in areas adjacent to the channel. Results from winter 2001/02 suggested that there may be differences in sediment yield among geologic substrates, with the Wildcat having relatively low sediment yield values. Treatment effects were significantly different (ANOVA, $p < 0.05$) when two large landslides were removed from the control sites; the HCP sites had significantly lower sediment yield. There was also a significant interaction between treatment and geologic substrates (ANOVA, $p < 0.05$). Control sites had sediment yield comparable to the pre-HCP treatment sites. The apparent treatment effect on sediment yield may be influenced by the fact that the HCP treatment sites have experienced only one or two post-harvest winters, while the pre-HCP treatment sites experienced relatively severe winters over a longer post-harvest period. In addition, the fact that the control sites tended to have higher sediment yield than the HCP treatment sites suggests that legacy effects of management may also be an important factor.

H41F MCC: Level 2 Thursday 0830h

Nitrogen Sources and Cycling in Aquatic Systems I Posters *(joint with B, OS)*

Presiding: **C Kendall,** U.S. Geological Survey**; R B Alexander,** U.S. Geological Survey**; E W Boyer,** State University of New York

H41F-1048 0830h POSTER

Water-Quality Trends in the Neuse River Basin, North Carolina, 1974-2003

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Data from two U.S. Geological Survey (USGS) sites in the Neuse River basin were reviewed for trends in major ions, sediment, nutrients, and pesticides during the period 1974-2003. In 1997, the North Carolina Division of Water Quality implemented management rules to reduce nitrogen loading to the Neuse River by 30 percent by 2003. Therefore, the 1997-2003 period was reviewed for trends associated with the management changes. The Neuse River at Kinston basin (2,695 square miles) includes much of Raleigh, N.C., with 8-percent urban and 30-percent agricultural land use (1992 data). The Contentnea Creek basin (734 square miles), a Neuse River tributary, is 42-percent agricultural and 3-percent urban. Agricultural land uses in the Contentnea Creek basin have changed over the last decade from predominantly corn, soybean, and tobacco row crops to corn, soybeans, and cotton, with reduced tobacco acreages, and development of the hog industry. Data for this analysis were collected by the USGS for the National Stream Quality Accounting Network and National Water-Quality Assessment Program. Data were examined for trends using the Seasonal Kendall trend test or Tobit regression. The Seasonal Kendall test, which accounts for seasonal variability and adjusts for effects of streamflow on concentration with residuals from LOWESS (LOcally Weighted Sum of Squares) curves, was used to analyze trends in major ions, nutrients, and sediment. The Tobit test, appropriate for examining values with reporting limits, was used for the pesticide analysis. Monotonic trends are considered significant at the alpha < 0.05 probability level. Long-term (1974-2003) decreasing trends in the Neuse River at Kinston were detected for dissolved oxygen, silica, and sediment concentrations; increasing trends were detected for potassium, alkalinity, and chloride. Decreasing trends in Contentnea Creek were detected for silica, sulfate, and sediment concentrations during 1979-2003; increasing trends were detected for pH, hardness, and alkalinity. A pattern of increase until 1990 followed by little change or decline was observed for specific conductance, dissolved solids, hardness, and sulfate in the Neuse River and for potassium in Contentnea Creek. No significant recent (1997-2003) trends were detected for dissolved oxygen, pH, specific conductance, hardness, dissolved solids, or major ions. The Neuse River data indicated a recent declining trend in sediment concentration. Nitrogen concentrations in the form of ammonia, total ammonia and organic nitrogen, and nitrite plus nitrate have declined in both the Neuse River and Contentnea Creek. Total nitrogen concentrations increased in the Neuse River until about 1990 and then declined, primarily because of declines in nitrate. Recent declines are evident in nitrite plus nitrate in the Neuse River and in ammonia concentrations in Contentnea Creek. The data also show a reduction in variation of extreme values after 1990 in Contentnea Creek. Both observations suggest that the 1997 Neuse River management rules have had a detectable effect on nitrogen concentrations. Concentrations of dissolved and total phosphorus and orthophosphate reduced in a step trend in 1988 at both locations. This reflects the 1988 phosphate detergent ban in North Carolina. Orthophosphate concentrations have continued a recent decline in Contentnea Creek. Contentnea Creek has sufficient period of record (1994-2003) of concentrations of atrazine, deethyl atrazine, alachlor, carbaryl, diazinon, and prometon to test for trends. Both alachlor and prometon concentrations showed significant declines. Recent changes in agricultural practices coupled with a 5-year drought probably have affected pesticide use and transport to surface waters.

H41F-1049 0830h POSTER

Submarine Groundwater Discharge and Associated Nitrogen Flux in Coral Reef Lagoons of Mauritius

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Recent eutrophication in several coral reef lagoons along the Indian Ocean island nation of Mauritius (20°S, 57°E) has highlighted the need for a greater understanding of nutrient sources to these lagoon waters. Submarine groundwater discharge (SGD) into the coastal environment is one possible transport mechanism for excess terrestrial nutrients to coral reef lagoons, since groundwater nitrate levels are an order of magnitude greater than coastal nitrate levels (330 and 30 μM respectively). However, the direct discharge of groundwater into the sea has been difficult to measure, because fluxes may be episodic and patchy in distribution. Here we utilize radium isotopes (224Ra and 223Ra), which desorbs from aquifer sediments when fresh water and salt water interact within the coastal aquifer, as naturally occurring SGD tracers. Given the positive correlations between radium activities, salinity and nitrate concentrations found in the lagoon waters of Mauritius, it is apparent that SGD is a source of nitrate to the coastal lagoons. Based on mass balance of 223Ra activities, submarine groundwater flux per meter of coastline is 116 m3/m along the west coast and more than twice as great on the east coast (323 m3/m). The nitrogen loading associated with SGD in the east coast lagoon (0.28 g N/m3) is likewise twice that in the west coast (0.14 g N/m3). Regions of the east coast lagoon have recently experienced eutrophication, while the west coast has not experienced significant algal blooms, suggesting that the nitrogen loading along the east coast may be negatively impacting the health of the coral reef lagoon. Given the sensitivity of the marine environment to excess nutrients and the potential groundwater transport of such nutrients far from their source, there is a clear need for greater understanding of groundwater nutrient transport to the lagoons of Mauritius.

H41F-1050 0830h POSTER

Tracing Nitrate Contributions to Streams During Varying Flow Regimes at the Sleepers River Research Watershed, Vermont, USA

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Quantifying sources and transformations of nitrate in headwater catchments is fundamental to understanding the movement of nitrogen to streams. At the Sleepers River Research Watershed in northeastern Vermont (USA), we are using multiple chemical tracer and mixing model approaches to quantify sources and transport of nitrate to streams under varying flow regimes. We sampled streams, lysimeters, and wells at nested locations from the headwaters to the outlet of the 41 ha W-9 watershed under the entire range of flow regimes observed throughout 2002-2003, including baseflow and multiple events (stormflow and snowmelt). Our results suggest that nitrogen sources, and consequently stream nitrate concentrations, are rapidly regenerated during several weeks of baseflow and nitrogen is flushed from the watershed by stormflow events that follow baseflow periods. Both basic chemistry data (anions, cations, & dissolved organic carbon) and isotopic data (nitrate, dissolved organic carbon, and dissolved inorganic carbon) indicate that nitrogen source contributions vary depending upon the extent of saturation in the watershed, the initiation of shallow subsurface water inputs, and other hydrological processes. Stream nitrate concentrations typically peak with discharge and are higher on the falling than the rising limb of the hydrograph. Our data also indicate the importance of terrestrial and aquatic biogeochemical processes, in addition to hydrological connectivity in controlling how nitrate moves from the terrestrial landscape to streams. Our detailed sampling data from multiple flow regimes are helping to identify and quantify the "hot spots" and "hot moments" of biogeochemical and hydrological processes that control nitrogen fluxes in streams.

H41F-1051 0830h POSTER

Septic Nitrate Contamination of Multiple Municipal Wells: Trends and Remedial Efforts

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Fifteen years of groundwater quality monitoring in the Spanish Springs Valley, Nevada, have shown increasing levels of nitrate in municipal wells. Three of the six municipal wells have nitrate concentrations just under the U.S. EPA MCL of 10 mg/L. More than 2,000 homes on septic sewage disposal systems are located within a four square-mile area - with almost half of these systems within 2,000 feet of one or more of the municipal wells. A 1999 USGS study concluded that increasing nitrate levels can be linked to local septic systems. This study, completed in January 2003, is a preliminary step to define the lateral and vertical extent of nitrate contamination in the valley and identify the vertical mixing zone of the pollutant. The preliminary conceptual model of contaminant migration was confirmed by the study. Although a discontinuous clay aquitard is acting to slow vertical migration of contamination, the combination of numerous septic systems and their proximity to shallow-screened, high-volume municipal wells, leads to the present situation. Concentrations of nitrate in groundwater collected from all existing shallow monitor wells were above the MCL, with a maximum concentration greater than three times the MCL. In addition, concentrations of nitrate in groundwater collected from deeper wells within the assumed plume were elevated as compared to background concentrations.

H41F-1052 0830h POSTER

Nutrient Uptake and Cycles of Change: the Ventura River in Southern California

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Watersheds in Mediterranean climates are characterized by extreme seasonal and inter-annual rainfall variability. This variability engenders cycles of sediment deposition and removal, algal growth, and the advance and retreat of riparian and aquatic vegetation. In turn, these changes dramatically alter the appearance and biological functioning of rivers and streams, regulating the uptake of nutrients. The Ventura River drains 580 sq. km of mountainous coastal watershed 100 km northwest of Los Angles, Ca. More than 90 % of the average annual rainfall of 500 mm falls between December and March with most of the annual runoff occurring within a few days. Since 1930, annual runoff has varied from 0.01 to 70 cm/ha, with a mean of 12 and median of 4 cm. We have been measuring dissolved nutrient concentrations at four locations on the lower 9 kilometers of the river for the past 3 years (annual runoff of 19, 0.6 and 14 cm, respectively) and quantifying the relative abundance of plants and

algae during 2003. A subsequent decrease in nutrient concentrations below a treated sewage outfall at km 8 provides estimates of nutrient uptake under changing conditions. Nitrate concentrations on the river peak in early winter, presumably from mineralization and mobilization after the advent of the rainy season, and decrease to a minimum by late summer. Phosphate, controlled by dry-season treatment plant outflows, has an opposite pattern. The seasonal variation in both is considerable (0 to 380 microM for nitrate, 0 to 35 microM for phosphate). Major winter storms, such as occur during severe El Nino years (peak flows > 1000 cms), begin a transformational cycle by completely scouring the channel of vegetation and fine sediment; this occurs, on average, once every 10 to 12 years (the interval has varied from 3 to 30 years). The scoured channel, with warmer water temperatures, the absence of shade and a nutrient rich environment, becomes dominated by filamentous algae (principally Cladophora, Rhizoclonium, Enteromorpha and Spirogyra spp.). In contrast, drought years occasion exuberant plant growth and the competitive replacement of algae by aquatic vegetation. Absent scouring winter flows, perennial aquatic plants become established, trapping fine sediment and narrowing the wetted channel; the rapid growth of riparian vegetation (Arundo donax and Salix spp.) provides increased shade to the narrowed waterway. These processes increasingly stabilize the channel and elevate the threshold flow of a scouring storm; the major storm of 2003, following the 2002 drought year (peak flow of 5 cms), produced appreciably less channel transformation than a similarly-sized storm in 2001 (peak flow of 500 cms). During the 2002 drought year, dry-season nitrate concentrations at the river mouth were reduced to near zero, likely due to reduced flows, extensive vascular plant growth supporting high rates of denitrification and vegetative uptake, and enhanced sediment processes from increased fine sediment entrapment. Higher nitrate concentrations at the same location in 2003 (circa 60 microM) exhibited a 3-fold increase compared with 2001, an algal dominated year with a similar flow regime, and N uptake below the treatment plant appears to be substantially decreased.

H41F-1053 0830h POSTER

Stochastic Assessment of Regional Groundwater Nonpoint Source Pollution with Spatially Variable, Transient Forcing: Conceptual Framework and Nitrate Case Study

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We introduce a general stochastic concept of regional groundwater nonpoint source pollution in production wells or other groundwater discharge areas; present an efficient numerical procedure for its implementation; and validate the approach using a case study. Our principal hypothesis is that regional variability of and uncertainty about well pollution from nonpoint sources is primarily caused by the spatio-temporal variability of the nonpoint source strength (recharge rate and recharge pollutant concentration) and the variable spatial distribution of pumping wells, pumping rates, and other groundwater discharge relative to the location of the nonpoint sources. We describe a conceptual model of random space functions (RSFs) for nonpoint sources and wells. The resulting stochastic flow and transport equations are subject to random forcing in the nonpoint source and pumping boundary conditions (external variability). The stochastic forcing analysis yields a transient probability distribution function of water quality (water quality pdf) in a regional set of randomly distributed, discrete production wells and other groundwater discharge areas. We introduce a novel three-step numerical approach for the stochastic forcing analysis and apply the method to determine the 150-year (1910-2060) nitrate pdf for an irrigated, semi-arid region with a history of high groundwater nitrate. Comparison of the simulated nitrate pdfs with results from regional and domestic well water surveys in 1970, 1986 and 2001 shows that stochastic forcing indeed accounts for the observed temporal nitrate dynamics (mean concentration) and for 70% of the spatial variability observed in domestic well water nitrate in that region.

URL: http://groundwater.ucdavis.edu

H41F-1054 0830h POSTER

Nutrient Transformations in Soils Under Aerobic and Anaerobic Conditions

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Poultry litter is most commonly land applied as a fertilizer for pastures. Soils vary according to landscape position and the biogeochemistry changes within the soils depending on the landscape position. This research focuses on nutrient speciation in aerobic and anaerobic environments. A 3.4 kg Ha-1 chicken litter application rate was used to determine the speciation of nutrients in these two environments. A 50 g sample of Ruston soil was placed in 250 mL centrifuge tubes and continuously stirred in anaerobic and aerobic environments. The Eh and pH were measured daily and a sample was collected at 0, 3, 7, 14 and 21 days. The Eh decreased from around 600 mV at day 0 to near 100 at day 2; whereas the aerobic sample had a decrease to around 450 mV. The pH increased from 6.5 to 7.0 in the anaerobic soil and from 6.5 to around 8.0 in the aerobic soil. The anaerobic soils had a rapid decrease in NO3- and a sharp increase in NH4+ to around 100 mg NH4+ kg-1 soil at day 7. The aerobic soil had an increase in NH4+ to 70 mg Nh4+ kg-1 soil at day 7 then decrease in NH4+ with a corresponding increase in NO3-. Both the anaerobic and aerobic soil had a rapid decrease in PO42- concentrations and remained low for 21 d.

H41F-1055 0830h POSTER

Predicting Groundwater Nitratre Concentration from Land Use in Nantucket, Massachusetts

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Ground water nitrate concentrations on Nantucket Island, Massachusetts were analyzed to assess the effects of land use on ground water quality. Exploratory data analysis was applied to historic ground water nitrate concentrations to determine spatial and temporal trends. Maximum likelihood Tobit and logistic regression analyses of explanatory variables that characterize land use within a 1000-foot radius of each well were used to develop predictive equations for nitrate concentration at 69 wells. The results demonstrate that historic nitrate concentrations downgradient from agricultural land are significantly higher than nitrate concentrations elsewhere. Tobit regression results demonstrate that the number of septic tanks and the percentages of high-density residential, undeveloped and forestland within a 1000-foot radius of a well are reliable predictors of nitrate concentration in ground water. Similarly, logistic regression revealed that the percentages of forest, undeveloped and low-density residential land are good indicators of ground water nitrate concentration greater than 2 mg/L. The methodology and results outlined here provide a useful tool for land managers in communities with shallow water tables overlain with highly permeable materials to evaluate potential effects of development on ground water quality.

H41F-1056 0830h POSTER

Stream Restoration Projects: Effects on Stream-Subsurface Water Interactions and Nitrate Dynamics

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Stream channel restoration has become a common practice in management of degraded lowland streams. This study examined the effects of various scales of restored channel features, such as steps, riffles, gravel bars and channel meandering on stream-subsurface water interactions (hyporheic exchange) and nitrate dynamics in streams near Toronto, Canada. The hyporheic zone was delineated using background stream and groundwater chloride concentrations and injected bromide tracer. The extent of hyporheic zone was dependent on the size of channel features, and the amount of hyporheic exchange was strongly influenced by saturated hydraulic conductivity. We observed penetration of stream water 0.1- 0.15 m into the streambed under a small constructed riffle, whereas stream water advection to a depth of 0.8 m was observed under a large constructed riffle. Stream water was a source of nitrate for the hyporheic zone at all study sites. As stream water enters the streambed, a steep decline in nitrate concentration occurred along the initial portion of the hyporheic flow paths. These patterns indicate that examined restored channel features increases stream-subsurface water interactions, and the hyporheic zone functions as a nitrate sink in these streams.

H41G MCC: 3022 Thursday 1020h

Form, Process, and Climate in Landscape Evolution II

Presiding: **D J Furbish,** Florida State University**; A D Howard,** University of Virginia

H41G-01 1020h INVITED

The Influence of the Grain Size Distribution of Sediments Supplied by Hillslopes on Rates of River Incision Into Bedrock and Steady-State Longitudinal Profile Form

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At the time-scale of landscape evolution, hillslope and channel erosion are strongly coupled through both the channel's role as baselevel for hillslope lowering and the hillslope's role in supplying sediments to the channel network. Here we use an experimentally-calibrated, process-specific model for fluvial incision into bedrock by saltating bedload to investigate the sensitivity of river longitudinal profile concavity and relief to the grain size distribution of sediments entering the fluvial system. We focus on the limited but illustrative case of topographic steady-state. Grain size strongly affects predicted incision rates, and thus steady-state profile form, by influencing the number and erosional efficiency of individual bedload impacts and the extent of bedrock exposure in the channel bed. The fraction of the total sediment load that moves as bedload depends on the initial grain size distribution as well as the rate of downstream particle comminution. Over a wide range of rock strength and uplift rates the model predicts that profile relief and concavity are most sensitive to bedload grain size and the downstream rate of change in coarse sediment grain size respectively. Rock strength and uplift rate have surprisingly modest influence on steady-state profile relief and concavity, in the absence of any modeled dependence of grain size on these variables. However, the grain size distribution of sediments produced by hillslope weathering and transport is likely to be influenced by bedrock lithology and rates of landscape denudation, and perhaps most importantly by climate. We use simple speculative relationships to quantify some of these linkages, and find that their effects on the grain size distribution produced by hillslopes may provide an essential yet indirect avenue for rock strength, rock uplift rate and climate to influence steady-state profile form.

H41G-02 1035h

Chemical Denudation, Hillslope Morphology, and Long Term Persistence of Unchanneled Valleys

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