Specific Conductance Measurements in Central and Western New York Streams—A Retrospective Characterization

Ketchumville Branch of Nanticoke Creek, near Maine, N.Y.

Introduction

U.S. Geological Survey (USGS) Data Rescue Program funds were used to recover data from paper records for 139 streamgages across central and western New York State; 6,133 different streamflow measurement forms, collected between 1970–80, contained field water-quality measurements. The water-quality data were entered, reviewed, and uploaded into the USGS National Water Information System. In total, 4,285 unique site visits were added to the database. The new values represent baseline water quality from which to measure change and will lead to a comparison of water-quality change over the last 40 years and into the future. Specific conductance was one of the measured properties and represents a simple way to determine if ambient inorganic water quality has been altered by anthropogenic (road salt runoff, wastewater discharges, or natural gas development) or natural sources.

The objective of this report is to describe ambient specific conductance characteristics of surface water across the central and western part of New York. This report presents median specific conductance of stream discharge for the period 1970–80 and a description of the relation between specific conductance and concentrations of total dissolved solids (TDS) retrieved from the USGS National Water Information System (NWIS) database from 1955 to present. The data descriptions provide a baseline of surface-water specific conductance data that can used for comparison to current and future measurements in New York streams.

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Synopsis of Regional Specific Conductance Data

Specific conductance, measured in microsiemens per centimeter (µS/cm) at 25 degrees Celsius (°C), hereafter referred to as specific conductance, is a standardized measure of the ability of water to conduct an electric current and is related to the amount of ions (atoms with negative and positive charges) in the water. A similar related measurement is the amount of TDS in water, measured in milligrams per liter (mg/L). While a specific conductance measurement can be made using a simple, hand-held meter and probe, the measurement of TDS requires a water sample be collected and sent to a laboratory where a specified volume of filtered water is evaporated, and the amount of solids left behind is then weighed and reported. In either case, these measurements determine the general inorganic (ionic) quality of the water.

The USGS in New York has collected surface-water-quality data since the 1950s; however, consistent and reliable water-quality information has only been retained in electronic databases since the late 1960s. In the 1970s, USGS hydrologists measured specific conductance as part of their visits to USGS streamgages across the United States. At the Ithaca office of the USGS New York Water Science Center, specific conductance data were collected at 119 streamgages between 1970 and 1980 for most streamgages in central and western New York (fig. 1); the Troy office of the USGS New York Water Science Center provided data from an additional 20 streamgages from the Delaware River Basin in New York for this report. These data were not collected regularly at all streamgages for the entire 10-year period because measurement meters were usually shared within the office and were susceptible to extreme outdoor temperature and battery failure. Furthermore, the results from these data were never transferred from the field notes to an electronic database system until recently through the USGS Data Rescue Program (Wippich, 2012). This program seeks to identify and preserve science data and information at

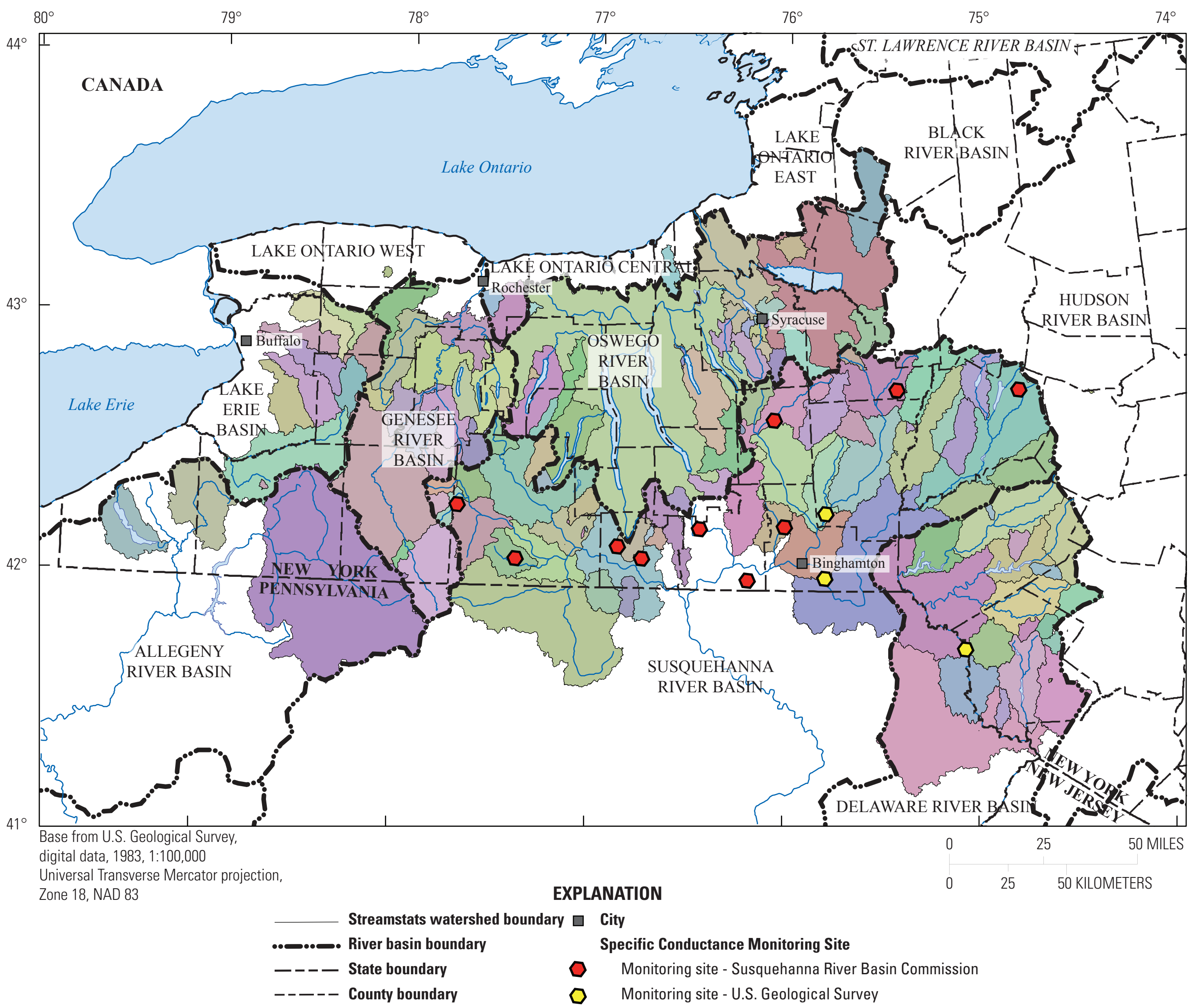

Figure 1. Locations of the watersheds of seven major river basins in New York where specific conductance measurements were collected between 1970–80 and where current (2012) near-real-time specific conductance streamgages are in operation in New York. Major river basins are outlined and named, while smaller watersheds are variously colored.

risk of loss due to obsolescence of media or formats, or from their storage environment, or both. The goal of this program is to make the unique USGS information accessible and available to the broadest possible audience and allow for new data interpretations that were never intended by the original collector. Since the 1980s, all water-quality data collected by the USGS have been entered directly into the NWIS database.

This report presents results of specific conductance data collected during water years[1] 1970 through 1980 at streamgages in central and western New York. Specific conductance data from NWIS were also used to verify the quality of data collected in the 1970s and to determine the relation between specific conductance and concentrations of total dissolved solids in New York streams when data for both properties were collected concurrently.

Specific Conductance Data by Streamgage

Stream discharge measurement field sheets for central and western New York beginning in the 1970 water year are stored in the files of the Ithaca office of the USGS New York Water Science Center. Field sheets were retrieved and the pertinent data transferred for water years 1970 through 1980 to electronic spreadsheets for inclusion into the NWIS database. Specific conductance data for a total of 139 watersheds (fig. 1) were retrieved and entered into the NWIS system (U.S. Geological Survey, undated). The data were analyzed to determine the range of specific conductance, data variability, and possible temporal trends over the period of record for each streamgage.

[1]Water year—The water year begins in October of the previous calendar year through September of the year of record, for example, water year 1970 is October 1, 1969, through September 30, 1970.

At all streamgages, annual variability in specific conductance was noted to usually fall within one order of magnitude of the median specific conductance for each streamgage. This range in values could be attributed to either change in the volume of stream flow and (or) seasonal effects, such as dissolved road salt runoff entering the stream. In this study, the median value of specific conductance at each streamgage for the period of record (1970–80) was used as a means to compare specific conductance between streamgages in central and western New York.

NWIS Data by Major River Basin

In New York, data for more than 12,000 individual surface-water and groundwater sites are stored in the New York portion of the NWIS database; the surface-water records go back to the early 1950s. Data for all streamgages in New York State were initially queried, and streamgages in the lower Hudson River Basin and on Long Island were eliminated due to the possible influence of tidal sea water on specific conductance. Approximately 44,000 individual data points representing 1,858 streamgages were then queried to select a representative specific conductance value for each streamgage within 10 New York river basins (Allegheny, Black, Delaware, Genesee, upper Hudson, Lake Erie (direct drainage), Lake Ontario (direct drainage), Oswego, St. Lawrence, and Susquehanna Rivers Basins; fig. 2). The number of streamgages selected for each drainage basin varied from as few as 71 in the Lake Erie direct-drainage basin to 488 streamgages in the upper Hudson River basin. The resulting box and whisker plots (fig. 2) show the range of values by basin as well as the median value; the basin median values were used as a means to verify the median values of the streamgage data within each basin for the 1970s.

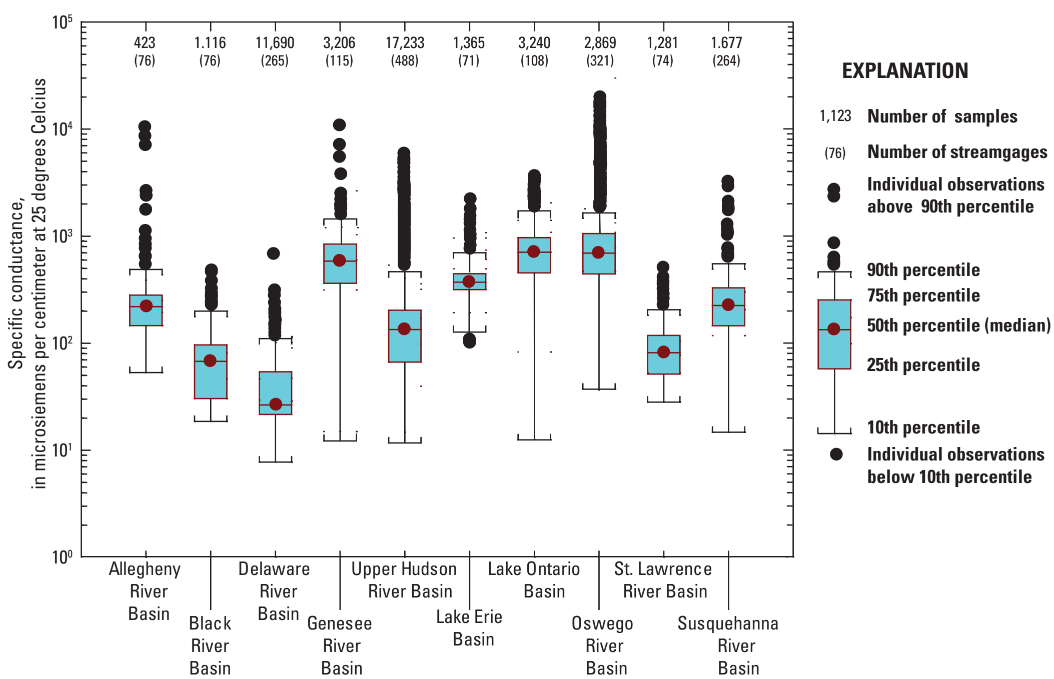

Figure 2. Box plots of specific conductance data at 1,858 streamgages within 10 major river basins in New York, showing numbers of streamgages for each basin, median values (red dots), first and third quartile ranges (brackets), and outliers (black dots). The Long Island and Hudson River Basins were not included in the study because of possible influence of tidal sea water on specific conductance.

As a result of this assessment (fig. 2), it was determined that the median specific conductance for 265 streamgages within the Delaware River Basin had the lowest (27 µS/cm) median specific conductance value of the entire study area; specific conductance in this study area ranged between 17 and 424 µS/cm. The greatest median specific conductance values were at the Lake Onatrio direct drainage basin (698 µS/cm with 108 streamgages) and the Oswego River Basin (680 µS/cm with 321 streamgages) with a range from about 30 to more than 22,000 µS/cm. Some of the largest specific conductance values occurred in basins associated with either streamflow within an oil or gas development area in the Allegheny River Basin or from natural brine springs and a former industrial brine-processing facility in the Onondaga Creek watershed (Oswego River Basin). Additionally, large specific conductance values were associated with anthropogenic sources, such as road salt runoff or wastewater treatment discharge from larger urban areas, such as Buffalo, Rochester, and Syracuse, in upstate New York.

The intent of compiling the NWIS data was to verify the quality of the specific conductance data collected for 1970 through 1980. While specific conductance data are easily collected today using a temperature-compensated meter, the 1970s method was more involved and prone to measurement error as the water sample was small, placed in a small measuring cup for analysis, and the result needed to be manually compensated using a field thermometer to the 25°C standard. Comparing the median values for each station to those of the major river basin data from the NWIS database indicates that the two sets of data are comparable.

Comparison of Specific Conductance to Total Dissolved Solids

Concentration of TDS can be used as a surrogate constituent for specific conductance, and at times these terms have, incorrectly, been used interchangeably. Hem (1985) indicated that, for natural waters across the United States, TDS can range between 0.55 and 0.75 percent of the value of specific conductance. Analysis of 1,858 paired specific conductance and TDS data records for New York from the NWIS database indicated that the ratio of TDS to specific conductance across New York was about 0.63—that is, a specific conductance measurement multipled by 0.63 should yield an equivalent TDS value. While the scatter of data points (fig. 3) is greater at the lower conductance range (less than 1,000 µS/cm), the ratio of 0.63 provides a good estimate of the concentration of TDS-derived specific conductance measurements at New York streamgages (fig. 3, regression equation and coefficient of determination (percent variability of TDS to specific conductance)).

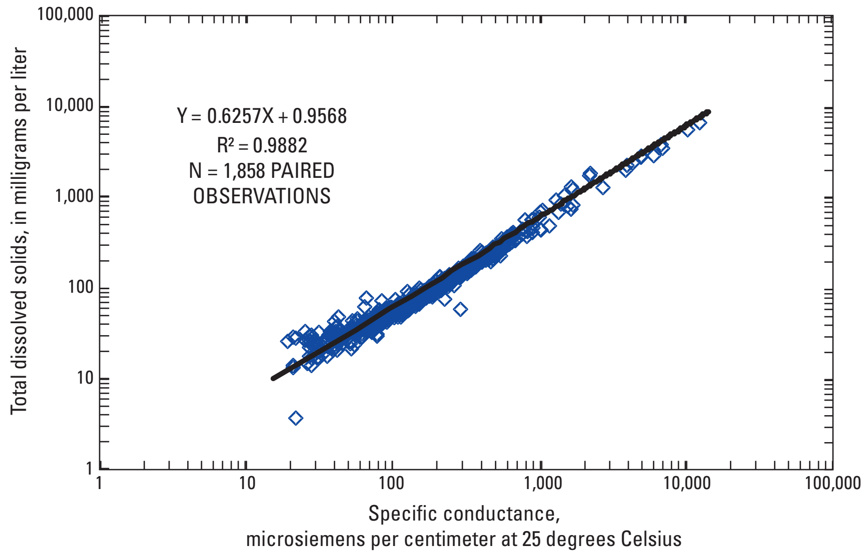

Figure 3. Comparison of specific conductance and total dissolved solids measurements for 1,858 samples where both parameters were collected in surface waters of New York. The linear regression relation (represented by the black line) and coefficient of determination (R^2) value for those paired data points (blue diamonds) are also shown. Data do not include samples from the lower Hudson River and streams on Long Island.

Retrospective Characterization

The characterization of specific conductance data of samples from streams in central and western New York collected between 1970 and 1980 provides a baseline from which to assess future changes in stream-water quality due to anthropogenic sources (road salt runoff, wastewater discharges, or natural gas development). The variation in specific conductance across watersheds in central and western New York is affected by any combination of land use, geology (different types of bedrock produce different water quality), inflows from population centers [nonpoint sources of specific conductance and point sources, such as wastewater-treatment plants or industrial discharges], and dilution of base flow by stormwater runoff. Using the median specific conductance value takes into account these varying factors and best represents specific conductance at each streamgage and the watershed upstream from the streamgage, as shown in figure 4 for the period of record.

One aspect to be taken into account in determining any change in median specific conductance between the 1970s and the present (2012) is the increased use of halite (road salt) used for winter-time road deicing. The use of road salt for deicing began in the 1950s, increased nationally through the 1970s and 1980s, and continues into the present, in varying amounts, depending on winter weather conditions (fig. 5). Road salt usage in New York has likely followed the national trend. Currently (2012), New York uses about one million short tons of halite each year for deicing purposes (Linberg and others, 2009); this is likely the major source of change in specific conductance as measured in New York streams during and after the 1970s.

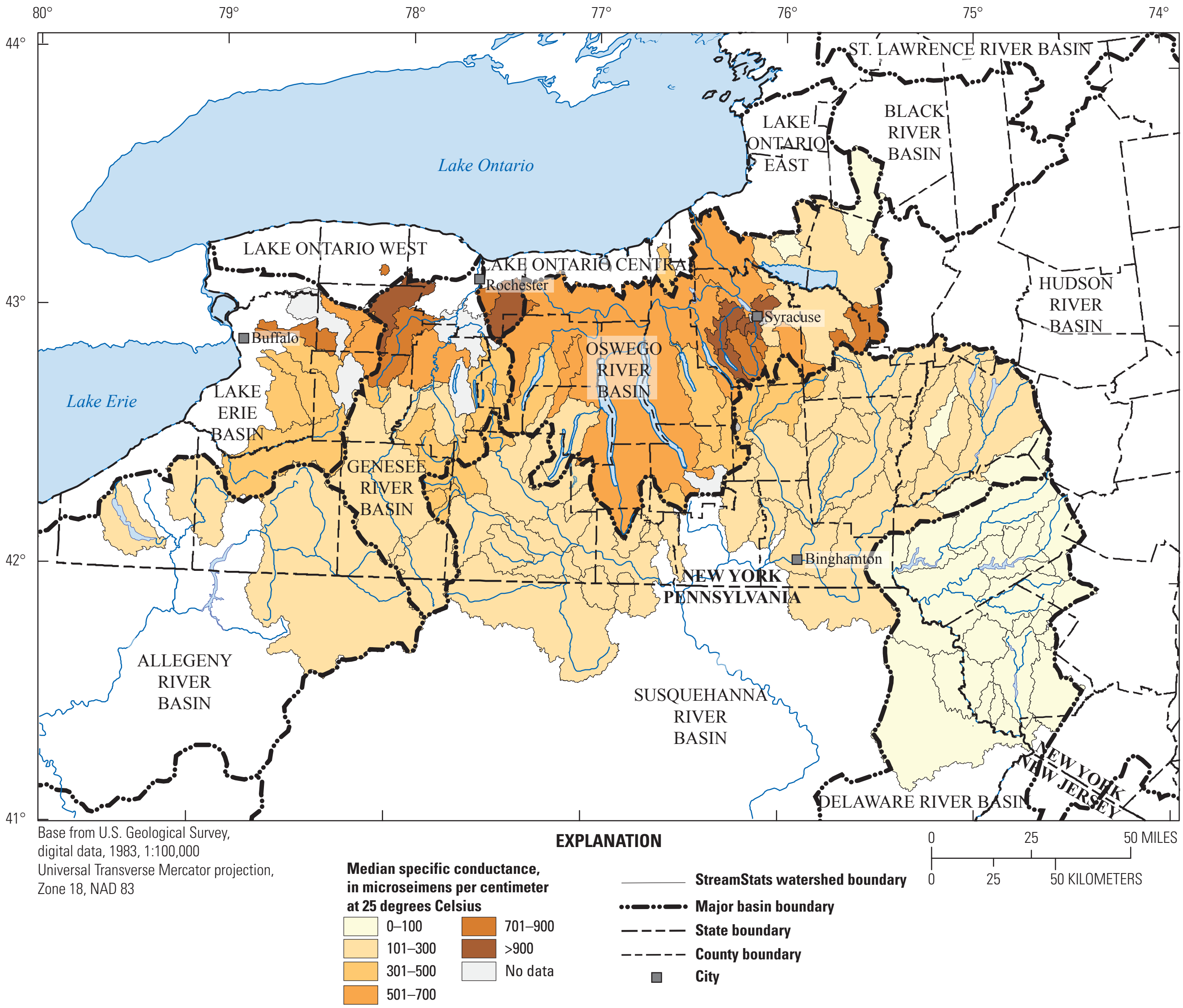

Figure 4. Ranges of median specific conductance values for 139 watersheds in central and western New York based on specific conductance data collected by the U.S. Geological Survey between 1970 and 1980. StreamStats watershed boundaries are from U.S. Geological Survey (2011).

Current Specific Conductance Monitoring

Currently (2012), several agencies, including the Susquehanna River Basin Commission (SRBC; undated), monitor and report specific conductance data in conjunction with natural gas development activities. The SRBC has about 30 water-quality sites in Pennsylvania and 10 in New York, which monitor specific conductance and several other water-quality properties (fig. 1). These data are then made available on the Internet. The USGS Water Science Center in Pennsylvania has also implemented similar specific conductance monitoring at 10 streamgages in northern and western Pennsylvania to address potentrial changes in stream water quality due to natural gas development activities. The USGS Water Science Center in New York, in cooperation with the New York State Department of Environmental Conservation (NYSDEC), has installed similar real-time specific conductance monitoring equipment at two steamgages on the Susquehanna River and one streamgage on the Delaware River (fig. 1) in areas where natural gas development could occur in the near future.

Summary

U.S. Geological Survey (USGS) Data Rescue Program funds were used to recover data from paper records for 139 streamgages across central and western New York State; 6,133 different streamflow measurement forms, collected between 1970–80, contained field water-quality measurements. The water-quality data were entered, reviewed, and uploaded into the USGS National Water Information System (NWIS). In total, 4,285 unique site visits were added to the database. The new values represent baseline water quality from which to measure change and will lead to a comparison of water-quality change over the last 40 years and into the future.

Specific conductance was one of the measured properties and represents a simple way to determine if ambient inorganic water quality has been altered by anthropogenic (road salt runoff, wastewater discharges, or natural gas development) or natural sources.

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The potential for further change in stream specific conductance may be anticipated due to changes in various anthropogenic sources, including the ongoing use of road salt for deicing and potential natural gas development. Through continued monitoring and characterization of water quality, including specific conductance monitoring, the effects of anthropogenic influences on streams and rivers in New York can be documented. Specific conductance will be one of the simpler methods that can be used to determine if these anthropogenic influences have any additional effect on the water resources of New York.

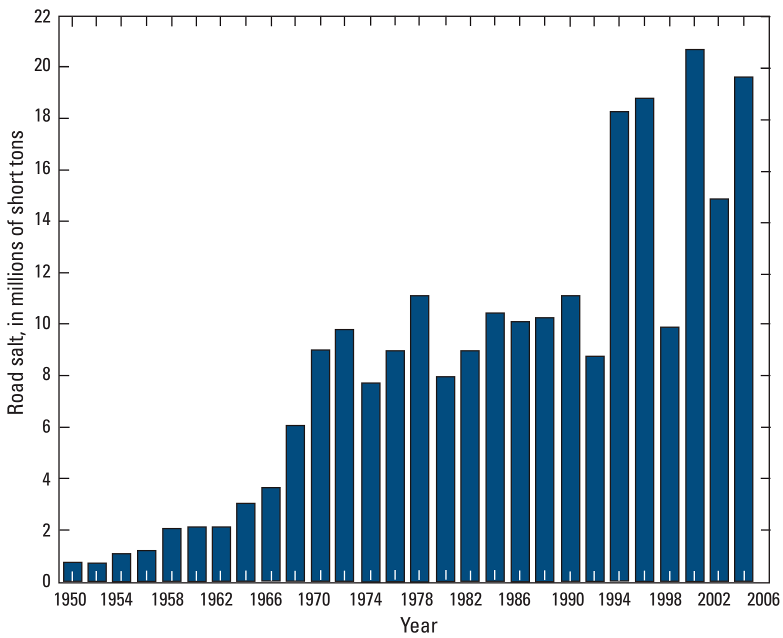

Figure 5. Trend in road salt use in the United States from 1950 through 2004. Adapted from Transportation Research Board (1991; data for 1950–1988) and Mullaney and others (2009; data for 1990–2004).

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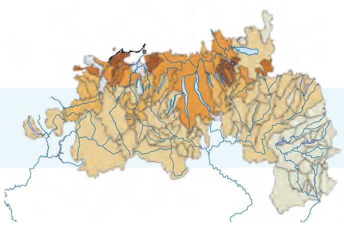

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