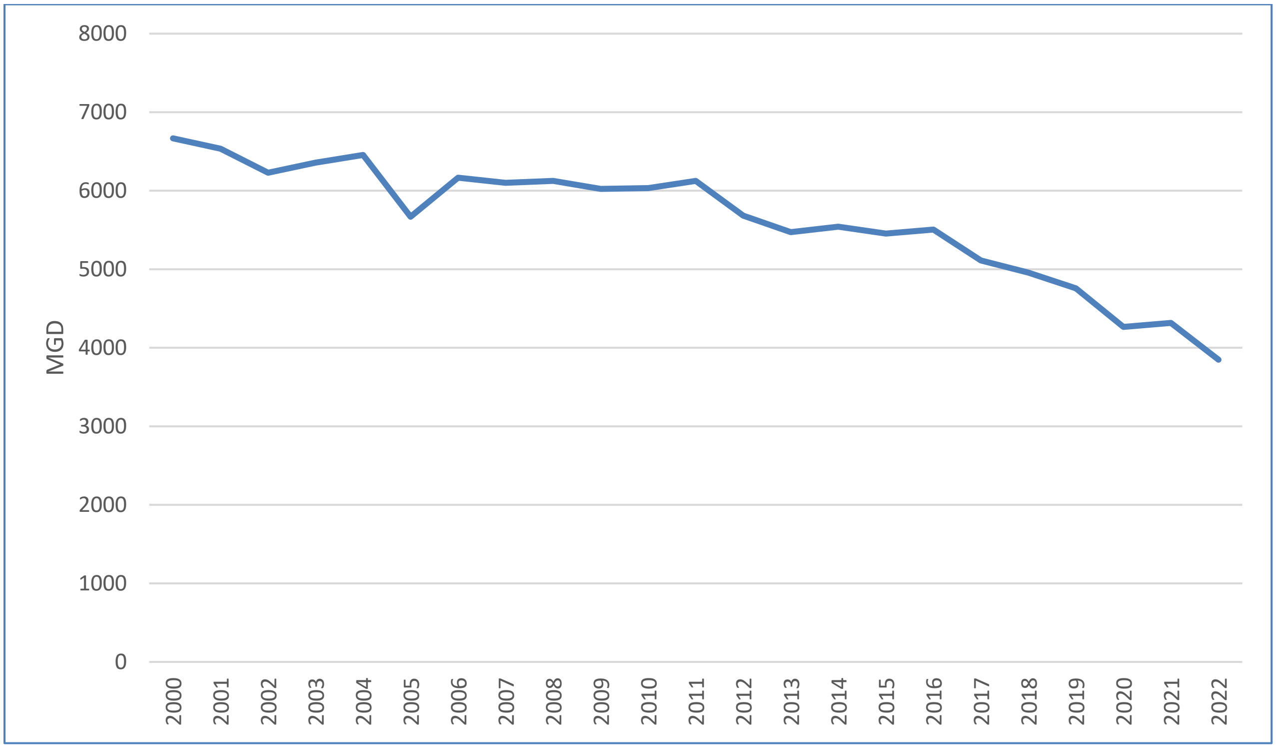
Nuclear power plants fall within the steam generating category; however, they use nuclear reactions instead of fossil fuel combustion to create the needed thermal energy. The typical nuclear power plant operating today requires 10 to 30 percent more cooling water, on a per-MWh basis, compared to a fossil fuel plant since nuclear stations generally operate at a lower steam temperature and pressure compared to fossil fuel-fired generating plants. This results in a somewhat lower efficiency in the conversion of thermal energy to mechanical and, ultimately, electrical energy. Consequently, more waste heat is created per MWh generated than would occur in a fossil fuel plant, and more cooling water is needed to absorb that waste heat.

Calvert Cliffs Nuclear Power Plant (CCNPP) withdraws an average of 3.4 billion gallons per day directly from Chesapeake Bay. This is the largest single appropriation of water in Maryland. While most of the water withdrawn by CCNPP is returned to the Chesapeake Bay, an estimated 18.4 mgd is lost to evaporation as a result of the heated discharge.

When assessing the significance of water withdrawal impacts, the nature of the source water body is a key factor. In estuaries such as the Chesapeake Bay, and the tidal portions of Chesapeake Bay tributaries, the quantity of water "lost" is less important because tidal influx continually replaces the water withdrawn. In these estuarine environments, the ecological impacts of water withdrawals can be significant, but the consumptive loss is not a concern. By contrast, consumptive loss in nontidal riverine systems can adversely affect aquatic habitat and other users of the water body. The Dickerson power plant was a major freshwater consumer until its surface water appropriation was deactivated in 2021 following the decommissioning of its coal-fired units.

Combined surface water withdrawals by steam electric plants in Maryland have steadily declined since 2000, reflecting the reduced amount of coal-fired generation. The coal units at Chalk Point, Dickerson, and Morgantown all had significant water appropriations until their decommissioning. Large natural gas-fired generating stations built over the last 25 years – CPV St. Charles, Keys Energy Center, and Wildcat Point – do not have surface water appropriation permits from Maryland. CPV uses reclaimed water from the Mattawoman Wastewater Treatment Plant (WWTP); Keys uses dry cooling technology; and Wildcat Point obtains cooling water via pipeline from a direct withdrawal point on the Susquehanna River in Pennsylvania. All other new generators built in Maryland have been solar and wind facilities that do not require water for ongoing operations.

Figure 1 Surface Water Withdrawals at Steam Power Plants in Maryland, 2000-2022



Groundwater Withdrawals

High-volume groundwater withdrawals have the potential to lower the water table of an area, thus reducing the amount of water available for other users. Excessive withdrawals from Coastal Plain aquifers can also cause intrusion of salt water into the aquifer. Although large volumes of groundwater are available in the Coastal Plain aquifers, withdrawals must be managed over the long term to ensure adequate groundwater supplies for the future. The impact of these withdrawals has been a key issue in Southern Maryland, where there is a significant reliance on groundwater for public water supply.

Currently, five power plants withdraw groundwater from Southern Maryland Coastal Plain aquifers for plant operations: CCNPP, NRG's Chalk Point and Morgantown power plants, NRG's combustion turbine facility (located at the Chalk Point plant and formerly owned by Southern Maryland Electric Cooperative (SMECO)) and KMC Thermo's combined cycle power plant. These five plants have historically withdrawn groundwater from three aquifers in Southern Maryland: the Aquia, the Magothy and the Patapsco. Chalk Point began withdrawing groundwater from the deeper Patuxent Aquifer in 2009. Groundwater is used for boiler feedwater in coal-fired power plants; as coal-fired units have ceased operating at Chalk Point and Morgantown, groundwater withdrawals at these sites have also declined. However, natural gas-fired units are still in operation and groundwater is required for inlet air cooling and emissions control.

Three additional Maryland power plants currently have groundwater appropriation permits, but these facilities withdraw from sources other than the Coastal Plain aquifers: Dickerson, located in

Montgomery County (New Oxford Formation); Perryman, located in Harford County northeast of Baltimore (Talbot Aquifer); and Vienna, located in Dorchester County on the Eastern Shore (Columbia Group Aquifer). These withdrawals are very small compared to the power plant withdrawals from Coastal Plain aquifers.

Figure 2 shows the total groundwater withdrawals expressed as daily averages from 2000 to 2022 for each of the power plants. Table 2 also lists the current groundwater appropriation limit for each of these withdrawals.

Figure 2 Average Daily Groundwater Withdrawal Rates at Maryland Power Plants (in mgd)

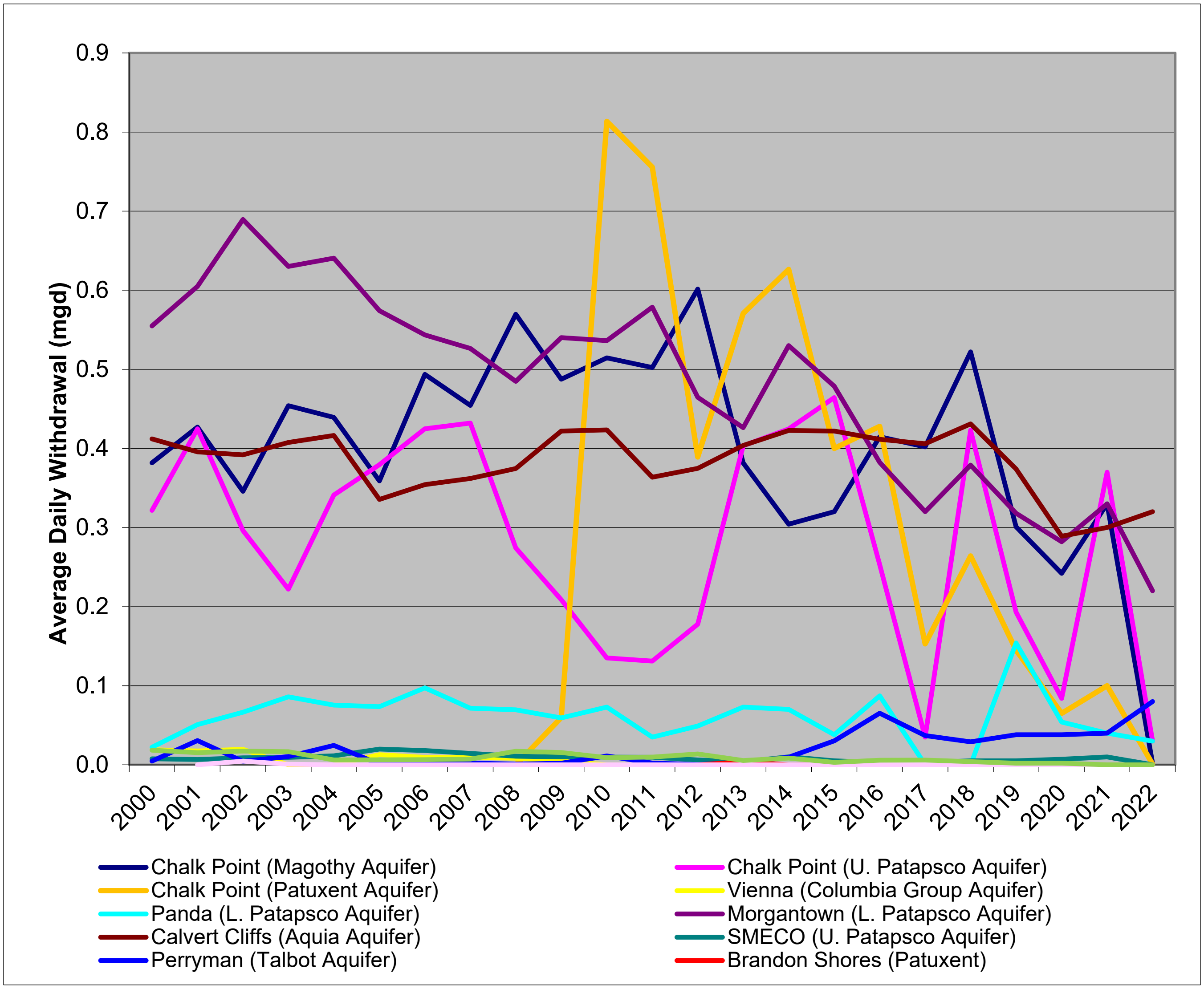


Table 2 Average Daily Ground Water Withdrawal Rates at Maryland Power Plants (in mgd)

	Chalk Point (Magothy Aquifer)	Chalk Point (U. Patapsco Group Aquifer)	Chalk Point (Patuxent Aquifer) See Note (a)	Vienna (Columbia Aquifer)	Panda (L. Patapsco Aquifer)	Morgantown (L. Patapsco Aquifer)	Calvert Cliffs (Aquia Aquifer)	SMECO (U. Patapsco Aquifer)	Perryman (Talbot Aquifer)	Brandon Shores (Patuxent)	Rock Springs (Baltimore Gabbro Complex)	Dickerson (New Oxford Formation)	Total Average Daily Withdrawal
Current Appropriation Limit	0.66	1.02	0.66	0.035	0.074[b]	0.7	0.45	0.02	0.942	0.0099	5.5 E-3	0.0055	3.9
2000	0.382	0.322		0.019	0.022	0.555	0.412	0.008	0.005			0.018	1.7
2001	0.427	0.425		0.018	0.051	0.605	0.396	0.007	0.031		0.00000	0.015	2.0
2002	0.346	0.296		0.020	0.067	0.689	0.392	0.009	0.004		0.00463	0.017	1.8
2003	0.454	0.222		0.023 See Note (b)	0.086	0.630	0.407	0.009	0.010		0.00070	0.017	1.9
2004	0.439	0.341		0.008 See Note (c)	0.075	0.641	0.416	0.011	0.025		0.00011	0.006	2.0
2005	0.359	0.379		0.013	0.074	0.574	0.336	0.020	0.001		0.00008	0.006	1.8
2006	0.494	0.425		0.009	0.097	0.543	0.354	0.018	0.002		0.00011	0.007	1.9
2007	0.454	0.432	0.000	0.009	0.072	0.526	0.362	0.015	0.002		0.00010	0.007	1.9
2008	0.570	0.274	0.000	0.008	0.069	0.485	0.375	0.011	0.001		0.00010	0.017	1.8
2009	0.488	0.209	0.060	0.005	0.059	0.540	0.422	0.010	0.002		0.00012	0.015	1.8
2010	0.514	0.135	0.813	0.000	0.073	0.536	0.423	0.010	0.011		0.00012	0.009	2.5
2011	0.502	0.131	0.756	0.000	0.035	0.579	0.364	0.010	0.002		0.00010	0.010	2.4
2012	0.601	0.178	0.389	0.001	0.049	0.465	0.375	0.006	0.000	0.00000	0.00011	0.014	2.1
2013	0.382	0.403	0.571	0.000	0.073	0.426	0.404	0.004	0.003	0.00384	0.00009	0.006	2.3
2014	0.304	0.425	0.626	0.000	0.070	0.530	0.423	0.010	0.010	0.00011	0.00005	0.009	2.4
2015	0.320	0.464	0.400	0.000	0.038	0.479	0.422	0.005	0.030	0.00015	--	0.003	2.2
2016	0.415	0.253	0.428	0.000	0.087	0.382	0.412	0.003	0.065	0.00009	--	0.006	2.1
2017	0.402	0.035	0.153	0.0002		0.320	0.406	0.003	0.037	0.00009	--	0.006	1.4
2018	0.522	0.423	0.264	0.000		0.379	0.431	0.005	0.029	0.00005	--	0.004	2.1
2019	0.301	0.193	0.145	0.000	0.154	0.318	0.374	0.005	0.038	0.00004	--	0.002	1.5
2020	0.242	0.084	0.065	0.000	0.054	0.282	0.289	0.007	0.038	0.00003	--	0.002	1.1
2021	0.330	0.370	0.100	0.000	0.040	0.330	0.300	0.01000	0.040	--	--	0.000	1.5
2022	0.002	0.030	0.001	0.000	0.030	0.220	0.320	0.00010	0.080	--	--	0.000	0.7

Source: U.S. Geological Survey, MDE Water & Science Administration.
Note (a): Well was installed in 2007. Routine withdrawal did not occur until approximately 2009.
Note (b): No report was submitted to MDE for the period July – December 2003. The amount shown was estimated using the total volume withdrawn of 4,131,683 gallons reported for the period January – June 2003.
Note (c): No report was submitted to MDE for the period January – June 2004. The amount shown was estimated using the total volume withdrawn of 1,505,770 gallons reported for the period July – December 2004.

Section 316(a) Thermal Regulations

Section 316(a) of the Clean Water Act regulates heated discharges into waters of the United States.
Relevant Documents

- 1977 EPA 316(a) Technical Guidance Manual
- Overview of CWA Section 316(a) Evaluations of Power Plants with Thermal Discharges in Maryland

316(b) Cooling Water Intake Structure Regulations

EPA developed new regulations issued in 2014 under section 316(b) of the Clean Water Act that had significance to the owners and operators of many power plants within Maryland, and also to electricity consumers within our state. Section 316(b) requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact. The withdrawal of cooling water has the potential to cause environmental impacts due to impingement and mortality of organisms, primarily fish, on screens that protect the intake system, and through entrainment and mortality of small organisms, primarily fish eggs and larvae, that pass through those screens and through the plant's entire cooling system. Development of the regulations originally took place in three phases: Phase I, which was completed in late 2001, applied to new facilities. Phase II, which was issued in 2004, consisted of regulations applicable to existing large facilities, defined as those withdrawing more than 50 mgd. Phase III consisted of regulations applicable to small existing facilities (i.e., those that withdraw less than 50 mgd). In 2007, the U.S. 2nd Circuit Court of Appeals decided in Riverkeeper, Inc., v. EPA that many parts of the Phase II rule were invalid or needed to be reevaluated by EPA. Thus, in 2007, the Phase II rule was suspended. A portion of this ruling with respect to the cost-benefit test was appealed to the U.S. Supreme Court. The court ruled in 2009 that the cost-benefit test is allowed; specifically, the court stated: "The EPA permissibly relied on cost-benefit analysis in setting the national performance standards and in providing for cost-benefit variances from those standards as part of the Phase II regulations." EPA issued a proposed revised rule for public comment in 2011, addressing the other issues required by the Riverkeeper case and the U.S. Supreme Court ruling on cost-benefit testing. PPRP submitted comments on the proposed rule. The EPA finalized the standards effective October 14, 2014 and further details are available at USEPA's 316(b) website.

Consequences for Maryland Power Plants

There were 7 power generating facilities in Maryland that had permits allowing for cooling water withdrawals greater than 2 mgd and which were covered by that rule. All of these facilities had 316(b) demonstration studies conducted in the late 1970's or early 1980's and all were eventually found to be in compliance with Maryland's 316(b) requirements. To attain compliance, some facilities were required to conduct additional studies to determine the extent of their entrainment and impingement (E&I) impacts and one was required to mitigate its impacts. Currently only 3 facilities remain in operation which use once-through cooling systems and are subject to this regulation (Calvert Cliffs Nuclear Power Plant, the H.A. Wagner and Brandon Shores steam electric power stations, and Wheelabrator Baltimore.