DRAFT – August 14, 2008 -- DRAFT

WATER USE TRENDS – TOMORROW'S FORECAST

Introduction

Water resources planning and management strategies draw heavily on the past to assess the present and predict the future. Historic information is routinely used to forecast floods, assess water availability, control stormwater runoff, manage droughts, and protect the aquatic environment. The practice of looking in the rear view mirror to steer forward, however, may be coming to an end. Climate change and varying water use demands may soon cause current assumptions and models to become outdated and inaccurate. Consistent with one of the top priorities of this State Water Plan, data collection, interpretation, and analysis will be essential to identifying and tracking water resource trends as they become evident. In response, a new generation of models, projections, planning guidelines, design parameters, and management policies may need to be developed that are adaptable to dynamic conditions and capable of providing a clear picture of the future.

Pennsylvanians withdraw about 9.7 billion gallons of water every day from a variety of surface and ground water sources. The thermal electric power industry is responsible for approximately 70% of those withdrawals. Public water supplies make up about 15% of statewide water use while industries use roughly 12%. Mining and agriculture account for close to 2% and 1% of water use, respectively. These current water use patterns will continuously evolve. Population shifts, energy demands, farming practices, infrastructure management, consumer sophistication, national and international policies, and climate change will all influence how water resources are managed over the next several decades. While acknowledging this considerable uncertainty, the future of water resource planning and management in Pennsylvania can be examined in general terms by considering a number of related assessments and relevant emerging trends. These topics are briefly addressed below with the intent of raising awareness and stimulating further discussion about their potential long term influence on water use, watershed protection, water resource planning, and water management.

Domestic Water Supply

Pennsylvania's population is nearing 12,500,000 and ranks sixth in the country, but it increased only about 1.2% over the period spanning 2000 to 2006. This slight population growth has not been uniform, but has been accompanied by a geographic population shift. Thirty-eight counties in the northern tier and western regions of Pennsylvania are losing population. Most urban centers,

including Philadelphia and Pittsburgh, are also losing residents. Conversely, population in the south-central, eastern, and northeastern counties is growing, due primarily to border state migration and suburban relocation. Pike and Monroe Counties experienced population growths of over 25% and 19% respectively during the six year period. Chester County's population increased by over 48,000 and York County gained nearly 34,600 residents. Berks, Bucks, Montgomery, and Monroe Counties all had population increases of over 25,000 while Lancaster, Lehigh, and Northampton Counties each saw their populations expand by over 20,000 residents. These trends are expected to continue, but an even greater population shift is looming if drought conditions in the western United States persist as predicted. The National Oceanic and Atmospheric Administration has recently conducted simulations that show Colorado River flows, by mid-century, falling to about half the amount consumed today from the river[1]. If these predictions are realized, the water rich northeastern and Great Lakes states could experience a wave of migration from some portion of the 30 million western sunbelt residents currently relying on the Colorado River for water.

Disproportionate population growth translates into an uneven geographic demand for water that will test the adaptive capability of public water supplies. Although per capita water use is expected to remain stable or decline, the customer base for many established water systems will likely contract while overall demand for domestic water will increase in the growing areas of the Commonwealth. To accommodate this redistribution of population, public water supply systems in and around densely populated urban centers will likely continue to consolidate. Institutional arrangements enabling common management of separate water systems to ensure optimum service and rates may also become more widespread. In addition, individual local water supplies will need to be developed or expanded to meet the extra service requirements created by people moving into suburban and rural settings. Protecting the quantity and quality of source waters tapped to address these added demands becomes a higher priority as relocation continues to dominate development patterns.

Increasingly sensitive instrumentation and analytical methods have recently revealed the presence of extremely low levels of unwanted substances in drinking water, including an array of pharmaceuticals and numerous toxic chemicals. The long term impact of those compounds on public health and the aquatic environment is generally unknown. Continued monitoring and research are necessary to understand the magnitude and extent of this issue and guide how these implications may need to be addressed through water resource management.

[1] Kunzig, Robert. "Drying of the West." National Geographic, February 2008

Energy Needs

Projections indicate that energy consumption in the United States will continue to grow in the coming decades. The expansion rate and types of new energy sources employed to meet these additional demands will be major factors in determining future water use in the Commonwealth.

Pennsylvania's wealth of natural resources and infrastructure positions it to play a central role in meeting future national energy demands. The Commonwealth is literally a "keystone" of electric generation and transmission and is directly affected by energy needs beyond its borders. It possesses an efficient power distribution network that is part of an energy grid spanning all or parts of 13 other states and the District of Columbia. In addition to serving all of its own energy needs, Pennsylvania exports approximately $5.0 billion in electricity each year[2].

In 2004, Pennsylvania enacted the Alternative Energy Portfolio Standards Act that requires 18% of the Commonwealth's retail electricity to be generated from alternative sources within 15 years. In addition, Governor Rendell released an energy independence strategy in 2007 designed to produce enough homegrown fuel to replace the current level of foreign imports. In July 2008, legislation was passed that supports these goals by establishing a new $650 million fund to expedite research and development of alternative and renewable energy projects, and to subsidize energy conservation and efficiency projects initiated by individuals and small businesses. By reducing energy use, and relying more on alternative energy sources such as wind and solar power, a parallel reduction in water use may be realized over power generated in thermal electric plants.

As previously noted the thermal electric generation sector currently dominates water use in the Commonwealth. In the Susquehanna River basin alone, there are eight fossil-fueled and three nuclear power plants that withdraw over 4.2 billion gallons of water per day and consume approximately 168 million gallons per day[3]. Based on anticipated growth in electric energy demand, projections show that as many as 15 new major power generation facilities will be needed in Pennsylvania by 2020. Increased energy production could stimulate greater water use and water consumption for raw mineral extraction, process water use and cooling water needs. Given the impingement and entrainment requirements of §316(b) of the federal Clean Water Act, instead of the "once through" cooling systems once prevalent, new facilities may be expected to recycle cooling water, thereby lowering withdrawal quantities but increasing water consumption through evaporation. These new units will need to be carefully sited so that the low flow regimes of their water sources are not adversely influenced. Similar water recycling requirements are being implemented at existing power generation

[2] Estimated from Energy Information Administration data by applying the average retail sales price (8.68cents/Kwh) to net 2006 exports

[3] Draft Comprehensive Plan for the Management & Development of the Water Resources of the Susquehanna River Basin, February 2008

facilities that will further reduce withdrawal needs while appreciably increasing water consumption. The cumulative outcome of these modifications in water usage has not been critically evaluated but will undoubtedly be important to future water use trends and water resource protection policies.

Estimates have placed Pennsylvania's known coal reserves at 72 billion tons, which if liquefied would be equivalent to about 40 years of current national imports of petroleum products[4]. Protecting the quality and quantity of water in the areas overlying these reserves will play a major role in planning their extraction and use.

Pennsylvania is also a significant producer of natural gas, and it is believed that even more extensive reserves are contained in the Marcellus Shale formation which underlies a substantial portion of western, north-central and northeastern Pennsylvania. Recent estimates have placed the Marcellus Shale natural gas reservoir at upwards to 500 trillion cubic feet, about 17 times the current annual production of the entire country. The hydrofracture stimulation technique used to develop the Marcellus Shale reserves generally requires 1-3 million gallons of water for each well, drawn over approximately 30 days. Some sites could potentially use up to 12.5 million gallons of water. Of these amounts, 50% would be consumed (i.e., injected, but not returned) while the remaining wastewater would be treated and discharged at the site or taken to a remote facility. In some areas, off-site treatment options may be limited by a shortage of available capacity. As with all potentially significant water uses, water sources used in this process must be carefully selected and operated to avoid dewatering smaller streams and disrupting aquatic communities.

The Commonwealth's Energy Independence Strategy advocates developing alternative energy technology, including biofuels production facilities.[5] Legislation signed in July 2008 also will help spur the production of home grown fuels by establishing new requirements for the percentage of ethanol and biodiesel that must be in gasoline and diesel fuel. Pennsylvania's first ethanol production plants, located in Clearfield and Lancaster Counties, are expected to be operational in 2010 or early 2011. These facilities will be fueled predominately by corn, and to a lesser extent by cellulose sources such as switch grass and wood pulp. Biodiesel production facilities mix animal fats or vegetable oils with petroleum-based diesel to produce blended diesel and home heating products. Biodiesel producers are currently located in Erie, Cumberland, Adams, York and Allegheny Counties. One of the primary raw materials needed to produce biodiesel fuel is soybean oil that can be extracted from locally grown crops. Biofuels production facilities use a significant amount of water in the manufacturing process and create large incremental water demands where they are located. The agricultural production of feedstocks, such as corn and soybeans, to support biofuels may also lead to an incremental increase in

[4] The Pennsylvania Energy Development Plan, April 2006 Draft
[5] News release, Office of the Governor, February 1, 2007

agricultural water use if irrigation becomes more common to increase crop yields. Exact water use estimates for the biofuels production cycle are still in development, but clearly this element of the energy field promises to be a significant water use factor for consideration going forward.

Agricultural Water Use

Pennsylvania's 58,000 farms are responsible for an estimated 1% of total water withdrawals, much of which is consumed. Lancaster County irrigates the most farmland, followed by Franklin and Adams Counties while the largest percentage of farmland is irrigated in Schuylkill and Erie Counties at just over 2%[6].

Estimates indicate that Lancaster, Franklin and Lebanon Counties use the most water to support livestock operations. Statewide, water use by livestock producers is projected to rise slightly over the next 20 years[7] due to an increased market and further concentration of animal feeding operations.

As global demand for food and fiber production demands increase and the value of various crops (such as corn) fluctuate with economic conditions, irrigation requirements and associated consumptive uses of water can be expected to rise. The escalating demand for corn and soybeans to be used as raw material for ethanol and biofuels facilities, along with a mounting worldwide market for grain, could also drive the value of cropland higher. If cropland value increases appreciably, pressure may build to place unused agricultural land into production. This could cause Pennsylvania to follow the developing national movement toward pulling farmland from conservation reserve programs and putting it into productive use. A substantial reduction in conservation reserve land area could lead to additional consumption of water for agricultural use, loss of established vegetative buffers along streams and reductions in wildlife habitat.

Climate change, growth and land development may directly influence agricultural water use as well. Climate variability and loss of productive land to development could intensify the demand for irrigated crop lands and eventually even change the types of local crops grown to those requiring more routine irrigation. Rising temperatures could also result in additional water use by livestock operations. Continued land development will not only reduce land area available for food production but may also encourage a demand for landscape nurseries and their need for irrigation water. Monitoring agricultural water use and consumption over the coming years and decades will remain a priority and the net outcome of this effort should be incorporated into the Commonwealth's water resources planning, management, and protection policies.

[6] U.S. Department of Agriculture, 2004
[7] Jarrett and Roudsari, 2007

Climate Change

This State Water Plan does not directly assess global climate change nor does it recommend specific actions to stabilize rising worldwide temperatures. However, climate change issues, and particularly the consequences of projected climate change on Pennsylvania's water resources, are factors that must be weighed in the overall water planning process.

In November 2007, the Intergovernmental Panel for Climate Change (IPCC) released its *Fourth Assessment Report*, stating that "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting in snow and ice, and rising global average sea levels". A continuation of these trends would trigger increases in the frequency and severity of storms, floods, droughts, and heat waves around the world.

Climate change is a global issue but most of its impacts will be experienced at the local to regional scale as world-wide changes in temperature and atmospheric dynamics interact with the characteristic features of each region. Although an extensive amount of research and global modeling has been conducted on climate change, only limited model simulations have been developed to assess potential climate impacts in specific regions, and in turn to evaluate the specific challenges climate change may pose to managing water resources, water supplies, water use, flooding and stormwater management, and other water related concerns.

One such initial regional modeling effort is reflected in the Northeast Climate Change Assessment Study published in 2006, and ongoing research by authors of that study.[8] Some of the conclusions of that initial modeling suggest that the future climate of the northeastern U.S. through the end of this century could include (1) winter temperature increases by an average of 1.6-4.8ºC; (2) summer temperature increases by an average of 2.4-4.8ºC; (3) a projected winter precipitation increase by an average of 11-14%, with small decreases in summer precipitation; (4) greater extremes in storm and drought events, with more concentrated, higher precipitation events, but also longer dry periods; and (5) fewer snow cover days and a smaller snowpack, with more precipitation falling in the form of rain, resulting in potentially less recharge to groundwater. Sea level rise must also be considered. Due to anticipated global sea level rise and Mid-Atlantic subsidence, a 16-24 inch rise in the Delaware River Estuary by the end of the century has been projected. A sea level rise of this magnitude would

[8] Hayhoe, K., C. Wake, T. Huntington, L. Luo, M. D. Schwartz, J. Sheffield, E. F. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T. J. Troy, and D. Wolfe, *Past and Future Changes in Climate and Hydrological Indicators in the U.S. Northeast,* CLIMATE DYNAMICS, 10.1007/s00382-006-0187-8 (2006)

physically damage existing water and wastewater infrastructure, and significantly alter water quality. Another major concern over rising sea levels is the potential for saline water reaching the Philadelphia drinking water intakes and the complexity and costs of potential mitigation options. If the Northeast Climate Change Assessment Study modeling results and rising sea level predictions are borne out, such changes would have important implications for future water planning and management across all of Pennsylvania. These repercussions affect the full range of water management considerations, from the design and operation of stormwater basins and mapping of floodplains, to the evaluation of the safe yield of stream sources and dependable recharge rates for aquifers. Water quality, as well as quantity, will be affected, as stream flow regimes affect pollutant assimilation and waterbody temperatures change and potentially affect such factors as dissolved oxygen concentrations. Most important, these models suggest that the traditional basis of almost all water planning (of using historical data and patterns as a predictor of future conditions) must be rethought, and that preparation for a more variable and unpredictable future hydrologic system should be made.

Preparing for the Future

A plethora of water resource challenges, many of them unforeseen, will constantly test the abilities and patience of all Pennsylvanians. The three major priorities of this plan – data collection, water conservation and water resource innovation, and integrated water resources management – form a stable foundation for water resources planning and management in the Commonwealth. This State Water Plan is the initial step of a continuous process that will apply these priorities and strive to provide reliable and current guidance for recognizing and addressing water resource trends and needs as they materialize.