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HURRICANE SANDY

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New York Water Science Center News Volume 16, April 2013

U.S. Geological Survey, New York Water Science Center Newsletter

Historic Storm-Tides | Storm-Tide Sensors | High-Water Marks | Fire-Island Breach | Hydrologic Conditions

USGS Storm-Tide Gaging Network Measures Historic Storm-Tide Elevations

Gale- to storm-force winds associated with the passage of Sandy across central New Jersey and eastern Pennsylvania that lasted 12 to 18 hours caused major to record coastal flooding in southeastern New York on October 29, 2012. Of 10 real-time tide gages operated by the U.S. Geological Survey (USGS) in coastal areas of Long Island and New York City, all recorded levels were above the National Weather Service (NWS) major coastal flood elevation (see table below). The locations of tide stations operated by the USGS in the southeastern New York region are shown on the Southeastern New York Coastal Monitoring Sites web page.

The south shore of New York City and western Long Island saw the bulk of the record water elevations, as these areas were to the immediate right of the storm's center of circulation as it made landfall in New Jersey. Widespread record coastal flooding occurred in Lower New York Bay, Jamaica Bay, and the western bays along southern Nassau County. The peak water levels recorded at all stations in these areas also exceeded the Federal Emergency Management Agency (FEMA) 100-year base flood elevations for these sites. In all cases, the peaks from Sandy have surpassed anything documented previously at these sites, including the Nor'Easters of Oct. 31, 1991 and Dec. 11, 1992 and Hurricane Irene, August 2011.

Record coastal flooding also occurred in western Great South Bay along southern Suffolk County and in the Peconic Estuary of eastern Suffolk County. The peak water levels recorded at most stations in these areas also exceeded the FEMA 100-year stillwater elevations for these sites. In all cases, the peaks from Sandy have surpassed anything documented previously at these sites.

The Long Island Sound shore of northern Nassau County experienced major coastal flooding. The peak water level recorded at the one real-time station in this area exceeded the FEMA 10-year stillwater elevation for this site. The peak from Sandy was within 0.5 ft of the record previously documented for this site-from the Dec. 11, 1992 storm.

U.S. Geological Survey station		Peak elevation				NWS major flooding elevation
Number	Name	Hurricane Sandy	Historical water level	Historical date	Period of record	
01302250	East Creek at Sands Point	[a] 11.39	9.58	3/15/2010	2007-2012	10.5
01302600	West Pond at Glen Cove	[a] 10.99	9.30	8/28/2011	2009-2012	10.0
01302845	Frost Creek at Sheep Ln bridge at Lattingtown	[a] 11.14	9.13	8/28/2011	2007-2012	10.0
01304057	Flax Pond at Old Field	[a] 10.36	8.88	8/28/2011	2007-2012	9.5
01304200	Orient Harbor at Orient	7.37	--	--	2012	6.0
01304562	Peconic River at County Hwy 105 bridge at Riverhea	8.60	--	--	2012	6.0
01309225	Great South Bay at Lindenhurst	[a] 7.73	5.27	8/28/2011	2002-2012	4.5
01310521	Hudson Bay at Freeport	[a] 10.12	7.35	8/28/2011	1999-2012	5.7
01310740	Reynolds Channel at Point Lookout	[a] 10.10	7.07	8/28/2011	1997-2012	6.5
01311143	Hog Island Channel at Island Park	[a] 10.89	7.75	8/28/2011	2010-2012	6.5
01311145	East Rockaway Inlet at Atlantic Beach	[a] 10.80	7.43	8/28/2011	2002-2012	6.5
01311850	Jamaica Bay at Inwood	[a] 11.65	7.52	8/28/2011	2002-2012	7.5
01311875	Rockaway Inlet near Floyd Bennett Field	[a] 11.75	7.58	8/28/2011	2002-2012	7.5

[a] New provisional peak elevation. Elevations are in National Geodetic Vertical Datum 29

Peak storm-tide elevations produced by Hurricane Sandy and historical peak water-level elevations, dates of occurrence, and periods of record at 13 U.S. Geological Survey estuary stations in southeastern New York.

A Message from Ward Freeman

New York Water Science Center Director

Another Newsletter and another extreme storm to report about — our thoughts go to all those dealing with the devastation from Superstorm Sandy.

The number of sensors deployed and measurements made for Superstorm Sandy were greater than any previous east-coast storm. For details see: http://ny.water.usgs.gov/sandyindex.html. We realize there's always room for improvement and we strive to learn from each storm. We are working to put the tools and networks in place to improve our ability to respond to the next extreme event. We hope the information the USGS provides helps to improve our understanding and our ability to respond to future storms.

Superstorm Sandy hit the coastline of New York and New Jersey like a freight train. The damage caused by Sandy, the largest Atlantic Hurricane on record, is estimated to be in the billions of dollars. Crews from the USGS New York Water Science Center — joined by USGS employees from as far away as Georgia — deployed storm-surge sensors, installed rapid-deployment streamgages, and collected hundreds of high-water marks. Deployment of sensors was done as the Hurricane was bearing down on the area. Coastal tide-gage data were conveyed in near-real time to the public and emergency managers. As the storm moved on our teams moved out to recover the data and document the impact from the storm. These data were checked and transmitted within days to the Federal Emergency Management Agency (FEMA) and the National Oceanic and Atmospheric Administration (NOAA) scientists for use in supporting deployment of emergency-response resources, production of inundation maps, and assessment and improvement of storm-surge forecast models. All of these data will help scientists, emergency managers, and other organizations evaluate the regional impact of Hurricane Sandy, and ultimately provide the insight required to help minimize loss of life and property during future coastal storms.

As always, please feel free to contact me about these or any other issues or program opportunities you may wish to discuss."

Visit the New York Water Science Center Web site at:
http://ny.water.usgs.gov
Or contact
(518) 285-5665
dc_ny@usgs.gov

Temporary Storm-Tide Sensors Supplement existing Coastal Gages in South-Eastern New York

In response to the forecasted landfall of Hurricane Sandy, scientists and technicians from the U.S. Geological Survey (USGS) deployed storm-tide sensors along the eastern seaboard from Virginia to Maine. As part of this effort, the New York Water Science Center deployed 38 storm-tide sensors, 4 wave-height sensors, 11 barometric-pressure sensors, and 4 rapid-deployment gages (RDGs) throughout Long Island, New York City, and Westchester County. Storm-tide and wave-height sensors are pressure transducers that are relatively quick and easy to attach to permanent structures, such as docks and piers, which are programmed to measure water level during a storm event. Sensor locations were selected to supplement 13 existing USGS real-time

USGS Scientist deploying storm-surge sensors. Inside of these steel housings, a self-contained pressure transducer measures the height of water above it. These measurements are made every 6 minutes and stored internally. After the storm, the elevation of each transducer is measured —relative to some datum— and data are retrieved.

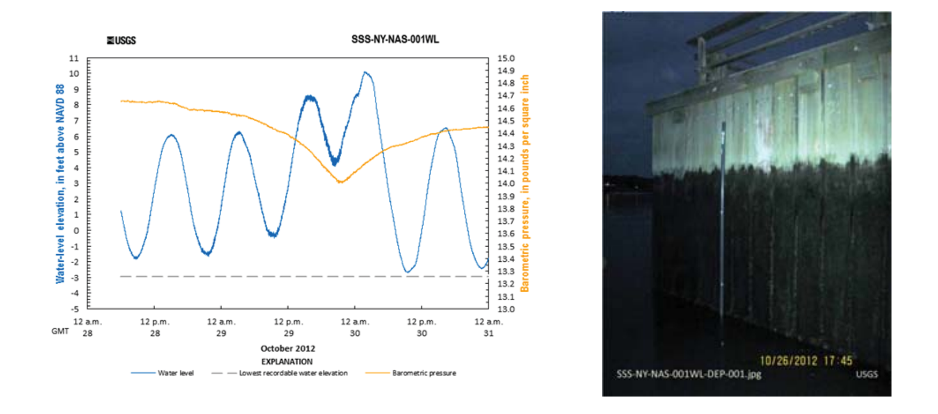
RDG installed on bridge over State Boat Channel, Captree Island, NY.

coastal gages in southeastern New York, and to ensure that sufficient data were collected in areas where National Oceanic and Atmospheric Administration (NOAA) models predicted significant storm surge and storm-tide flooding. As defined by NOAA, the storm surge is the storm-generated rise in water levels above predicted astronomical tides, whereas storm tide is the rise in water level due to storm surge plus astronomical tide. Hurricane Sandy posed a particularly dangerous threat, as the landfalling storm was expected to transition into a large and powerful extra-tropical cyclone, take an unprecedented track towards the northeast coast, and hit during a period of normal high tide, which alone would have caused minor flooding in low-lying coastal communities.

After the storm, USGS scientists and technicians retrieved the temporary storm-tide sensors and RDGs within 10 days after Hurricane Sandy's landfall. Two of the four RDGs were damaged during Hurricane Sandy and did not record the maximum storm tide, but the existing coastal gages generally fared better because they incorporate flood-resilient design features. The surviving RDGs—in Suffolk and Westchester Counties—recorded peak storm-tide elevations of 5.2 and 10.2 ft (feet) above mean sea level (NAVD 88 -- North American Vertical Datum of 1988), respectively.

The water levels recorded by the storm-tide sensors ranged from 4 to 10 ft (above mean sea level) in Suffolk County, from 6 to 8 ft in the Peconic Estuary, from 8 to 12 ft in northern Nassau County, and from 9 to 17 ft in New York City.

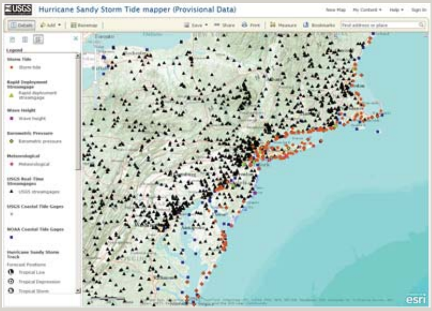
All storm-tide data collected by the USGS for Hurricane Sandy are displayed and archived on the Hurricane Sandy Storm Tide Mapper and are summarized in a recently released USGS report. Data from the mapper was conveyed in near-real time to FEMA and NOAA scientists for use in supporting deployment of emergency-response resources, production of inundation maps, and assessment and improvement of storm-surge forecast models.



Water elevation and barometric pressure measured at Oyster Bay Harbor, at Oyster Bay, NY during Hurricane Sandy. Also shown is a photo of the storm-surge sensor housing at the same location.

High-Water Marks Serve as an Independent Verification of the Storm-Tide Sensor Data and as Indicators of Peak Storm Tide

Field teams, with help from the North Carolina, Georgia, and upstate New York Water Science Center offices, documented more than 350 high-water marks (HWMs) within 10 days of the storm along the Hudson River, New York City, and the Long Island Coastline. Each day, teams were given a general geographic area in which to identify and flag HWMs. Staff searched for structures with mud- or water lines and (or) areas with debris lines (red arrow on photos show some examples). Multiple HWMs were flagged at some locations to corroborate elevations. Any HWM was considered an independent location if separated by more than 1,000 ft away from other HWMs. Teams were equipped with U.S. Geological Survey (USGS) HWM discs, nails, stakes, hammer, and flagging tape to mark HWMs. The elevation of each HWM was measured using survey-grade Global Navigation Satellite System (GNSS) equipment; all elevations were collected relative to NAVD 88 (or North American Vertical Datum of 1988). Data for each HWM including location, description and quality of the mark, photo documentation, and elevation were recorded. These data are available on the Hurricane Sandy Storm Tide Mapper and have been published in a USGS report (McCallum and others, 2013).



During and after the storm, data were collected and relayed immediately for display on the Hurricane Sandy Storm Tide Mapper, which allowed FEMA and other emergency management officials to examine the data and best direct federal response activities.

Fire Island Breach

Hurricane Sandy resulted in three open breaches in the barrier island system along the south shore of Long Island, N.Y. In response, the National Park Service has sought assistance from the U.S. Geological Survey (USGS) New York Water Science Center (NYWSC) to help evaluate the open breach condition in Federal Wilderness near the Old Inlet area of Fire Island National Seashore, N.Y. The NYWSC evaluation is initially focusing on two activities: (1) measurement of water velocities and depths within the Wilderness breach, and (2) collection of water levels within Great South Bay (GSB) adjacent to the breach.

Oblique aerial photographs of Pelican Island and Fire Island, New York. The view is looking northwest across Fire Island towards Great South Bay. This location is within Fire Island National Seashore near Old Inlet—a very narrow portion of the island that has experienced breaching in previous large storms. The island breached during Hurricane Sandy, creating a new inlet. Despite the breach, the fishing shack (yellow arrow) remained standing.

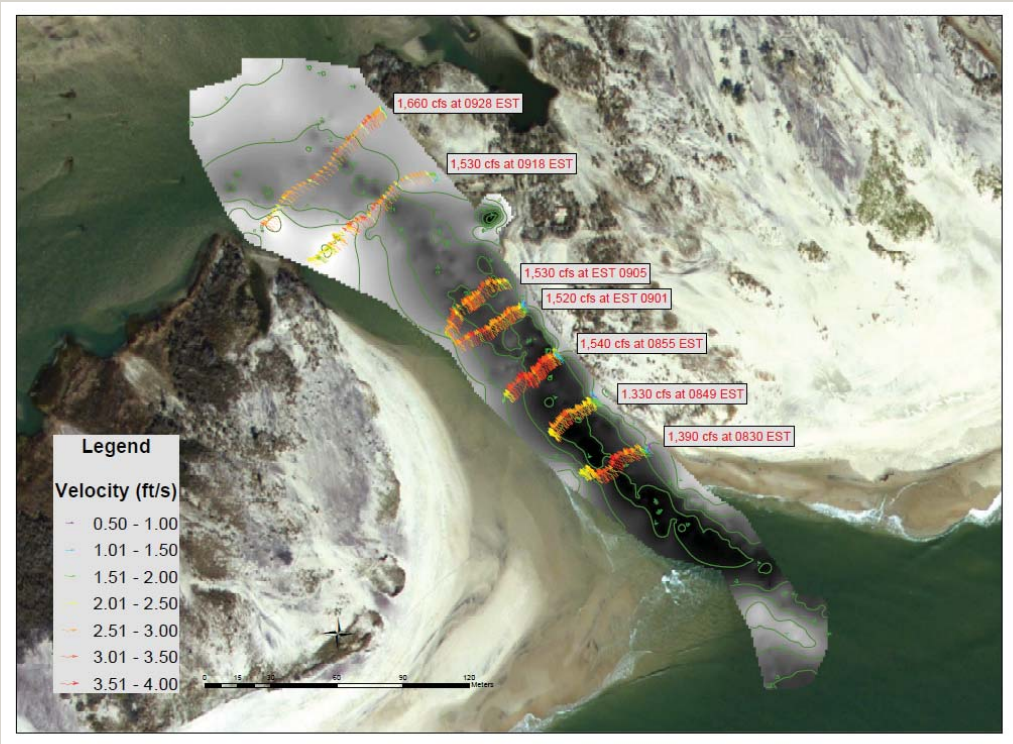
On November 6, 2012, USGS NYWSC personnel collected data to evaluate channel geometry, water velocity, and discharge of an open breach in the Federal Wilderness area of Fire Island National Seashore, N.Y. The breach resulted from major coastal flooding and overwash created by Hurricane Sandy on October 29, 2012. Data were collected using a Sontek1 M9 Acoustic Doppler Current Profiler (ADCP) with Real-Time Kinematic (RTK) Global Positioning System (GPS). Data were processed into a Geographic Information System (GIS) for interpolation and display.

An initial series of transects was collected starting about 3 hours before ocean high tide on November 6, 2012. Data were collected perpendicular to flow through the breach beginning at 0830 Eastern Standard Time (EST) and ending at 0928 EST. The first set of transects was taken near the seaward side of the breach, with subsequent sets collected progressively closer to the bayward side of the breach. Discharge ranged from 1,330 ft3/s (cubic feet per second) during the beginning set of transects to 1,660 ft3/s during the final set of transects (see Photo).

A second series of transects was collected starting about 3 hours before ocean low tide on November 6, 2012. Data collection began at 1410 EST and ended at 1500 EST. The first set of transects was taken perpendicular to the flood tidal channels bayward of the former Great South Bay (GSB) shoreline; subsequent sets were collected progressively closer to the seaward side of the breach. Discharge ranged from 1,060 ft3/s during the beginning set of transects to 1,380 ft3/s during the final set of transects.

Additional data were collected along the approximate centerline and adjacent to the shores of the channel to map the inundated area of the breach. The overall mapped area includes data collected during discharge measurements of both incoming and outgoing tide conditions. The Digital Elevation Model (DEM) was created by plotting the depths of all data points collected relative to North American Vertical Datum of 1988 (NAVD 88) and interpolating the elevation of the bathymetric surface between these points.

The average water surface elevation for all data collected was 1.38 ft NAVD 88. The volume of material lost during the breach beneath the average water surface elevation represented by a Triangular Irregular Network (TIN) was 47,700 yd3 (cubic yards).

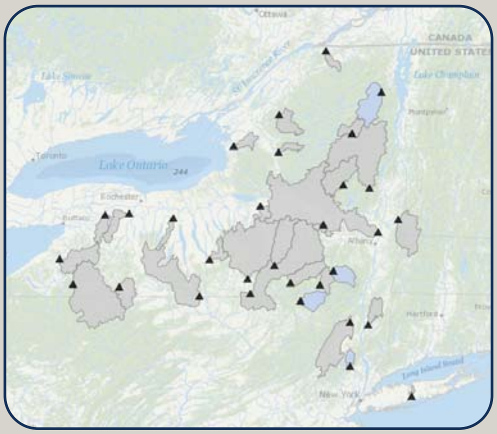


Bathymetry and Tidal Discharge of Wilderness Breach—November 6, 2012.

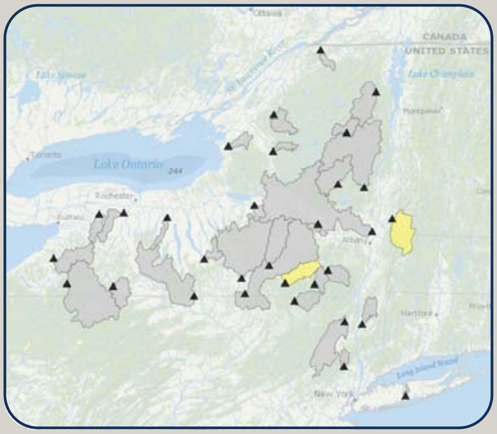
Surface Water and Groundwater Conditions in New York

Monthly and seasonally (shown below), hydrologists at the New York Water Science Center synthesize and summarize streamflows and groundwater levels for New York. Hydrologic condition reports are available at http://ny.water.usgs.gov/infodata/conditions.html: Visual representation of the streamflow and groundwater conditions are shown on the NY WSC's Hydrologic Conditions Mapper. Streamflows and groundwater levels have been about the same from October 2012 - March 2013. That is, streamflow was in the wet or normal ranges at all of the index stations with the majority in the normal ranges and groundwater levels at the observation wells varied around the State from wet to very dry with the majority of the wells in the wet or normal ranges.

A. Streamflow

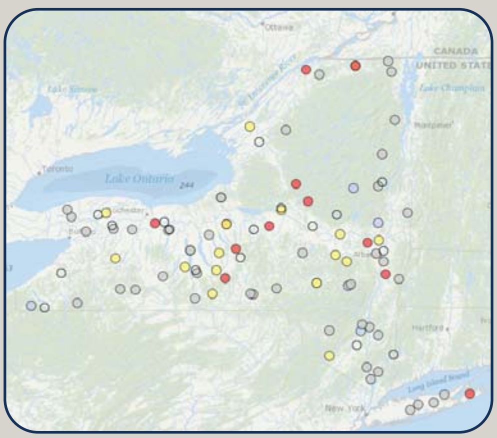


Autum 2012 (October, November, December)

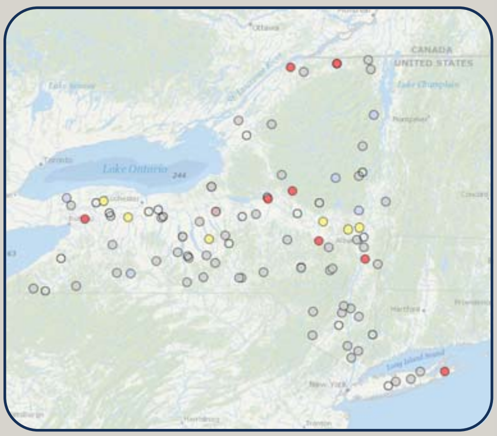


Winter 2013 (January, February, March)

B. Groundwater



Autum 2012 (October, November, December)



Winter 2013 (January, February, March)

EXPLANATION

Basin boundry — Drought Region — Streamgage — Groundwater well

Percentages of Monthly Means (Period of Record)

WET — NORMAL — DRY — VERY DRY

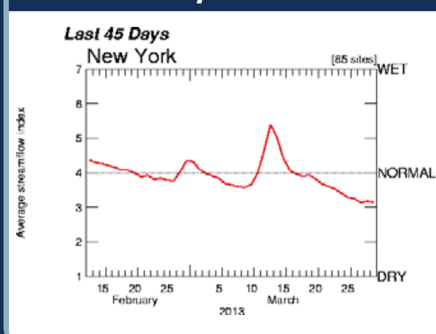
Seasonal conditions at selected (A) streamgages and (B) groundwater wells in New York. USGS maintains and operates most streamgages and groundwater wells in cooperation with various federal, state, and local agencies. Winter (January, February, March), Spring (April, May, June), Summer (July, August, September), Autumn (October, November, December).

USGS Water Watch & Groundwater Watch

WaterWatch is a USGS World Wide Web site that displays maps, graphs, and tables describing real-time, recent, and past streamflow conditions for the Nation. Real-time streamflow information (stage and flow) generally is updated on an hourly basis. WaterWatch provides maps that show the location of more than 3,000 long-term (30 years or more) USGS streamgages.

Groundwater Watch is a USGS World Wide Web site that displays maps, graphs, and tables describing groundwater level data from wells currently in a regular measurement program. Three types of water-level data are displayed, including periodic, continuous data that are periodically retrieved, and real-time data generally updated on an hourly basis. Groundwater Watch contains water levels and well information from more than 20,000 wells that have been measured by the USGS or USGS cooperators at least once within the past 365 days.

45 Day Index Plot



Among other things, WaterWatch summarizes streamflow conditions in a region (state or hydrologic unit) in terms of the long-term typical condition at streamgages in the region. For example, this plot shows that streamflow over the last 45 days was at or above normal conditions for New York until the end of March when it fell below normal.

New Reports from the New York Water Science Center

Baldigo, B.P., Duffy, B.T., Nally, C.J., and David, A.M., 2012, Toxicity of waters from the St. Lawrence River at Massena Area-of-Concern to the plankton species Selanastrum capricornutum and Ceriodaphnia dubia: Journal of Great Lakes Research, v. 38, p. 812-820, doi:10.1016/j.jglr.2012.09.008

Brown, C.J., Eckhardt, D.A., Stumm, Frederick, and Chu, Anthony, 2012, Preliminary assessment of water chemistry related to groundwater flooding in Wawarsing, New York, 2009-11: U.S. Geological Survey Scientific Investigations Report 2012-5144, 36 p.

Burns, D.A., Aiken, G.R., Bradley, P.M., Journey, C.A., and Schelker, Jakob, 2012, Specific ultra-violet absorbance as an indicator of mercury sources in an Adirondack River basin: Biogeochemistry, doi:10.1007/s10533-012-9773-5

Eckhardt, D.A. and Sloto, R.A., 2012, Baseline groundwater quality in national park units within the Marcellus and Utica Shale gas plays, New York, Pennsylvania, and West Virginia, 2011: U.S. Geological Survey Open-File Report 2012-1150, 20 p.

Heisig, P.M., 2012, Hydrogeology of the Susquehanna River valley-fill aquifer system and adjacent areas in eastern Broome and southeastern Chenango Counties, New York: U.S. Geological Survey Scientific Investigations Report 2012-5282, 21 p.

Kappel, W.M., Sinclair, G.J., Reddy, J.E., Eckhardt, D.A., deVries, M.P., and Phillips, M.L., 2012, Specific conductance measurements in central and western New York streams--A retrospective characterization: U.S. Geological Survey Open-File Report 2012-1174, 6 p.

Lawrence, G.B., Shortle, W.C., David, M.B., Smith, K.T., Warby, R.A.F., a nd Lapenis, A.G., 2012, Early indications of soil recovery from acidic deposition in U.S. red spruce forests: Soil Science Society of America Journal, v. 76, p. 1407-1417, doi:10.2136/sssaj2011.0415

Miller, T.S. and Pitman, L.J., 2012, Hydrogeology of the stratified-drift aquifers in the Cayuta Creek and Catatonk Creek valleys in parts of Tompkins, Schuyler, Chemung, and Tioga Counties, New York: U.S. Geological Survey Scientific Investigations Report 2012-5127, 44 p. 3 pls

Shaw, S.B. and Eckhardt, D.A.V., 2012, An assessment of radon in groundwater in New York State: Health Physics, v. 103, no. 3, p. 311-316.

Chu, Anthony, Stumm, Frederick, Joesten, P.K., and Noll, M.L., 2013, Geophysical and hydrologic analysis of an earthen dam site in southern Westchester County, New York: U.S. Geological Survey Scientific Investigations Report 2012-5247, 64 p.

Nystrom, E.A., 2013, Flood-inundation maps for the White River at Spencer, Indiana: U.S. Geological Survey Scientific Investigations Map 3251, 20 sheets, 8 p. pamphlet.

Nystrom, E.A. and Scott, T., 2013, Groundwater quality in the Mohawk River Basin, New York, 2011: U.S. Geological Survey Open-File Report 2013-1021, 43 p.

Riva-Murray, Karen, Bradley, P.M., Chasar, L.C., Button, D.T., Brigham, M.E., Scudder Eikenberry, B.C., Journey, C.A., and Lutz, M.A., 2013, Influence of dietary carbon on mercury bioaccumulation in streams of the Adirondack Mountains of New York and the Coastal Plain of South Carolina, USA: Ecotoxicology, v. 22, no 1, p. 60-71, doi:10.1007/s10646-012-1003-3

Schwab, W.C. and others, 2013, Geologic evidence for onshore sediment transport from the inner continental shelf, Fire Island, New York: Journal of Coastal Research, doi:10.2112/jcoastres-d-12-00160.1

NYWSC's Monthly Webex Presentations
Next Up:

"Measurements of Storm-Tide Impacts from Hurricane Sandy--Time Series, Flood Marks, and Breach Dynamics"

April 15 @ 1 PM

for more information contact Rich Reynolds (rjreynol@usgs.gov)

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The USGS Water Mission Area (WMA) has the principal responsibility within the Federal Government to provide the hydrologic information and interpretation needed by others to achieve the best use and management of the Nation's water resources. WMA actively promotes the use of its information products by decision makers to:

- Minimize loss of life and property as a result of water-related natural hazards, such as floods, droughts, and land movement.
- Effectively manage groundwater and surface-water resources for domestic, agricultural, commercial, industrial, recreational, and ecological uses.
- Protect and enhance water resources for human health, aquatic health, and environmental quality.
- Contribute to wise physical and economic development of the Nation's resources for the benefit of present and future generations.

If you have an environmental or resource-management issue in which you would like to partner with the USGS to investigate, please contact any of our senior management staff (listed below). Projects are supported primarily through the Cooperative Water Program. This is a program through which any State, County, or local agency may work with the USGS to fund and conduct a monitoring or investigation project.

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