

A Partial Summary of USGS Activities Related to the FHWA and State Highway Agencies

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Introduction

Part of the mission of the U.S. Geological Survey (USGS) is to assess the quantity, quality, and trends of the Nation's water resources, to advance the understanding of natural processes related to these resources, and to provide information that will assist resource managers and policymakers in making sound decisions. The USGS has a long history of jointly funded investigations with the Federal Highway Administration (FHWA) and State highway agencies to provide data and information to address various issues related to water resources and the Nation's transportation infrastructure. These issues cover a wide spectrum and include items such as regional flow statistics, flood documentation, regional stream characteristics, bridge scour, and water-quality assessments.

The following table and text provides a partial summary of current or recently completed USGS activities related to highway issues. Table 1 organizes the current and recent activities into categories and subcategories and gives a quick overview of the USGS programs and the State and (or) Federal agencies that are helping sponsor the programs. The text following table 1 provides more detailed information on the various activities. The text initially describes activities that have been, or are being conducted on a national level and is followed by state activities listed alphabetically by State. If you should have questions regarding this information, please contact Stephen Benedict at benedict@usgs.gov.

Table 1. Partial summary of USGS activities related to the FHWA and State Highway Agencies

Project Type	Sponsoring Agencies/States
Regional Flow Frequency/Statistics Investigations	
- National Flood Frequency Program	USGS
- StreamStats Program/automated basin characteristics	AZ, CT, CO, DE, IL, ID, IN, KS, KY, MD, MN, MS, NJ, NM, NY, OH, OK, OR, PA, RI, SD, TN, WA, WI, UT, VT
- Investigation of rural flow-frequency	AL, AZ, CT, DE, FL, HI, IL, IA, KS, MS, NM, NY, OK, SC, SD, TN, UT, VA, WI
- Investigation of urban flow-frequency	DE, KS
- Investigation of small watershed flow-frequency	KS, ME, TX, VA
- Investigation of hydrograph timing, rainfall hyetographs, and rainfall-duration-frequency maps	TX
Bridge Scour and Sediment Transport	
- National Bridge Scour Project	FHWA
- Scour at Contracted Bridge Sites	NCHRP
- Near real time scour monitoring	AK, GA, WI
- Data collection and analysis	ME, MS, SC, FHWA
- Investigation of Scour in cohesive soils using the EFA	IL, SC
- Channel stability and scour assessment	AK, AZ, MO, MT, PA, SD
- Investigation/modeling of sediment transport	TN, TX
- Investigation of bio-engineered bank protection and A-jacks scour countermeasures	OR, UT
Hydrologic and Hydraulic River Investigations	
- Investigation of bridge site hydrology and hydraulics	AL, GA, MN, MS, MO, NY, NC, TN
- Investigation and modeling of multi-dimensional flows	NC, PA
- Flood documentation	DE, IA, MS, NH, NV, NY
Stream Characteristic Investigations	
- Regional channel characteristics/bankfull discharge	NY, OH, WV
- Investigation of Manning's roughness coefficients	AZ
Gages	
- Tidal gages	DE, NJ
- Crest stage gages to estimate annual peak flows	GA, HI, IA, KS, LA, ME, MI, MN, MS, MO, MT, NV, NJ, NM, NY, ND, OH, SC, SD, TN, VT, VA, WV, WI
- Continuous-record discharge and stage gages	AK, FL, HI, IN, IA, LA, ME, MD, MI, MN, MS, MO, MT, NH, ND, SC, TN, VT, WA, WV
- Real time monitoring network on hurricane evacuation routes; monitors stage, rain, wind, and traffic count	LA
Water Quality/Environmental Investigations	
- Evaluation of Stormwater Runoff Models	FHWA, MA
- Monitor water quality/quantity at selected sites	HI, MA, MN, MT, NV, TN, VT
- Investigation of wetland impact/remediation	DE, MT, PA
- Investigation of stream restoration	MD
- Investigation of the impact of deicing chemicals	IN, OH, VT
- Investigation of habit impact by bridge pier	PA
- Investigation of BMP	SC, WI
Internet Publication of Historic Reports and Data	MS

Partial Summary of USGS National Activities

National Bridge Scour Project (FHWA)

The National Bridge Scour Project was funded by the FHWA to collect field data on scour at bridges during major floods. The project has collected data during six major floods and has compiled data collected by various state-funded projects. The final report (cited below) was published in 2005

Mueller, D.S. and Wagner, C.R., 2005, Field observations and evaluations of streambed scour at bridges Washington, D.C., U.S. Department of Transportation, Federal Highway Administration, FHWA-RD-03-052, 122 p.

Scour at Contracted Bridge Sites (NCHRP and University of Louisville)

The objective of NCHRP Project 24-14 was to collect field data from which processes affecting scour magnitude in contracted bridge openings could be identified, to support verification of physical and numerical model studies, and to improve guidelines for applying scour-prediction methods at contracted bridge sites. Detailed data were collected at 15 bridge sites and predicted scour based on one- and two-dimensional flow models were compared to measured scour. Results of this investigation are documented in report cited below and will be posted as an NCHRP web document in January 2006:

Wagner, C.R., Mueller, D. S., Parola, A. C., Hagerty, D. J., and S.T. Benedict "NCHRP Project 24-14 Scour at Contracted Bridges" Transportation Research Board, National Research Council, Washington D.C. (2004).

National Flood Frequency

The National Flood Frequency Program, Version 3, (NFF) is a Windows-based computer program, developed by the USGS Office of Surface Water (OSW), that compiles into a single, user-friendly package more than 2,000 regression equations developed by the USGS for estimating flood-frequencies in 289 regions of the Nation, the Commonwealth of Puerto Rico, and the island of Tutuilla, American Samoa. NFF also has the ability to generate flood-frequency plots and unit hydrographs, and to weight regression equation estimates with drainage-area ratio estimates based on flows at nearby gaged sites to obtain improved estimates for ungaged sites. The software and documentation can be downloaded from the NFF Web site at <http://water.usgs.gov/software/nff.html>. Documentation for the program includes: Water Resources Investigations Report 02-4168, which discusses the technical approaches used to develop the regression equations and other functionality of NFF, and provides a manual that explains use of the software: and Fact Sheet 084-02, which briefly explains the software and its use. In addition, links to on-line reports, fact sheets, and other documents are provided from the NFF Web site to document procedures for individual states.

During fiscal year 2004, the NFF database was updated with new equations for Alaska, Idaho, Ohio, Tennessee, Vermont, Wisconsin, Wyoming, Connecticut and Kentucky. Along with the new database comes the ability to display 90-percent prediction intervals with the estimates for some of the updated States. In addition, a report documenting version 4 of the software has been approved for publication. The new software version will be named the National Streamflow Statistics Program (NSS). The name change was required because the new version will provide the ability to solve regression equations for estimating any types of streamflow statistics that are available for each state, such as mean flows and 7-day, 10-year low flows. NSS will also implement region-of-influence regressions that have been developed for several states. The new software is expected to be released during the winter of 2006.

StreamStats Program

The USGS Office of Surface Water (OSW) has partnered with ESRI, Inc. to develop a prototype Web application named StreamStats that greatly reduces the time needed to estimate streamflow statistics for ungaged sites and to make published streamflow statistics for USGS data-collection stations easily accessible. A prototype version of StreamStats is now available for review on the Web at <http://streamstats.usgs.gov> for Idaho, Vermont, and Washington, and internal testing is being done for Pennsylvania. The StreamStats prototype incorporates (1) a map-based user interface for site selection, (2) a GIS program that determines boundaries of the drainage basins for ungaged sites, measures the physical characteristics of the drainage basins, and solves regression equations to estimate streamflow statistics for the sites, and (3) a GIS database needed to display maps and determine the physical characteristics of the drainage basins. In addition, a database that provides streamflow statistics and other information for data-collection stations will be available by the end of 2004. Work also is underway to implement StreamStats in Connecticut, Rhode Island, Maryland, Delaware, Kentucky, Tennessee, Mississippi, Colorado, Oregon, Utah, Indiana, Minnesota, New Jersey, New York, South Dakota, Oklahoma, and Washington. Several enhancements to the program are planned. The USGS encourages review of the prototype application, and requests comments be sent GS-W StreamStats@usgs.gov.

Evaluation and Update of the Federal Highway Administration (FHWA) Pollutant Loadings Model for Highway Stormwater Runoff

Valid, current, and technically defensible stormwater runoff models are needed to (1) interpret data collected by field studies, (2) support existing highway and urban runoff planning processes, (3) meet National Pollutant Discharge Elimination System (NPDES) requirements, and (4) provide methods for calculation of Total Maximum Daily Loads (TMDLs) in a systematic and economic manner. The FHWA formulated a model to predict pollutant loadings and impacts from highway stormwater runoff in 1990. Unfortunately, the 1990 FHWA model has several limitations that affect the use of the model; defensibility and representativeness of model results, and documentation of model results. The 1990 FHWA model was written for the DOS operating system, and does not always work on more recent (Windows 2000/XP) operating systems. The model was based on data collected from the mid 1970's through the mid 1980's. Changes in materials used to build roads and vehicles, the advent of vehicular emission controls, and changes in the formulation of fuels and lubricants have substantially changed the composition of runoff in the last 20 years. Research also indicates that water-quality monitoring methods may substantially effect measurements of concentrations, flows, and the resultant calculation of runoff loads.

The 1990 FHWA model was framed as a dilution model with the assumption that background concentrations were zero. This approach was chosen to examine the effects of highway runoff on receiving waters and to highlight the potential effects of best management practices (BMPs) on receiving waters. Currently (2006), however, regulators and decision makers will not accept a model with a background concentration of zero, and regulators are focusing on concentrations at low-flows such as the 7Q10 or 4B3, which are included in state and federal water-quality standards. This study will evaluate the 1990 FHWA model and update the model using new information and data. More specifically, the study will implement a Monte Carlo model in a new software platform as a prototype for a new national model, update the existing model with more recent streamflow and water-quality information, and expand the model to address regulatory concerns. This model will provide a "best estimate" (mean or median) and confidence intervals for expected EMCs. The model also will utilize this EMC estimate and estimates of precipitation, and runoff coefficients to produce a population of estimates for loads based on the location and site characteristics of highway sites of interest.

Standard tools and techniques for obtaining and processing information and data about highway runoff quality and quantity and the quality and quantity of upstream flow in the receiving waters were needed to support this new national FHWA model. The USGS in cooperation with the FHWA has developed and tested a highway runoff database as well as computer applications that can be used to automatically download and process water-quality and streamflow data from the USGS National Water Information System (NWIS) Web. The following is a brief summary of each product and its current status:

- **Highway-Runoff Database (HRDB v. 1.0): A Data Warehouse and Preprocessor for the Stochastic Empirical Loading and Dilution Model.**

Status: In Second Stage of Technical Review

The highway-runoff database application was developed to serve as a data warehouse for highway-runoff data-sets that can be used to facilitate estimation of statistical properties of runoff coefficients, runoff-quality statistics, and relations between water-quality variables in highway runoff. This highway runoff database currently includes over 39,000 event mean concentration values from analysis of more than 100 different water-quality constituents. These EMC values were collected at 100 highway-runoff monitoring sites in the conterminous United States during more than 2,600 storm events as documented in 6 highway-runoff quality data sets. The user may select and export water-quality data in tab-delimited or comma-delimited format. The user may generate water-quality statistics for data with censored values by use of the robust Regression on Order Statistics (ROS) method. The user may export paired water-quality data in a format suitable for regression analysis. Finally, the user may export precipitation, runoff flow, and runoff coefficient data in tab-delimited format. In each case the user may select data from different sites and different data sets based on highway-runoff monitoring site characteristics.

- **Kendall-Theil Robust Line (KTRLLine--version 1.0)--A Visual Basic Program for Calculating and Graphing Robust-Nonparametric Estimates of Linear-Regression Coefficients Between Two Continuous-Variables.**

Status: Final USGS Approval Review

The Kendall-Theil robust line program was developed because this nonparametric method is resistant to the effects of outliers and nonnormality in residuals that commonly characterize water-quality data sets. A single-segment model or a multi-segment model may be specified. The program was developed to provide regression equations with an error component for stochastic data generation because nonparametric multi-segment regression tools are not available with the software that is commonly used to develop regression models.

- **Methods for Compilation and Interpretation of Data for Development of Transport Curves for Planning-Level Estimates of Water-Quality at Unmonitored Sites in the Conterminous United States.**

Status: In Second Stage of Technical Review

This report documents methods for data compilation and analysis of water-quality-transport curves that meet data-quality-objectives for planning-level estimates of stream water-quality at unmonitored sites in the 84 U.S. EPA ecoregions in the conterminous U.S. Transport curves are regression relations used to estimate constituent concentrations from measured or estimated water discharge values. This national synthesis effort was based on data available on the USGS National Water Information System (NWIS) Web. A total of 24,581 surface-water-quality monitoring stations with drainage areas ranging from 0.002 to 1,040 square miles were identified throughout the conterminous U.S. and cataloged for retrieval of water-quality data. A total of 252 regional transport curves were developed for suspended sediment, total phosphorus, and total hardness. Four computer applications were developed to download, process, and build a database of about 1.2 million paired streamflow and water quality measurements for 14 water-quality constituents commonly measured in runoff studies. The user may utilize the regional regression models, or develop their own regional, local, or site-specific estimates with these data and methods.

- **Methods for Compilation and Interpretation of Data for Development of Transport Curves for Planning-Level Estimates of Streamflow at Unmonitored Sites in the Conterminous United States.**

Status: In Preparation

This report documents methods for data compilation and analysis of streamflow statistics that meet data-quality-objectives for planning-level estimates of streamflow at unmonitored sites in the 84 U.S. EPA ecoregions in the conterminous United States. This national synthesis effort was based on data available on the USGS National Water Information System (NWIS) Web. Streamflow statistics are available in a database for 2,783 USGS streamflow-gaging stations within the conterminous United States that were selected because they have at least 24 years of daily discharge records during the period 1961-2004 and drainage areas ranging from 10-500 square miles. The streamflow statistics were calculated using standard methods. Four computer applications were developed to download, process, and build a database of summary statistics for USGS streamflow-gaging stations that may be used to estimate a population of streamflows by ecoregion or by using selected gaging stations. The user may choose regional statistics, or develop their own regional, local, or site-specific estimates with these data and methods.

- **Stochastic Empirical Loading and Dilution Model.**

Status: In Preparation

The stochastic empirical loading and dilution model is designed to use Monte Carlo methods to provide information on the probability distributions of: (1) precipitation characteristics, (2) highway-runoff volumes, (3) highway-runoff concentrations, (4) upstream flow, (5) upstream receiving-water concentrations, and (6) structural best management practice performance. This information will be used to: estimate the probability distributions of (7) concentrations and (8) loads in receiving waters downstream of the highway outfall. These estimates will provide the information necessary to estimate the probability of exceeding a water-quality standard. The stochastic empirical loading and dilution model is designed as a database application that will facilitate generation of local or regional planning-level estimates based on site-specific characteristics.

- **FHWA/USGS NDAMS web page (<http://ma.water.usgs.gov/fhwa/>)**

Status: On-line and active.

We have maintained the FHWA/USGS NDAMS web page (which receives about 70,000-80,000 visits per year) since 1996. In 2005 we added a Stochastic Empirical Loading and Dilution Model WEB page, and posted the 1990 FHWA model, documentation (which we scanned into PDF format), and data on-line.

Partial Summary of USGS Water Science Center Activities Supported by State Highway Agencies

Alabama

- Performed hydrologic, hydraulic, and scour analyses at selected bridge sites for the Alabama Department of Transportation
- Currently updating the statewide flood-frequency equations.

Alaska

- The Alaska Science Center, Water Resources Office, operates 48 partial record stations (crest-stage gages), and 16 flood hydrograph (seasonal or perennial continuous stream gages) in cooperation with the Alaska Department of Transportation and Public Facilities (ADOT&PF). These gages are primarily designed to collect peak streamflow from small basins to enhance the ability to predict magnitude and frequency of flooding in vast regions of the state that are sparsely monitored and where little hydrologic information exists for design of roads, bridges, and other streamside structures.
- An additional program with ADOT&PF that focuses on streambed scour monitoring and modeling had these accomplishments in 2005:
 - Monitored near real time pier scour at 16 sites around Alaska with pier-mounted sonars;
 - Surveyed channel crossings at 41 scour-critical bridges.
 - Published: Conaway, J.S., 2005, Application of acoustic Doppler current profilers for measuring three-dimensional flow fields and as a surrogate measurement of bedload transport, in Proceedings of the World Water and Environmental Resources Congress, Anchorage, Alaska, 2005, 10 p.
 - Alaska streambed scour website: http://ak.water.usgs.gov/usgs_scour/
- Finally, another study with ADOT&PF examines the geomorphology and river dynamics of the lower Copper River. Primary data activities included:
 - Collection of Light Detection and Ranging (LIDAR) data of the lower Copper River for use in flow models
 - Three bridges that pass most of the flow of the Copper River (Bridges 339, 340, and 342) were instrumented to monitor scour on a continuous basis
 - A new instrument, the H-360 radar sensor, was used successfully to monitor stage of the Copper River at the Million Dollar Bridge.

Arizona

- Currently engaged in a small channel morphology/bridge scour program with Maricopa County.
- In planning stages of a multi-year project for upgrading a portion of the State's flood-frequency equations and implementing Streamstats.
- Development of new guidelines for estimating Manning's roughness coefficient, and vegetation maintenance plan guidelines for vegetated urban channels in Maricopa County.

Arkansas

- No highway related projects at this time.

California

- No highway related projects at this time.

Colorado

- No highway related projects at this time.

Connecticut

- In process of implementing StreamStats; Mapping Division completed in 2004 the centerline hydrography data layer with stream and watershed attributes.

Delaware

- Monitoring a remediated wetland created by DeIDOT in a former borrow pit, along with an adjacent natural wetland. Monthly water level and rainfall data are reported to DeIDOT annually.
- DeIDOT partially funds two tide gages on Atlantic coastal bays.
- An administrative letter was released to the Federal Emergency Management Agency to describe completed mapping of high-water marks throughout the Red Clay Creek basin in northern Delaware and indirect measurements of discharge at streamgaging stations in the basin to define water surface elevations and discharges for a new peak of record that occurred on Sept. 15, 2003, as a result of record rainfall generated by remnants of Hurricane Henri.
- A 2-year study in cooperation with DeIDOT to update flood-flow frequency regression equations, and to implement StreamStats in Delaware is expected to be completed by March 31, 2006.

District of Columbia

- No highway related projects at this time.

Florida

- Working on a 10-year coop program with the Florida State Department of Transportation that began in 1996. The intermediate goal of this program is to determine annual peak stages and discharges for 30 small basin sites in northern Florida. The anticipated climax of this program will be an update of the flood frequencies for all Florida gages, probably in the 2007 program.

Georgia

- Ongoing statewide flood and bridge-site studies at sites selected by GADOT. Open-File Reports published as needed.
- Maintain a statewide network of 50 crest-stage gages as part of ongoing flood-frequency study.
- Continue bridge scour research project. The overall investigation combines the field monitoring data of bridge scour with physical modeling in the Georgia Tech laboratory, and 3 dimensional numerical modeling also at Georgia Tech. USGS is monitoring scour at three bridges in Georgia that have been instrumented with an array of recording fathometers and Acoustic Velocity Meters on two of the bridges. The three sites transmit the scour data via satellite telemetry, and the data can be viewed near real-time via the web.

Hawaii

- Operates a network of 43 crest-stage gages and one real-time continuous-record streamgage to monitor peak stages and discharges at or near highway crossings on the islands of Kauai, Molokai, Maui, and Hawaii. The peak-flow data collected at these stations adds significantly to peak-flow data collected at continuous stations and improves regional coverage of peak-flow measurements in Hawaii.
- Monitors storm-water quality and quantity from a portion of the H-3 freeway near Aiea, and receiving water bodies. Samples are collected quarterly at 5 stations, and streamflow is continuously monitored at 3 of these stations. This project was expanded in 2005 to include monitoring of sediment and turbidity during stream-channel realignment along the freeway route.
- Monitors storm-water quality and quantity from a portion of the H-1 freeway near the University of Hawaii Manoa campus. A stormwater monitoring station and raingage are now in operation. Samples will be collected quarterly.
- Updating flood-frequency estimates for unaged streams in Hawaii.
- Recent publications:
Young, S.T.M., and Ball, M.T.J., 2005, Rainfall, streamflow, and water-quality data during stormwater monitoring, Halawa Stream drainage basin, Oahu, Hawaii, July 1, 2004 to June 30, 2005: U.S. Geological Survey Open-File Report 2005-1280, 23 p.

Idaho

- No highway related projects at this time.

Illinois

- Illinois StreamStats--The USGS flood-frequency update study for Illinois, published in 2004, found that the inclusion of 14 years additional streamflow data collected since the previous 1985 flood-frequency study resulted in appreciable changes in the expected magnitude of large floods in various regions of Illinois. The new methods are based on variables that can be easily and consistently measured with GIS technology, but are difficult and resource-intensive to reproduce by manual methods. An automated Internet Map Server (IMS) tool, Illinois StreamStats, that makes peak flood discharge computations at gaged and ungaged rural sites consistent, easy to determine, and publicly available to the users in Illinois will be developed and served. Illinois StreamStats will provide a map-based point and click interface to determine watershed delineations and basin characteristics. StreamStats is interfaced with the National Flood Frequency program to return peak flood discharges at various frequencies. Project will begin in 2006.
- Field Verification of SRICOS-EFA and Synthetic Hydrograph Generation for Illinois Streams--The Scour Rate In Cohesive Soils-Erosion Function Apparatus (SRICOS-EFA) Methodology outlined in the National Cooperative Highway Research Program Report 24-15, provides a potentially useful methodology for assessing scour in cohesive sediments, but field validation data for the method are limited. The overall objective of this study is to test the SRICOS-EFA method for estimating scour depth of cohesive soils in Illinois streams. Also, means of generating future hydrographs at ungaged locations in a risk-analysis framework is needed and will be developed for the methodology. This project is still in the planning phase and will likely begin in 2006.
- Report published last year

Soong, T.W., Ishii, A.L., Sharpe, J.B., and Avery, C.F., 2004, Estimating Flood-Peak Discharge Magnitudes and Frequencies for Rural Streams in Illinois: U.S. Geological Survey Scientific Investigations Report 2004-5103, 147 p.

Indiana

- INDOT cooperatively funds 20 continuous-record gaging stations.
- The USGS Indiana Water Science Center, Geohydrologic Studies section had a cooperative project in FY 2005 with INDOT to evaluate the use of geophysical logs to evaluate trends in ground-water quality at a former deicer storage site. Preliminary comparisons of results from electromagnetic-induction logging of polyvinyl chloride cased observation wells in 2005 with data from previous years revealed decreased formation conductivity since the start of INDOT efforts to pump saline water from the aquifer. Preliminary results from limited water-quality sampling indicated decreases in dissolved solids and chloride concentrations in ground water that corresponded to aquifer zones with decreased formation conductivity. A proposal to prepare a USGS report to document these findings is planned.

Iowa

- Cooperatively funds 31 continuous-record gaging stations.
- Cooperatively funds 90 crest-stage gages.
- Cooperatively funds ongoing flood-profiles project to document water-surface profiles of significant flood events.
- Cooperatively funds an investigation to develop and evaluate flood-frequency discharge estimation methods for rural, ungaged streams in Iowa with drainage areas less than 50 square miles. Develop regional regression and probabilistic rational methods for flood estimation. Evaluate the predictive accuracy of flood estimates calculated using the newly developed regional regression equations, the probabilistic rational method, the 2001 regional regression equations, and the Iowa Runoff Chart by comparing estimates computed using these four methods to estimates computed using Bulletin 17B flood-frequency analyses.

Kansas

- The Kansas Water Science Center streamflow statistics project has provided improved estimates versus the ungaged regression equations for 5427 stream segments for flood frequency and various duration flows.
- The Kansas StreamStats is on the web at <http://ks.water.usgs.gov/Kansas/studies/strmstats/>.
- Cooperatively funds 32 crest-stage gages.
- The Kansas Water Science Center continues to verify theoretical stage-discharge ratings using direct measurement of flow at Flood Alert streamgages operated by Johnson County. Once the ratings for all stations are verified, peak-flow information can be used to develop flood-frequency equations for urban sites.
- Currently, there are few active streamgages with drainage areas less than 10 mi² used to compute flood frequency. National Weather Service precipitation estimates from significant events shortly after their occurrence will be used to determine areas where indirect measurements are needed. The relation between discharges per unit area (Q/DA) will be related to the probability of the precipitation event, the season of the year, and other basin characteristics. These relations will be tested to determine flood frequency at ungaged sites for streams less than 10 mi² and if successful will improve flood frequency estimates for ungaged sites in small watersheds. Initially data collection will focus on the Topeka NWS radar area.

Kentucky

- No highway related projects at this time.

Louisiana

- Cooperative program to operate 10 continuous real-time streamflow data collection stations, 19 real-time stage stations, 21 crest-stage gages, and 14 flood-profile gages.
- Cooperative program to operate a real-time monitoring network located on hurricane evacuation routes. Presently operating 12 real-time stations monitoring water level, precipitation, wind speed and direction, and traffic count. Network used to determine when flood inundation or wind speed will close highway evacuation routes in coastal Louisiana. Network is planned to be expanded to 22 sites.
- Recent publications:

Ensminger, P.A., and Wright L.S., 2003, Low-Flow Characteristics of Louisiana Streams: Louisiana Department of Transportation and Development Water Resources Technical Report no. 70, 159p.

Gilbert, J.J., and Green, E.J., 2003, Estimation of scour and channel stability for selected highway crossings of streams in Louisiana: Louisiana Department of Transportation and Development Water Resources Technical Report no. 67C, 114 p.

Wright, L.S., and Ensminger, P.A., 2004, Regionalized Regression Equations for Estimating Low-Flow Characteristics for Selected Louisiana Streams: Louisiana Department of Transportation and Development Water Resources Technical Report no. 75, 32 p.

Maine

- **Abutment Scour**—The USGS is collecting abutment-scour information during low flows at 50 older bridges in Maine with vertical concrete abutments and wingwalls. The information collected at the bridges, along with hydraulic modeling, will provide the necessary data to test the computation of abutment scour predicted by several common methods against actual abutment scour.
- **Small watershed peak flows**—For 17 basins that have drainage areas of between 1 and 10 square miles, peak flows for selected recurrence intervals are being computed with the Rational Method, TR-20, Probabilistic Rational Method and statewide regression equations. Computed flows are being compared to peak flows of selected recurrence intervals at USGS streamflow gages. Actual peak flows for 9 rainfall events at 4 sites with drainage areas of less than 1 square mile are being computed by the Rational Method and TR-20, using actual rainfall data. Computed peak flows are being compared with actual peak flows at USGS crest-stage gages.

- **Small watershed data collection**—Ongoing peak-flow data collection (crest-stage gages) on 15 streams, all basins less than one square mile. Nine sites have 5 complete years of data collection; four sites have 4 complete years of data collection. Two sites were discontinued and new sites established in the last year because of site problems.
- **Continuous streamflow data collection**—Ongoing data-collection at 10 USGS streamflow gages.

Maryland

- MDSHA provided about 50 percent funding for 21 streamgaging stations during fiscal year 2005.
- A study is underway in cooperation with USEPA of the effects of stream restoration activities on streamflow, water quality, and ground water in a small urban watershed with a major highway in its headwaters.

Massachusetts

- Continued assessment of stormwater discharges from state highways in Massachusetts and the development of a statewide predictive model - (USGS- Massachusetts Highway Department cooperative program)

The purpose of the project is to document highway runoff and constituent concentrations discharged from common highway-drainage conveyance structures in Massachusetts from four primary highway sites and four additional test sites during a two-year period. This study will also evaluate the potential transferability of these data to other highway sites by relating constituent concentrations to average daily traffic volumes. These data will be used to populate a statewide version of the new national highway-runoff model (developed by the USGS under agreement with the FHWA), which will be used for estimating highway-runoff concentrations and loads throughout Massachusetts.

- The cooperative project with the FHWA to evaluate and update the Federal Highway Administration Pollutant Loadings Model for highway stormwater runoff is complete. Publications documenting the findings of this investigation are in preparation with tentative titles as follows:

"Methods for Compilation and Interpretation of Selected Water-quality data for Development of Planning-level Estimates of Stream Water-quality at Unmonitored Sites in the Conterminous United States", by Granato, G.E., Carlson, C.S., and Sniderman, B. S.

"A Visual-Basic Program for Calculating and Graphing Robust Nonparametric Estimates of Linear-Regression Coefficients Between Two Continuous Variables", by Granato, G. E.

Michigan

- The Michigan Water Science Center operates 10 continuous record streamgages and 5 crest-stage gages for the Michigan Department of Transportation.

Minnesota

- Operating a network of 77 crest-stage gages and one continuous discharge gage for flood frequency analysis. Updated data are being analyzed for a new Flood Frequency Report on Small Streams for MN. This report is planned for publication in FY 07.
- Provide hydraulic investigation support as requested, including bridge scour.
- Continued year three of a multi-year cooperative project to investigate the effects of a proposed four-lane divided highway on the water quality and hydrology of relatively pristine streams and wetlands that drain to a large lake important for fisheries and tourism.
- The Basin Characteristics project prepares hydrologically enhanced 1:24,000 Digital Elevation Model (DEM) data for use with automated basin characteristic and flood frequency ArcView extension. The Basin Characteristics project is updating basin characteristics for over 10,000 level 4-7 HUs in Minnesota and surrounding States.
- Stream-Slope Research: Testing automated methods of generating stream-slopes with DEMs against the manual and semi-manual methods.

- All basin characteristics data is available on-line at the Minnesota Watershed Information Project <http://gisdmnspl.cr.usgs.gov/watershed/index.htm>. This web page allows users to get basin characteristics and watershed areas for over 10,000 level 4-7 watersheds in and around Minnesota

Mississippi

- Continue to provide streamflow records, hydrologic analyses of basins, and hydraulic analyses of the flooding potential at selected stream crossings, known as bridge-site studies. Provide Mississippi Department of Transportation (MDOT) the capability to query and view the bridge-site-study data and provide all current reports with embedded figures in MS Word. In FY 2005, provided data for 43 bridge-site studies and also responded to numerous data requests.
- Continue to operate and maintain 97 crest-stage gages and 1 flood hydrograph gage
- Streambed soundings were obtained at two major coastal bridges that were destroyed by Hurricane Katrina on August 29, 2005, and provided to MDOT and their consultant as needed to assist in the design-build phases of these bridges. Streambed soundings were also obtained at two other coastal bridges to document scour that occurred.
- Continue to prepare an updated version of the 1991 flood-frequency reports to include the use of GIS determined basin characteristics for development of regional flood-frequency equations and the implementation of StreamStats.
- Digitized and processed inundation boundaries for the April 1979 flood atlas of the Jackson metro area and the Hurricane Camille and Betsy flood atlases along the Mississippi Gulf Coast are available via ArcIMS at the MS Water Science Center home page at: <http://ms.water.usgs.gov/> When accessing the home page, the inundation boundaries can be found under the heading: **Surface-Water Data and Maps**, which is within the listing along the left side of the home page.
- 166 historical reports are available for viewing or downloading at: <http://ms.water.usgs.gov> 106 of these reports are historical flood and flood frequency reports. HA-590 – 611, present bridge backwater data for 35 floods at 22 sites. When accessing the home page, the historical reports can be found under the heading: **Publications**, which is within the listing along the left side of the home page.

Missouri

- Bridge scour project completed. Findings of the Level 1, Level 1+, and Level 2 analysis were published in the following report:
Huizinga, R.J., and Rydlund, P.H., Jr., 2004, Potential-Scour Assessments and Estimates of Scour Depth Using Different Techniques at Selected Bridge Sites in Missouri: U.S. Geological Survey Scientific Investigations Report 2004-5213, 41 p.
- Operation of network of 38 crest-stage gages to be used with future flood frequency study.
- Operation and maintenance of 6 stream-gaging stations as part of the state-wide stream-gaging network.
- Potential hydraulic analysis at selected bridge sites.

Montana

- Bridge-scour data collection and analysis program ongoing since 1991.
- Small-stream peak-discharge data collection program ongoing since 1955. Currently operating over 100 crest-stage gages and 2 flood-hydrograph continuous-record streamflow gages.
- Ongoing cooperative project to investigate the hydrology of selected wetland areas affected by proposed highway projects.
- Began project to collect sediment samples downstream from road construction sites with activities that disturb streambeds to assess the impact of these activities on water quality.

Nevada

- Maintain a Statewide network of 24 crest-stage gages.
- A proposal has been submitted to the Nevada Department of Transportation to compute sediment loads in the Clear Creek Drainage to assess the impact of runoff from a U.S. Highway. The proposal included limited water-quality data collection during the sampling.
- A web based fact sheet is being written on a thunderstorm event that resulted in localized flooding north of Reno.

New Hampshire

- New Hampshire Department of Transportation (NHDOT) funds approximately one-third of New Hampshire's stream-gaging network.
- A cooperative investigation between NHDOT and the USGS is underway to develop hydraulic models of the Cold River and Warren Brook, two reaches that were devastated during the October 2005 floods in southwestern New Hampshire.

New Jersey

- Operate and maintain the New Jersey Tide Telemetry System, which includes 28 real-time tide gages, 29 tidal crest-stage gages, and 5 computer base stations. These gages are located on various back bays and tidal estuaries of coastal rivers. The purpose of the System is to provide real-time data for road closures and evacuations, and also to develop a long-term tide database for design purposes.
- Operate and maintain 46 crest-stage gages on small drainage basins of less than 2 square mile, and 16 older crest-stage gages under 9 square miles in drainage area. After 10-years of record have been recorded, a study to compare the gaged results with the various flood magnitude and frequency estimation methods will be initiated.

New Mexico

- The crest-stage gage network of about 80 gages will expand to 120 gages over the next three years. Site locations greater than 900 square miles and sites between 10 to 50 square miles are lacking throughout New Mexico. Currently, 35 gages are operated with recording pressure transducers to automate the data collection process and 37 more gages will be equipped for a total of 72 gages. The data loggers are programmed to record at 5-minute intervals based on event sampling. Several events were recorded and validated using cork lines registered in the crest-stage gages.
- A 2006 flood-flow frequency report is planned which will include new and updated basin/climatic characteristics using the USGS National Elevation Dataset (NED) and other raster data layers. Average basin slope and average basin elevation are statistically significant in several regional regression equations.
- StreamStats: A U.S. Geological Survey Web application for stream information has been partially funded by the NMDOT for FY 2005-2006. Information about the program can be found at <http://water.usgs.gov/osw/programs/streamstats.html>. The GIS based product provides streamflow, basin, and climatic characteristics at gaging stations and provides estimates of selected characteristics at ungaged sites based on regional regression equations.

New York

- Flood investigations including bridge-site studies and localized flood-frequency analyses.
- Documentation of notable floods through collection of flood information such as peak stages and discharges at discontinued gages, flood profiles along flooded streams, and indirect flood discharge measurements at miscellaneous flooded sites. Hurricane Ivan resulted in near 100-year discharges in the Delaware River Basin (Brooks, 2005). Flooding during April 2005 resulted in record flooding in the Esopus Creek and Neversink River basins (reports documenting this flood are in progress). Several indirect measurements were made.

- Have computed basin characteristics for more than 500 gaged basins throughout New York using GIS techniques and coverages. These characteristics include several land use categories, meteorological parameters, and numerous morphometric variables (based on the physical shape, drainage structure, and relief of each basin and main channel). These characteristics have been used in an update of flood-frequency relations for New York (final report is with our publication unit and will be published in early 2006). GIS datasets and software will be available on a DVD in the report to allow automated calculation of flood frequency discharges.
- Maintain a statewide network of 48 crest-stage gages.
- Continue to investigate the use of GIS techniques and coverages to automate the computation of flood discharges at any unregulated site on streams in New York (STREAMSTATS).
- An effort to update a report showing the maximum known stages and discharges at nearly 1500 gaging stations in New York is in progress. Recurrence intervals will be assigned to each peak discharge, where feasible. A report will be published in 2006.
- A multi-year effort to develop regional models (curves) of bankfull discharge and hydraulic geometry for streams of New York State. Relations have been developed by hydro-physiographic region and by Rosgen stream type to help define stable reach characteristics for reference reaches used to plan natural-channel-design restoration projects. The study is collaboration between the USGS, New York City Department of Environmental Protection, Cornell, and New York State Departments of Transportation, State, and Environmental Conservation. Selected streams in about 80 percent of the State have been surveyed at this time.

Reports

Brooks, L.T., 2005, Flood of September 18-19, 2004 in the Upper Delaware River Basin, New York: U.S. Geological Survey Open-File Report 2005-1166, 123 p.

Mulvihill, C.I., A.G. Ernst, and B.P. Baldigo. 2005. Regionalized equations for bankfull-discharge and channel characteristics of streams in New York State: hydrologic region 6 in the southern tier of New York. U.S. Geological Survey, SIR 2005-5100, Troy, NY.

(<http://ny.water.usgs.gov/pubs/wri/sir055100/sir2005-5100.pdf>)

Mulvihill, C.I., A.G. Ernst, and B.P. Baldigo. in press. Regionalized equations for bankfull-discharge and channel characteristics of streams in New York State: hydrologic region 7 in the Finger Lakes of New York. U.S. Geological Survey, SIR xxxx-xxx, Troy, NY.

Westergard, B.E., C. I. Mulvihill, A.G. Ernst, and B.P. Baldigo. 2005. Regionalized equations for bankfull-discharge and channel characteristics of streams in New York State: hydrologic region 5 in central New York. U.S. Geological Survey, SIR 2004-5247, Troy, NY.
(<http://ny.water.usgs.gov/pubs/wri/sir045247/>)

North Carolina

- Two-Dimensional and One-Dimensional Numerical Models for Bridges in North Carolina

The objectives of the proposed study are to (1) provide the NC DOT hydraulics unit a two-dimensional numerical modeling workshop to familiarize staff engineers with the process and techniques associated with two-dimensional modeling at bridges and (2) develop a one-dimensional step-backwater model and two-dimensional hydrodynamic model for an NCDOT selected riverine bridge and compare results to field data to evaluate the ability of each model to represent field conditions. This information will help to provide an initial basis for ongoing development (through additional modeling studies at other bridge sites across the state) of modeling guidelines that will ensure cost-effective hydraulic analysis.

- Maintain Flood Frequency Estimates and Information on the Web

Continuing flood frequency project with an objective to "produce, provide and maintain flood frequency estimates on the web". The project is currently focused on developing a GIS and Microsoft ACCESS database for 15,000 bridge crossings that will include lat/long, station number, drainage area, and a digital image of selected USGS data available at those sites. The information for the 15,000 bridge sites will be made web accessible in FY06.

North Dakota

- Operate and maintain 30 crest-stage gages
- Operate and maintain 1 streamflow gaging station
- Operate and maintain 1 lake gage

Ohio

- The final report was published for a long-term study of highway deicing chemicals and their effects on shallow ground water: Kunze, A.L., and Sroka, B.N., 2004, Effects of highway deicing chemicals on shallow unconsolidated aquifers in Ohio—Final report: U.S. Geological Survey Scientific Investigations Report 2004–5150, 187 p.
- A network of 18 crest-stage gages was operated in cooperation with ODOT and the Ohio Department of Natural Resources. The crest-stage gage data are being used to augment existing flood-frequency information available for Ohio.
- As part of a study to develop curves or equations for estimating bankfull depths and widths of natural streams, channel morphology and bed- and bank-material characteristics were measured at 50 stream sites in Ohio. Field data were analyzed and regionalized using a combination of graphical and statistical techniques, resulting in a set of regional curves and regression equations to estimate bankfull width, mean bankfull depth, bankfull cross-sectional area, and bankfull discharge. Using peak discharges from 40 of the sites located at streamflow-gaging stations, multiple-regression equations were developed to estimate flood-peak discharges from bankfull cross-sectional area for recurrence intervals ranging from 2 to 100 years. A report on the findings is in press (November 2005).
- Will begin program in the near future for developing and implementing StreamStats in Ohio.

Oklahoma

- Completed project in FY05: "Trends in Peak Flows of Selected Streams in Oklahoma". The objectives: document whether significant trends exist in the magnitude of annual peak flows and mean-annual flow; evaluate possible causes of the trends, to include analysis of trends in precipitation and water use; and document if these trends have a significant effect on flood magnitudes as indicated by flood-frequency analyses of selected streamflow sites.

Findings are documented in: Tortorelli, R.L., 2005, Trends in annual peak flows and mean annual flows of selected streams within and near Oklahoma, Scientific Investigations Report 2005-5192, 116 p.

- Building GIS coverages and developing necessary analytical protocols to adapt StreamStats for application in Oklahoma. This work began in July of FY2005 and will be completed in 4 years.

Oregon

- Initiated a project for estimation of streamflow characteristics using regression equations, including flow duration and low-flow, at ungaged sites for the entire state of Oregon. These coverages and equations will be implemented into Oregon StreamStats.
- Currently investigating existing bio-engineered sites at four gaging stations in Oregon to document how bio-engineered bank protection performs over a range of hydraulic conditions. The stage, discharge, and velocity information, combined with the covering, design and construction of the bio-engineered bank protection installations will assist in evaluating and improving current design procedures.

Pennsylvania

- Investigating the wetlands, riparian zones, and channel stability at Valley Creek and Saucon Creek. A database is being developed to store similar data for multiple sites with the anticipation of further data analysis as the database builds.
- Allegheny River channel hydraulics are being evaluated before and after pier replacement. Pier engineering involves an innovative design to protect substrate that serves as habitat for endangered mussels. A hydrodynamic model is being used as part of the evaluation.

South Carolina

- Operates 6 continuous-record gaging stations and 52 partial-record crest-stage stations.
- **Clear-water pier and contraction scour envelope curves**

In October 2002, the USGS and SCDOT began a cooperative program to investigate clear-water pier and contraction scour in the Piedmont and Coastal Plain of South Carolina. Data were collected at 116 bridges and measured scour was compared with selected predictive equations. Envelope curves for evaluating potential clear-water pier and contraction scour in the Piedmont and Coastal Plain were developed. The findings of the investigation are presented in the following report which will be released online in early 2006:

Benedict, S.T., and Caldwell, A.W., 2006, Development and evaluation of clear-water pier and contraction scour envelope curves in the Coastal Plain and Piedmont Provinces of South Carolina: U.S. Geological Survey Scientific Investigations Report 2005-5289.

- **Live-bed pier and contraction scour envelope curves**

In October 2005, the USGS and SCDOT began a cooperative program to investigate live-bed pier and contraction scour in the Piedmont and Coastal Plain of South Carolina. A primary objective of this investigation is to develop field-derived envelope curves for live-bed pier and contraction scour in the Piedmont and Coastal Plain. The live-bed scour envelope curves combined with the previously developed clear-water scour envelope curves will allow an evaluation of all scour components at bridges in these regions without sole reliance on theoretical equations derived from laboratory investigations.

The purpose and objectives of this project include (1) the documentation of historic occurrences of live-bed pier scour and contraction scour at approximately 80 bridges in the Piedmont and Coastal Plain of South Carolina using ground penetrating radar; focus will be given to old bridges and bridges that have had large floods; (2) a comparison of observed scour with predicted scour in order to assess the scour prediction methods of HEC-18; (3) the investigation of various physical relations that may help explain live-bed scour processes in South Carolina, and (4) if possible, the development of envelope curves for evaluating the potential for live-bed pier and contraction scour in South Carolina. Data have been collected at 26 bridges, and hydraulic models and scour analysis are being made at these sites. Data collection and analysis for the remaining sites will take place in FY06 and FY07.

- **Trends in abutment-scour prediction equations**

The U.S. Geological Survey, in cooperation with the Federal Highway Administration, compared predicted abutment-scour depths for selected equations with field measurements of abutment-scour collected at 144 bridges in South Carolina. Additionally, soil erosion rates based on the EFA were determined at 5 sites. Data from this investigation have been compiled into electronic spreadsheets for use by other researchers. The findings of the investigation are presented in the following report which will be released online in late 2006:

Benedict, S.T., Deshpande, N., Aziz, N.M., and Conrads, P.A., 2006, Trends of abutment-scour prediction equations applied to 144 field sites in South Carolina: U.S. Geological Survey, Open-File Report 03-295.

- **Rural flood frequency investigation**

The USGS in cooperation with the SCDOT will begin a rural flood frequency investigation in 2006. The objectives of this investigation are to update the magnitude and frequencies of peak streamflows of unregulated and regulated streams in South Carolina, when adequate data are available. The South Carolina Water Science Center will coordinate with the Georgia and North Carolina Water Science Centers to establish consistent physiographic regions at the state boundaries and will also seek to establish consistent explanatory variables and (or) regional equations at the state boundaries. The project will result in updated regional rural-flood-frequency equations for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals.

- **Performance of four best management practices for highway runoff**

In June 2004, the U.S. Geological Survey and the SCDOT began a cooperative investigation to collect water-quality data to be used to assess the performance of four Best Management Practices (BMP) for highway runoff in Beaufort and Colleton Counties. This investigation has four objectives: (1) determine event-mean concentrations, (2) calculate loads entering and leaving the BMPs, (3) estimate the removal efficiency of the commercially available BMPs for selected constituents such as suspended sediment, metals, oil and grease, and fecal indicator bacteria in roadway runoff, and (4) evaluate the relation between water-quality constituent concentrations and loads to average daily traffic data by correlation analysis. To reduce uncertainty in the removal efficiency estimation and average daily traffic correlation evaluation, a data set of 12 to 15 sampling events will be used.

South Dakota

- Operate a network of 48 crest-stage gages for the purpose of peak flow analysis
- Work is continuing on updating peak-flow frequency estimates for gaged streams in the state. Analyses for most stations have been completed and results are under review by DOT staff. A joint-probability approach is being utilized to resolve complexities in the Black Hills area associated with high outliers for many sites that resulted from a particularly large storm in 1972.
- Work is continuing on a multi-year study initiated in 2003 to evaluate scour potential at bridges on primary highways using a combination of Level 1.5 and Level 2 analyses. Level 1.5 analyses have been completed for about 80 percent of the primary bridges in the state. Efforts during 2006 will shift primarily to performing Level 2 analyses at selected sites, with a focus on sites where Level 1.5 results indicate potentially scour-critical conditions may occur.
- Implementation of Streamstats in South Dakota was initiated in 2005 and will continue through 2008. An important initial activity has been formation of a statewide steering committee that will help guide decisions regarding utilization of existing geospatial information, and possible procurement of additional, relevant geospatial information.
- A reconnaissance study is being initiated to evaluate the potential of using paleoflood hydrology techniques to improve flood-frequency estimates for the Black Hills area through extension and extrapolation of existing peak-flow records. The initial phase will focus on evaluating the utility of paleoflood surveys for estimating magnitudes and ages of historical peak-flow events. Implementation of subsequent phases would include more detailed application of field surveys and performing appropriate analytical procedures for developing flood-frequency relations.

Tennessee

- Providing hydraulic interpretative support and miscellaneous flood-measurement support to Tennessee Department of Transportation (TDOT) as needed.
- Operating an ongoing network of 40+ crest-stage gages at or near highway crossings and operating another 15 stage-discharge gages across the state for the purpose of flood-frequency analysis and general resource evaluation.
- Routinely updating basin characteristics files and statewide flood-frequency equations for ungaged streams in Tennessee. Our most recent update was based on the region-of-influence statistical model and was completed in FY 2003.
- Continuously monitoring turbidity and relating turbidity to sediment concentrations on a stream in West Tennessee. This was initiated in FY2004.

- Large-scale study of the effects of highway construction on stream ecology throughout Tennessee—looking specifically at sediment export from disturbed areas, the efficiency of sediment control structures (EPSCs) at construction sites, sediment transport processes, the effects of sediment on downstream habitat and biotic communities, and improved methods for monitoring sediment-related effects. This work began in FY2004 and should continue through FY2012.
- Building GIS coverages and developing necessary analytical protocols to adapt Streamstats for application in Tennessee. This work began in January of FY2004 and will be completed in 2006.

Texas

- **Bed mobility in Edwards Plateau, Central Texas (FY06-07): ON-GOING**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project funded by the Texas Department of Transportation to investigate gravel transport phenomena within the Plateau. Gravel transport within high gradient streams is contributing to recurring infrastructure damage in the study area. The Department hopes that the research will contribute to enhanced design guidance on bridges and low-water crossings. The primary USGS focus will be on spatial documentation of gravel transport through imagery and field investigations. Contact Frank T. Heitmuller (ftheitmu@usgs.gov) for further information.

- **Storm statistics for Texas (FY05-06): ON-GOING**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project extended from the completed hyetograph project to document the distribution of storm depth, storm duration, and storm arrival rates throughout eastern New Mexico, Oklahoma, and Texas for selected values of minimum inter-event time ranging from 6 to 72 hours. A total of 774 National Weather Service hourly rainfall stations having 155 million values of data were processed. A report is forthcoming. Contact William H. Asquith (wasquith@usgs.gov) for further information.

- **Unit hydrographs for Texas (FY00-07): ON-GOING**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project funded by the Texas Department of Transportation to investigate the timing characteristics for unit hydrographs on small to moderately sized rural and urban watersheds in Texas. Unit hydrographs for 93 watersheds in Texas have been estimated through a myriad of techniques including linear programming, instantaneous unit hydrograph, and gamma distribution fitting to peak and time to peak values. The project has been on going for many years and several publications are completed or in progress. The project has rainfall and runoff data for a total of 3,018 storms from 229 watersheds in Texas. This data resides in ASCII files and under version control.

Asquith, W.H., Cleveland, T.G., Xing, Fang, Thompson, D.B., 2006, Unit hydrograph estimation for applicable Texas watersheds: Texas Department of Transportation Research Report 0-4193-4, Center for Multidisciplinary Research in Transportation, Texas Tech University, [approved by TxDOT and through USGS colleague review].

Asquith, W.H., Thompson, D.B., Cleveland, T.G., and Fang, Xing, 2004, Synthesis of rainfall and runoff data used for Texas Department of Transportation Research Projects 0-4193 and 0-4194: U.S. Geological Survey Open-File Report 2004-1035, 1,050 p.

Asquith, W.H., and Roussel, M.C., 2003, Atlas of inter-occurrence intervals for selected thresholds of daily precipitation in Texas: U.S. Geological Survey Water-Resources Investigations 03-4281, 204 p.

Cleveland, T.G., He, Xin, Asquith, W.H., Fang, Xing, and Thompson, D.B., 2006, Instantaneous unit hydrograph selection for rainfall-runoff modeling of small watersheds in North and South Central Texas: ASCE Journal of Irrigation and Drainage, [accepted and in the production queue].

- **Timing Parameters of Hydrograph (FY04-05): COMPLETED**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project funded by the Texas Department of Transportation to investigate the timing characteristics for runoff hydrographs on small to moderately sized rural and urban watersheds in Texas. This project was built on the foundation laid by an on-going unit hydrograph research project and a now-completed rainfall hyetograph project. The major publication from the timing project is

Roussel, M.C., Thompson, D.B., Fang, Xing, Cleveland, T.G., and Garcia, C.A., 2005, Timing-parameter estimation for applicable Texas watersheds: Texas Department of Transportation Research Report 0-4696-2, Lamar University, Beaumont, Texas, 28 p.

In brief, the authors conclude that the Kerby (1959) [overland flow] and Kirpich (1940) [channel flow] methods are preferable for time of concentration estimation in Texas. Contact Meghan C. Roussel (mroussel@usgs.gov) for further information.

- **Rainfall Hyetographs (FY00-04): COMPLETED**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project funded by the Texas Department of Transportation into rainfall hyetographs for small watersheds and from a 155 million value NWS rainfall data base. The project also investigated the distribution of storm depth across Texas. The project was successfully completed and several reports were produced. Contact William H. Asquith (wasquith@usgs.gov) for further information.

Asquith, W.H., Roussel, M.C., Thompson, D.B., Cleveland, T.G., and Fang, Xing, 2005, Summary of dimensionless Texas hyetographs and distribution of storm depth developed for Texas Department of Transportation Research Project 0-4194: Texas Department of Transportation Research Report 0-4194-4, Center for Transportation Research, University of Texas at Austin, 68 p.

Williams-Sether, T., Asquith, W.H., Thompson, D.B., Cleveland, T.G., and Fang, Xing, 2004, Empirical dimensionless, cumulative-rainfall hyetographs developed from 1959-86 storm data for selected small watersheds in Texas: U.S. Geological Survey Scientific Investigations Report 2004-5075, 125 p.

- **Hydrologic Scale (FY03-05): COMPLETED**

The SW research group with Texas Water Science Center is engaged with Texas Tech University in a project to evaluate the performance of various hydrologic methods (rational, unit hydrograph, regional regression equations) at a variety of watershed scales (drainage area). The major contribution of the USGS to the project is summarized in the following report. Contact William H. Asquith (wasquith@usgs.gov) for further information.

Asquith, W.H., and Thompson, D.B., 2005, Alternative regression equations of estimation of annual peak-streamflow frequency for undeveloped watersheds in Texas using PRESS minimization: Texas Department of Transportation Research Report 0-4405-2, Center for Multidisciplinary Research in Transportation, Texas Tech University, 27 p.

In brief, the authors conclude that bias exists in historical USGS regional regression equations for peak-streamflow frequency estimation because of remaining curvilinearity between discharge and drainage area even in log-space. This bias can be removed by an alternative transformation, which is determined through minimization of the PRESS statistic. This report reduces the 96 current regional equations for Texas to six with a modest increase in standard error.

- **Small Watershed Gaging Program: (FY06-10, and three more 5-year increments)**

The Texas Department of Transportation and the USGS are initiating a program to install 50 crest-stage gages for flood-peak recording on small watersheds in western Texas. Ten of these gages will have autonomous stage and rainfall recording for production of rainfall and runoff data sets. Three of the gages will also be operated as continuous real-time gages. Long-term data collected at these gages will be used for flood frequency analysis.

Utah

- Recently completed a multi-year cooperative investigation with UDOT to monitor and assess the performance of A-Jacks scour countermeasures at two bridge sites. The report titled "Hydraulic and geomorphic monitoring of experimental bridge scour mitigation at selected bridges in Utah, 2003-05" is in press and should be published by the end of January 2006.
- Began a multi-year cooperative project with UDOT to update the National Flood Frequency equations for the state of Utah. In conjunction with this update, the USGS StreamStats program will be implemented for the state of Utah. StreamStats is a web-based GIS model user interface that allows for immediate point and click catchment delineation and regression model calculation.

Vermont

- Vermont Agency of Transportation (VTrans) is currently funding a crest-stage gage network.
- VTrans is funding two streamgaging stations (Potash Brook in South Burlington, VT and Allen Brook in Williston, VT) for continuing research of storm water management on small urban streams.
- A cooperative investigation between VTrans and the USGS began in 2005. The first phase of this study was designed to assess the current knowledge of road deicing effects in the New England region, evaluate how deicing practices in Vermont have changed during the past 20 years, and describe levels of chloride and other salt components in Vermont's surface waters. Based on findings of this effort, research will be designed and conducted during the project second phase, currently under way, to evaluate deicing impacts on Vermont stream-water quality.

Virginia

- Continuation of Simulation of Flood Hydrographs for Small Drainage Basins in Virginia

The objectives of the study are to evaluate existing methods used by VDOT to estimate flood hydrographs from small drainage basins, and evaluate the use of dimensionless hydrographs to estimate runoff volumes. Annual peak-flow data will be used to for a flood frequency analysis.

- Continuation of Basin Boundary Delineation and Annual Flood Peaks of Streams in Virginia

The objectives of the study are (1) to develop digital basin boundaries at approximately 550 current and historic surface-water gaging stations, (2) to update annual flood-peak data for these gages in preparation for a flood frequency analysis study, and (3) to collect annual peak flow data at the 6 remaining small basin sites for future flood frequency analysis.

- Maintain and operate a network of 45 crest-stage gages to determine annual peak flows, document extreme flow events, and improve flood frequency estimates.

Washington

- In FY04 and 05, the USGS, in cooperation with the Washington State Department of Transportation, operated a streamflow gage on the Skagit River downstream from a rockslide that occurred in November 2003. The purpose of the gage was to provide early warning in the unlikely event of a second rockslide damming the river. With no additional movement of the slide occurring, the gage was discontinued in FY06.

West Virginia

- Operates and maintains 20 crest stage gages.
- Provides some funding for operation and maintenance of streamflow-gaging stations.

- Collection of stream geomorphic data in the Appalachian Plateaus physiographic province at USGS streamflow-gaging stations and some ungaged locations.
- Recent publications:

Keaton, Jefferson N., Messinger, Terence, and Doheny, Edward J., 2005, Development and analysis of regional curves for streams in the Valley and Ridge physiographic province, Maryland, Virginia, and West Virginia: U.S. Geological Survey Scientific Investigations Report 2005-5076, 109 p.

This report is available at <http://pubs.usgs.gov/sir/2005/5076/>

Wisconsin

- A report describing bridge scour monitoring activities was recently completed. The reference for the final report is:

Walker, J. F., and Hughes, P.E., 2005, Bridge Scour Monitoring Methods at Three Sites in Wisconsin: U. S. Geological Survey Open-File Report 2005-1374, 8 p.

- A network of about 90 crest-stage gages will continue to be operated in cooperation with WisDOT to provide on-going peak-flow data for flood-frequency information and analysis.
- Completed GIS determination of basin outlines for stations contained entirely within Wisconsin; working on stations that cross state boundaries. Plans are to determine basin characteristics using GIS techniques.
- Completed review of flood frequency literature. Currently investigating alternatives for frequency analysis and regionalization. Plans are to update three regression equations using GIS-based basin characteristics. Revised report will be printed in FY2007.
- Currently investigating use of the StreamStats application, which allows for automated determination of basin characteristics and flood frequency analysis for ungaged sites.
- Evaluation of Storm Water Treatment Technologies for Highway Runoff: Comparing Structural BMPs at Milwaukee's Historic Third Ward River Walk and I-794 Freeway Test Site -The Wisconsin Department of Transportation (WisDOT) is required to improve the quality of runoff from roadways under their control as part of the National Pollution Discharge Elimination System (NPDES) and an agreement with the Wisconsin Department of Natural Resources (WDNR). In addition, future state and federal regulations will prescribe new performance standards for non-point runoff management and calculation requirements for total maximum daily loads (TMDLs) of contaminants discharging in watershed basins.

One way to improve the quality of roadway runoff, particularly in urban areas, is to use structural Best Management Practices (BMPs). There are several commercially available BMPs that could be used, but these new technologies lack field performance testing and validation, especially in Wisconsin type climates. So it is essential to field test these devices to determine their contaminant removal efficiency and practical application for WisDOT.

This study is funded by the National Cooperative Highway Research Program and is being conducted by the WisDOT in cooperation with the U.S. Geological Survey. The objective of this study will evaluate two structural BMPs to determine their removal efficiency.

Data collection and analysis is complete and a final report will be available in 2006.

- Pollutant Loadings to Storm Water Run-Off from Highways: The Impact of a Highway Sweeping Program-Phase II - This study is in cooperation with the National Cooperative Highway Research Program and is being conducted by the WisDOT in cooperation with the U.S. Geological Survey. The study site is located on USH 151 near IH 90/94/39, in Madison WI. The objective of this study is a continuation of a previous highway sweeping study that will evaluate the effectiveness of a highway-sweeping program as a best management practice (BMP) for reducing pollutant levels. Phase II would address the data collection and analysis issues that occurred during the Phase I study by using new technology for monitoring and calibrating flow, eliminating freeway median area, improved sample processing and change in laboratory procedures for particle size distribution.

Phase I Report

Waschbusch, R.J. 2003, Data and Method of a 1999-2000 Street Sweeping Study on an Urban Freeway in Milwaukee County, Wisconsin, U. S. Geological Survey Open file Report 03-03, 41P.

- Evaluation of Storm Water Treatment Technologies for Parking-lot Runoff.
The Wisconsin Department of Transportation (WisDOT) has a Cooperative Agreement with the Wisconsin Department of Natural Resources (WDNR) (November 2002), Trans401 (December 2002), and NR 216 (September 2002), that require the Department to establish a Storm water Management program to reduce Total Suspended Solid (TSS) loading from highway surfaces. The regulations require the Department evaluate and assess best management practices (BMPs). This study is made possible by a partnership with the Madison Gas and Electric Company (MG&E), United States Geological Survey (USGS), Stormwater Management Inc., and the Wisconsin Department of Natural Resources (WDNR). The site is a parking lot located in downtown Madison, WI at the MG&E facilities plant and the BMP to be evaluated is gravity filtration.

This study would complement research just completed on a filtration BMP called the StormFilter (Evaluation of Storm Water Treatment Technologies for Highway Runoff, under the direction of Bob Pearson, WDOT). The StormFilter was evaluated using runoff from Highway 794 in Milwaukee. A 45 percent reduction in TSS loads was observed for the 15 storms used for the evaluation. Before these results are applied to other highways or DOT facilities, such as park and rides, maintenance yards and rest areas, it must be determined if the findings are unique to the characteristics of the runoff from elevated freeways.

Data collection is continuing and a final report is scheduled to be available in 2007.

Wyoming

- No highway related projects at this time.