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Streamgaging in Pennsylvania: 1883–2009

Introduction

The Commonwealth of Pennsylvania contains 83,602 miles of streams within its borders. These streams are natural resources that influence the lives and economy of Pennsylvania residents daily. The water resources are used on a daily basis for recreation, power generation, drinking water, agriculture, industry, and many other uses, emphasizing the importance of this valuable resource. The effects of too much or too little water can be devastating to communities throughout the Commonwealth. The amount of water (flow) in a stream has been a critical piece of information since before the founding of Pennsylvania. In 1612, John Smith navigated the "Sasquesahanough" River while exploring the newly discovered territory (Haile, 1998). In 1630, Dutch pioneers traveled up the Delaware River to settle in Bucks County.

Historical Streamgaging Activities

The first documented streamflow measurement (streamgaging) in Pennsylvania was in the Philadelphia area by the Department of Public Works. Measurements of flow from four locations in the Delaware River Basin were documented and published, beginning in 1883.

The first streamgaging station operated in the United States by the U.S. Geological Survey (USGS) was established in 1889 on the Rio Grande near Embudo, N.M. Specific appropriation for streamgaging was made by the Act of August 18, 1894, which contained the budget line item of $12,500 "for gauging the streams and determining the water supply of the United States, including the investigation of underground currents and artesian wells in the arid and semiarid sections" (Grover and Hoyt, 1906).

As annual appropriations for hydrographic surveys increased, the work of the USGS was expanded and organized by the adoption of standard methods and by grouping states into Districts. In each District, a District Hydrographer and a corps of assistants collected data to study the hydrographic resources. As a result of the Act of August 18, 1894, the states of Pennsylvania, Maryland, Virginia, and West Virginia were combined to form the Middle Atlantic District.

Systematic streamgaging by the USGS in Pennsylvania began in the 1890s. E.G. Paul, the resident hydrographer of the Middle Atlantic District, made the first flow measurements by the USGS at several locations on main-stem streams throughout the Commonwealth in the late 19th century, including the earliest documented flow measurements completed in 1897 on the Susquehanna River at Harrisburg.

In 1904, streamgaging was extended into western Pennsylvania, where a group of streamgaging stations was established in the headwaters of the Ohio River.

In 1907, because of a reduction of Federal appropriations, the USGS streamgages in Pennsylvania were turned over to the Pennsylvania Water Supply Commission. By the end of 1909, only seven streamgages in Pennsylvania were maintained by the original USGS Middle Atlantic District.

By 1910, the staff of the Water Supply Commission in Pennsylvania were making flow (discharge) measurements at 72 locations across the Commonwealth—20 in the Delaware River Basin, 23 in the Susquehanna River Basin, 2 in the Potomac River Basin, and 27 in the Ohio River Basin.

In 1923, during the first administration of Governor Gifford Pinchot, the Department of Forest and Waters and its administrative arm, the Water and Power Resources Board, were created. This change combined the Water Supply Commission with the Forest Service of the Department of Forestry.

In 1931, the Pennsylvania Department of Forest and Waters and the USGS entered into a cooperative agreement that provided for collecting and reporting streamflow data in Pennsylvania. A surface-water district office was established at Harrisburg on June 1, 1931. This was the start of the USGS Pennsylvania District (now located in New Cumberland, Pa.). The cooperative program was placed under a district engineer

Hydrographer making a cable-car measurement

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of the USGS, who would become Chief of the State Water-Resources Service. Those Service personnel consisted of both Commonwealth and USGS employees. The program consisted of 97 streamgages and included the collection of other hydrologic data needed for the forecasting of floods.

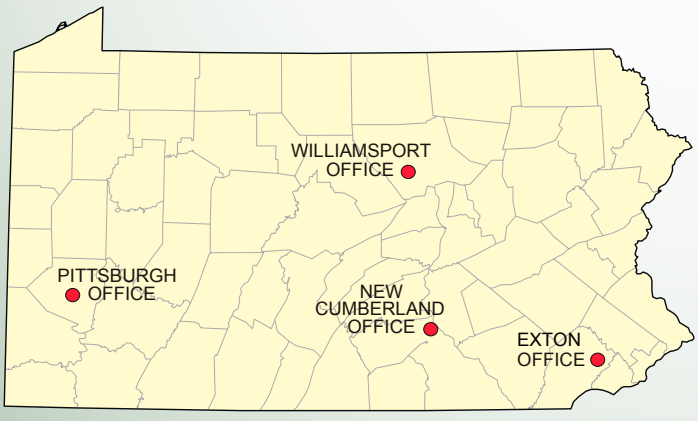
Following the flood of March 1936, an increase in Commonwealth funding allowed for more streamgages and additional hydrologic investigations. As a direct result, a subdistrict office of the USGS Pennsylvania District was established in Pittsburgh in 1938.

Prior to 1936, the cooperative program was only with the Commonwealth of Pennsylvania. Between 1936 and 1940, two new cooperators, the cities of Harrisburg and Bethlehem, joined with the USGS Pennsylvania District to operate streamgages in connection with their water supply. The city of Bethlehem remains a cooperator today.

Over the next few decades, the Pennsylvania streamgaging network expanded steadily. As a result of a large increase in the number of streamgages in the Philadelphia area, a subdistrict office of the Pennsylvania District was established in Philadelphia in 1965 (now located in Exton, Pa.). Following the 1972 flooding that resulted from Hurricane Agnes, a determination was made to establish a field office in central Pennsylvania. In 1974, a field office began operating out of Williamsport. By 1977, the number of streamgages had grown to about 260.

In 1986, the USGS, the National Weather Service (NWS), and the Susquehanna River Basin Commission (SRBC) partnered to develop a state-of-the-art Flood Forecast and Warning System in the Susquehanna River Basin. That same year, the Pennsylvania Department of Environmental Resources, Bureau of Water Resources Management, partnered with the USGS to upgrade many of the cooperative streamgaging sites to include satellite telemetry for transferring data to the USGS computer databases. These partnerships substantially increased the number of streamgages in Pennsylvania and allowed for an upgrade of the majority of the streamgaging network to include satellite telemetry.

Today the staff of the USGS Pennsylvania Water Science Center (PaWSC, formerly the Pennsylvania District) is operating a network of nearly 240 streamgages, in cooperation with about 53 Federal, State, and local partners. The gages in Pennsylvania are maintained from the four offices within the Commonwealth.



USGS offices in Pennsylvania

Advances in Streamgaging Technology

Many advances have been made in the collection and processing of stream-surface elevation (stage) and flow data. In early years, stage data were collected by observers reading manual gages (such as a staff gage). That process eventually evolved to an automated process of a float and tape stilling-well system that recorded stage on either an analog strip-chart recorder or a digital 'punch' paper-tape recorder.

Outside vertical staff gage used to measure the depth of the water

In Pennsylvania, the first documented automatic stage recorder was installed on Wallenpaupack Creek at Wilsonville in 1913. The first recorder installed by USGS hydrographers was on the Loyalsock Creek streamgage at Loyalsockville in 1925.

By 1928, 10 streamgages had been equipped with automatic recorders. At the time of the new cooperative program with the Commonwealth in 1931, 47 of the 97 streamgages were automated.

As technology improved, sites where data were collected with sufficient frequency to define a daily mean flow (discharge) along with stage variations within a day (continuous-record stream stage) became the model for streamgaging throughout the Commonwealth.

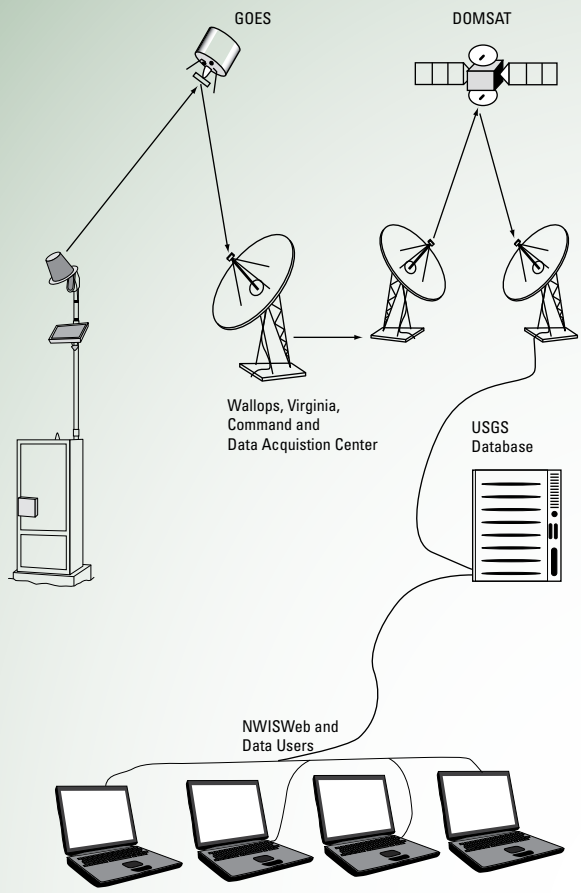
Today, stations used to compute discharge are 100-percent automated. The PaWSC maintains about 240 continuous-record streamgages within the Commonwealth. Stream-stage data are generally collected at 15-minute intervals.

The USGS in Pennsylvania has been a leader in the testing, development, and deployment of the satellite-telemetry method to transmit streamflow data. As part of the Water Resources Division (WRD) Satellite Data Relay Project beginning in 1974, Pennsylvania participated in the testing of the Earth Resources Technology Satellite (ERTS) and the Geostationary Operational Environmental Satellite (GOES) data-collection systems.

By 1977, the Pennsylvania USGS offices had become leaders in data collection and transmissions using the GOES data-collection system. Of the nearly 260 continuous-record streamgages in operation at that time, about 10 percent were collecting and transmitting data at 2- to 4-hour intervals through the GOES data-collection and transmission system.

In the early 1980s, with cooperation from one of our Federal partners, the U.S. Army Corps of Engineers (USACE), the streamgages providing data to support the USACE flood-control projects were upgraded to a state-of-the-art satellite-telemetry system.

Today, water-resources data are transmitted from nearly 430 data-collection platforms at streamflow, precipitation,



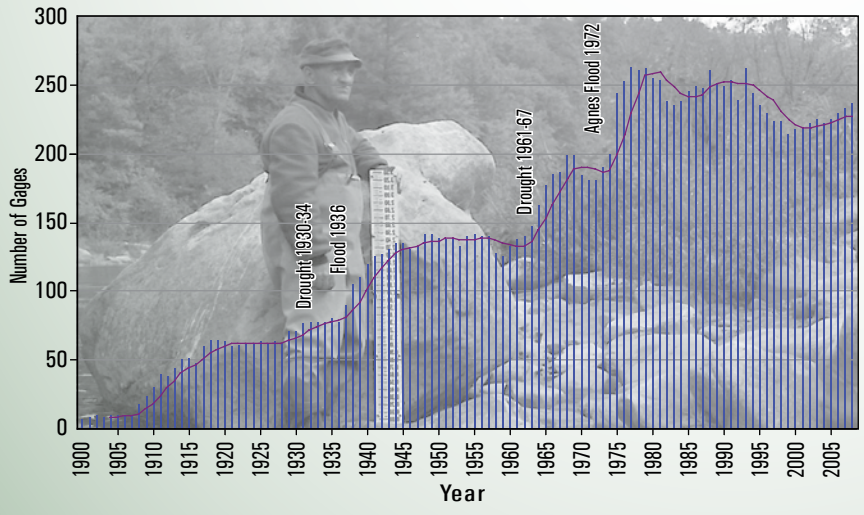
Path of data flow from field to user

groundwater, and water-quality data-collection sites throughout the Commonwealth. These data are processed and delivered real time through the internet to the public and our cooperators. Recent technology allows many of those locations to transmit data on an hourly basis. This feature has greatly enhanced the ability of our partners to manage the water resources within the Commonwealth.

Historically, Pennsylvania collected streamflow data using mechanical current meters to physically measure the water velocity along with other physical methods to measure stream width and depth. Although these methods and instruments have proven to work well, new technological advancements have improved the way those data are collected.

Stream gager making a streamflow measurement using a bridge crane and a current meter

The PaWSC has made a commitment to upgrade its capabilities to collect flow data using the newest acoustic technology available. Each hydrographer in the PaWSC has been supplied with an acoustic doppler current meter. The PaWSC also has purchased a number of acoustic doppler current profiler (ADCP) systems. The ADCP is an acoustic instrument used to measure water velocities. Water-velocity measurements are made by transmitting sound at a known frequency into the water and measuring the Doppler shift, or change in sound frequency, from signals reflected off particles in the water. ADCPs also can measure water depths and, when deployed from a moving boat, can measure the velocity of the boat. The capability of ADCPs to measure water velocity, depth, and boat velocity allows them to be used to measure discharge in rivers and estuaries, especially during extreme and unsteady conditions. The primary advantages of making discharge measurements using the ADCP as compared with point-velocity meters, such as the Price AA current meter, are that in most situations (1) the time required to complete a measurement is reduced, an advantage for personnel safety and for making measurements in unsteady-flow



Number of streamgages in operation in Pennsylvania since 1900

ADCP mounted on a tether boat

Bridge-mounted radar water-level sensor

conditions; (2) the ADCP allows data to be collected throughout most of the water column and cross section rather than at discrete points; (3) the ADCP is deployed at the water surface, appreciably reducing the chance of snagging by debris, another safety advantage; (4) the instrument can be boat-mounted, thus eliminating the installation, maintenance, and liability of costly manned cableways; (5) complex flow regimes, such as vertical bi-directional flow, can be accurately identified and measured; and (6) many parameters are available for analyzing the quality of the streamflow measurement.

In addition, the PaWSC is continually striving to develop and test new methods for non-contact stage and velocity measurement of streams. An ongoing project to develop and test instrumentation will accurately read surface velocities within a river system, use those velocities to compute a discharge, and transmit those discharge values in real time to our partners. These data will be most valuable to our partners during times of unsteady flow when, for example, ice or debris jams are causing pooling and backwater conditions.

The PaWSC continues to build on their core capabilities to collect, analyze, and disseminate hydrologic data. The 21st century brings unprecedented opportunities in streamgaging and hydrologic investigations.

Continuing stresses on water resources within the Commonwealth will require the PaWSC to maintain a stable long-term network of data-collection sites and the most technologically advanced data-collection systems available. An understanding and characterization of the natural hazards and water availability within Pennsylvania are critical to the economy, water resources, and quality of life of our citizens. The USGS PaWSC will strive to continue to have a major role through its streamgaging network to provide for the growing needs of the Commonwealth for surface-water information.

By Randall R. Durlin

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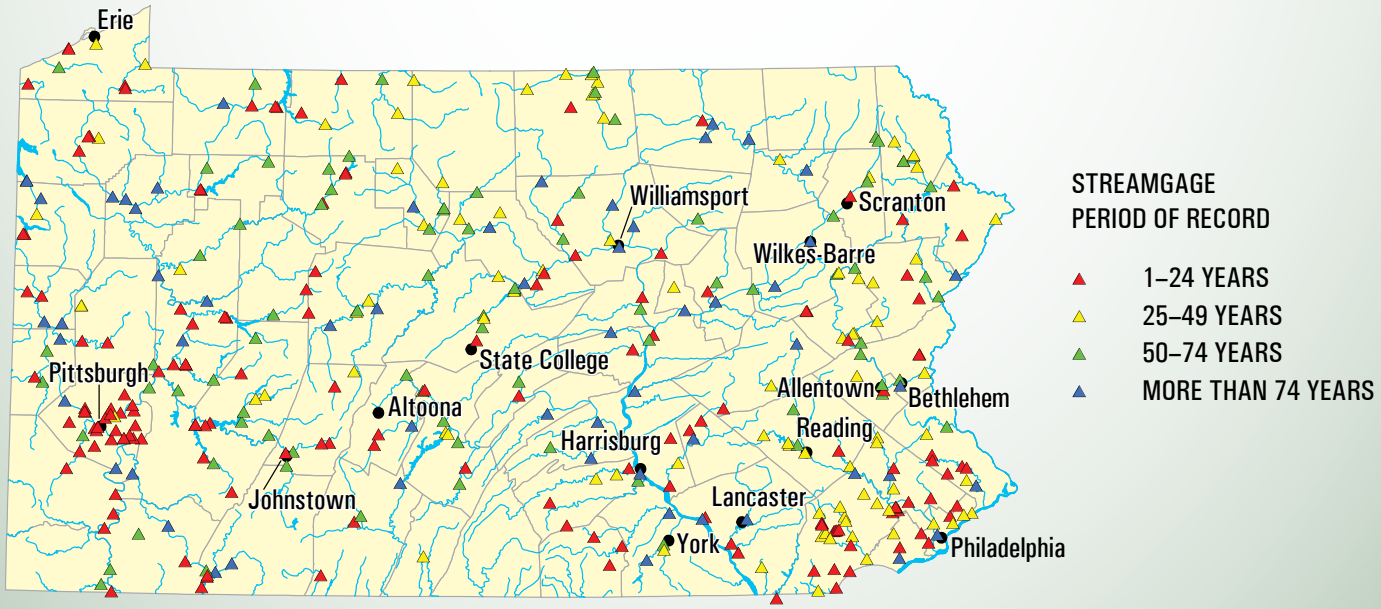

Location and period of record for Pennsylvania streamgages