PROGRAMS & ABSTRACTS

ROCKY MOUNTAIN HYDROLOGIC RESEARCH CENTER
47TH ANNUAL MEETING

ENVIRONMENTAL STUDIES IN COLORADO AND WYOMING

Saturday, August 15, 1992, 9 am to 4 pm
Wild Basin Lodge near Allenspark, Colorado

Rocky Mountain Hydrologic Research Center, 47th Annual Meeting
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Del Wayne Nimmo, National Park Service, *All points biomonitoring: New notions about determining the quality of water*

Kathy A. Tonnessen, National Park Service, *Investigating the ecological effects of air pollution in the National Parks: The role of hydrology and hydrochemistry*

Mark Williams, INSTAAR and University of Colorado, George Ingersoll, U.S. Geological Survey, **Dick Somerfeld**, U.S. Forest Service, and **Don Cline**, University of Colorado, *High-resolution measurements of snow-covered area and snow-water equivalence in the Colorado Front Range*

Jennifer Back, Colorado State University, Jill Baron, National Park Service, and Owen Bricker, U.S. Geological Survey, *Stable isotopes as tracers of hydrologic inputs to alpine lakes*

James Saunders and **William Lewis, Jr.**, University of Colorado, *Practical ecological modeling of the South Platte River below Denver*

Julie Sueker, U.S. Geological Survey and University of Colorado, *Surface-water chemistry and hydrology of subalpine watersheds in Rocky Mountain National Park*

Elizabeth Boyer and **George Hornberger**, University of Virginia and **Ken Bencala** and **Diane McKnight**, U.S. Geological Survey, *Hydrologic controls on the dynamics of dissolved organic carbon in the Snake River/Deer Creek catchment*

Lesley Smith and ***William Lewis, Jr.****, University of Colorado, Seasonality of Methane emmisions from five lakes and associated wetlands of the Colorado Rockies*

Chris Rowe, **Tim Kern, and John Stednick**, Colorado State University, *Water-quality characterization of the upper Arkansas River Basin, Colorado*

Winfield Wright, U.S. Geological Survey , and **Larry Fukui**, Chem-Nuclear Geotech, *Mobilization of dissolved selenium in the Mancos shale and associated alluvium in the irrigated Grand and Uncompahgre valleys, Western Colorado*

Elizabeth Law-Evans and **Dana Stright**, Metropolitan State College of Denver, *Future water resources in Southwestern Colorado: An historical analog scenario*

John Elliott, U.S. Geological Survey, *Geomorphic and paleoflood studies associated with the Gunnison River Basin Global Change Program*

For additional information: Robert Jarrett, (303)236-6447

ALL POINTS BIOMONITORING: NEW NOTIONS ABOUT DETERMINING THE QUALITY OF WATER

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Since the early 1980's, widespread use of single species for testing wastewater (under the NPDES point-source program) has become a reality. Other approaches such as the rapid bioassessment methodology have also been used...all generally known as "biomonitoring." Since 1983, I have used aquatic species, in conjunction with chemical analysis, to address nonpoint source pollution although I still regard the research as still in its infancy. Today's discussion is about some recent case studies in national parks but I will also give examples in Whitewood Creek, SD; South Platte below Denver, CO; and Chalk Creek (St. Elmo), CO. Throughout the fabric of the discussion, it is my intention to weave in the notion of "all points" versus "nonpoint" considerations while discussing water resources. The reasoning is that the negative "non" gives the connotation of "non problem" or "non important." Another message is to "TRUST THE ORGANISMS," because the organisms are the ones living, or attempting to live, in the environment being studied. Biomonitoring assists us in objectively planning approaches about "problem issues," and often changes our perceptions about what we term as high quality or low quality water.

INVESTIGATING THE ECOLOGICAL EFFECTS OF AIR POLLUTION IN THE NATIONAL PARKS: THE ROLE OF HYDROLOGY AND HYDROCHEMISTRY

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Under the Clean Air Act, the National Park Service (NPS), along with other Federal Land Managers, is required to protect resources in class 1 areas from damage caused by air pollution. The NPS responded to that mandate by organizing the Air Quality Division, located in Denver, Colorado. Within the Air Quality Division, the responsibility for performing research and monitoring of ecological resources in parks falls to the Biological Effects Program, whose objectives include: to understand the effects of air pollution on park resources; to document these effects through field surveys and experiments; to predict changes in the severity of effects with changes in air pollution; to assist the regions and parks in understanding and then monitoring the effects of air pollution; and to provide information needed for new source permit review. To realize these objectives, we have focussed our research efforts on two types of air pollutants: ozone and acid deposition.

Currently the research staff are reviewing what is known about the effects of acid deposition on watersheds and surface waters in parks, especially those ecosystems located at relatively high elevations in both the eastern and western United States. We plan to focus future efforts on researching the severity and frequency of episodic acidification of low-ANC surface waters in these affected areas. We will need to consider the role of hydrology and hydrochemistry in exacerbating or ameliorating the impact of acidic deposition on streams, ponds, and lakes along the east coast (Great Smoky Mountains, Shenandoah, and Acadia National Parks) and in the west (Sierra Nevada, Cascades, and Rockies).

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HIGH RESOLUTION MEASUREMENTS OF SNOW-COVERED AREA AND SNOW WATER EQUIVALENCE IN THE COLORADO FRONT RANGE

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George Ingersoll — USGS and CU-Geography

Dick Sommerfeld — RMFRES, USFS

Don Cline — CU-Geography

Seasonally snow-covered areas of the Earth's mountain ranges are important components of the global hydrologic cycle. They account for the major source of the water supply for runoff and ground water recharge over wide areas of the mid-latitudes, they are sensitive indicators of climatic change, and they are a major determining factor in the global radiation budget due to the high albedo of snow covered area (SCA). Furthermore, the release of ions from the snowpack is an important component in the biogeochemistry of alpine areas. The hydrology of snowmelt is therefore essential for understanding watershed processes in response to global change and other anthropogenic perturbations.

Understanding the linkage of processes at the plot scale with processes at the regional scale is essential if we are to extend our understanding of hydrology and biogeochemistry to a global scale. Here we present initial results to link point measurements of snow properties with these same properties at the regional scale of the Colorado Front Range. In particular, we take the first steps towards determining how to combine remote sensing data with field surveys to yield the most reliable measurements of SCA and snow water equivalence (SWE).

Intensive field measurements of SCA and SWE were conducted at two sites: Loch Vale watershed in Rocky Mountain National Park and Glacier Lakes in the Snowy Range, Medicine Bow National Forest. The field measurements of SCA were used to validate aerial photographs of SCA taken on a weekly to biweekly basis from Green Lakes Valley in the south to Glacier Lakes in the north. The aerial photographs were scanned, digitized, orthocorrected, filtered with a brightness threshold to discriminate SCA, overlain on a DEM, and then compared to ground-based measurements of SCA. In turn, the estimate of SCA from aerial overflights will be used to validate estimates of SCA made from Landsat images.

Next, individual basins were classified according to physical criteria into terrain units of similar net solar radiation, elevation, slope, aspect, and wind redistribution. Digital terrain models were used to determine the physical attributes, distribute net solar radiation, and to calculate wind redistribution of snow. Parameterization of initial values of SWE in each terrain unit were made from precipitation collectors. Validation of the estimates of SWE was conducted by comparing model calculations of SWE with field measurements. Our intent is to then combine the SWE from each terrain unit with local meteorological measurements as input to energy balance models to calculate snowmelt runoff.

Stable Isotopes as Tracers of Hydrologic Inputs to Alpine Lakes

Jennifer Back[1], Jill Baron[2], and Owen Bricker[3]

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ABSTRACT:

A study using stable isotope compositions of lake water, precipitation, snowmelt and glacial melt was begun in the summer of 1991. Three alpine lakes in Rocky Mountain National Park were chosen for the study. The initial data indicate a seasonal trend in isotopic composition of lake water. We propose that the trend in isotopic composition represents a mixture of water originating from different sources with distinct isotopic signatures. As different sources of water become dominant over the summer season, the isotopic content of the lake water will reflect the change in source. Most early summer lake water ^{18}O values fall between -19.00 and -17.00 per mil. ^{2}H values range from -135.0 to -115.0 per mil. The purpose of this investigation is to determine the relative hydrologic importance of each source by identifying their unique isotopic signatures and applying isotopic mass balance techniques.

Practical Ecological Modelling of the South Platte River below Denver

by James F. Saunders, III and William M. Lewis, Jr.
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Governmental regulation of water quality has become relatively complicated, especially for nonconservative chemical contituents. As a consequence of the increased regulatory complexity, computer models have become increasingly important in regulatory decisions. Complex models can require a large data base; the accuracy of site-specific modelling depends heavily on an extensive data gathering effort. A good model can serve as a stimulus for an improved understanding of ecological processes, as well as a tool for planning and regulation. The South Platte River is subject to many uses, including domestic water supply, agriculture, and recreation. At the same time, it must serve as habitat for aquatic organisms. Regulatory agencies are responsible for ensuring that designated uses are protected.

Sewage from Denver and other municipalities has been discharged historically to the South Platte. As recently as the 1960s, water quality in the South Platte below Denver was severely degraded. Major steps have been taken in the last 25 years that have greatly improved water quality. However, there remains concern that aquatic organisms are not adequately protected. Of particular concern are the concentrations of dissolved oxygen and unionized ammonia. Debate has centered on the steps necessary to further improve water quality. This debate has provided impetus for development of a site-specific water quality model.

Previous modelling efforts have been hampered by a lack of data suitable for model calibration. Extensive data collection efforts by the Metro District have resulted in a data record that is adequate for model development. In particular, the District has invested heavily in the characterization of diel variation in major chemical constituents. Diel data sets have been essential for estimating rates of the major biological processes.

Modelling has yielded important new insights regarding the relative importance of the key biological processes influencing dissolved oxygen and total ammonia. For example, nitrification was long thought to occur at rates that would rapidly deplete oxygen in the South Platte. Instead, analysis shows that nitrification proceeds at a relatively low rate and that sediment oxygen demand is most likely responsible for the depletion of dissolved oxygen. Revelations about the relative importance of key biological processes have considerable impact on the selection of wastewater treatment options intended to improve water quality in the Platte. The modelling work has also provided focus for future data gathering efforts. Sediment oxygen demand was estimated by residual in the current study, but the unanticipated importance of this process underscores the need for direct measurement. In addition, the importance of seepage chemistry in a gaining stream was not appreciated previously and merits further attention.

SURFACE WATER CHEMISTRY AND HYDROLOGY OF SUBALPINE WATERSHEDS IN ROCKY MOUNTAIN NATIONAL PARK

Julie K. Sueker, U.S. Geological Survey and University of Colorado

Rocky Mountain National Park contains headwaters of the South Platte and Colorado Rivers. These headwaters are important sources of downstream water for domestic, industrial and agricultural uses. Water originating in high-mountain ecosystems generally is considered to be pristine. However, the quality of water from pristine watersheds may be altered dramatically by atmospheric deposition (sources of nitrates, sulfates and other acidic ions), geochemical weathering (sources of metals and inorganic ions), and biological processes (sources of natural organic matter). Changes in source-water chemistry may have significant effects on downstream water quality and use. Quantifying water quality in "pristine" head-waters is important in determining background levels of surface-water constituents to downstream users.

Process-oriented research will explore the surface water chemistry and hydrology of three watersheds in Rocky Mountain National Park. Surface-water samples and stream discharge data will be collected from Spruce Creek (~11 km^2), Boulder Brook (~11 km^2), upper Big Thompson River (~160 km^2) and North St. Vrain Creek (~120 km^2) drainages. Water will be sampled for major inorganic ions, pH, alkalinity, conductance, and total organic matter. Trends and differences in water chemistry will be investigated for drainage basins which have similar geology and vegetation but vary in size and ecosystem distribution. Sampling schedule includes daily sampling during snowmelt, and weekly sampling during summer and winter runoff seasons. Research questions include: (1) what is the magnitude and duration of ionic pulse(s) during snowmelt; (2) how do climate, geology, soil, basin slope and aspect, and vegetation coverage and distribution affect surface water chemistry and hydrology; (3) can data from small watersheds be used to represent larger watersheds in regional-scale computer simulation models, and; (4) what are potential changes and sources of change in surface water quality and quantity?

This research will increase our understanding of surface-water chemistry and hydrology of pristine watersheds. This study will be coordinated with and directly benefit ongoing research by the National Park Service (since 1982), and the U.S. Geological Survey (since 1991) in the Loch Vale Watershed; and with the U.S.G.S. National Water Quality Assessment program now being implemented.

HYDROLOGICAL CONTROLS ON THE DYNAMICS OF DISSOLVED ORGANIC CARBON IN THE SNAKE RIVER/DEER CREEK CATCHMENT.

Elizabeth Boyer, George Hornberger (both at University of Virginia, Dept. of Environmental Sciences, Charlottesville, VA), Ken Bencala (U.S. Geological Survey, Menlo Park, CA), and Diane McKnight (U.S. Geological Survey, Boulder, CO).

Hydrological mechanisms controlling the spatial and temporal variation of dissolved organic carbon (DOC) were investigated in two headwater streams of the Rocky Mountains, Snake River and Deer Creek, located near Montezuma, CO. Measurements show that stream DOC levels peak annually early in the snowmelt runoff event, just before maximum discharges are observed, then decline rapidly as melting continues. We examined possible hydrological mechanisms to explain the observed variability of DOC by first simulating the hydrological response of the catchment using TOPMODEL and then routing the predicted flows through a simple model that accounted for changes in DOC. Conceptually, the DOC model can be taken to represent a terrestrial (soil) reservoir in which DOC builds up during low flow periods and is flushed out when infiltrating meltwaters cause the water table to rise into this "reservoir". Further investigating this conceptual model, a field study was implemented to look at the spatio-temporal trends of DOC. At a variety of locations within the catchment DOC was measured in the stream, vadose zone, and groundwater. Wells and stream gages provided a measure of the water table dynamics.

SEASONALITY OF METHANE EMISSIONS FROM FIVE LAKES AND ASSOCIATED WETLANDS OF THE COLORADO ROCKIES

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Methane emissions were measured over a 15-month interval for five lakes and five associated wetland sites in the Southern Rockies of Colorado at elevations between 2800 and 3600 m. Three of the five lakes accumulated dissolved methane under ice, despite the presence of oxygen; accumulation was a high as 50-fold over background concentrations in the shallowest lake. The winter accumulation was released over a very short period during the spring thaw. This pulsed release of methane to the atmosphere may be widespread at high latitudes and may play a role in the observed seasonality of tropospheric methane concentrations in the northern hemisphere. During the ice-free period, the mean emission rate was 1.6 mmol m^{-2} d^{-1} over open water for the rive lakes, but the mean was much higher (13 mmol m^{-2} d^{-1}) over the macrophyte beds located in one of the lakes. Open water emissions occurred primarily through diffusion rather than bubbling. For wetlands near the lakes, emissions ranged from negligible to almost 6 mmol m^{-2} d^{-1}; the average across all sites was 2.1 m^{-2} d^{-1} during the warm season. There were no measurable emissions during the winter months. The data from this study and information that has accumulated on other lake types over the last 15 years indicate that lakes may be a larger source strength of methane than reported estimates.

WATER QUALITY CHARACTERIZATION OF THE UPPER ARKANSAS RIVER BASIN, COLORADO

Chris Rowe, Tim Kern, and John Stednick

Department of Earth Resources

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This research is part of a larger project designed to identify acid mine drainage and heavy metal source areas and prioritize remediation options in Lake County, Colorado. The overall project defines landscape elements and subsequent streamflow routing mechanisms, that effectively control surface water chemistries. Using our proposed methodology, critical areas can be identified for remediation prior to any adverse episodic response. This approach prioritizes problem areas based on the toxicological implications of specific heavy metal concentrations to humans and wildlife.

This presentation specifically looks at water quality analysis techniques. Despite reams of data on water chemistry in the area around Leadville, concerns exist about the usability of previous research. This work will review the historic database, along with concerns about use of this database, the techniques we employed in sample collection and analysis, and the methodology to identify sampling locations by a coordinated use of GIS software and water quality data.

The proposed water quality collection and presentation provides an excellent measure of basin water quality, with ample quality assurance, while not becoming cost prohibitive. With this approach, the majority of resources can be committed to preventing, in the case of Lake County, acid mine drainage from reaching main watercourses. The structure of the system used in this effort should be easily transferable to other regional non-point water quality issues (acid mine drainage, agricultural stream loading, and forest water quality issues).

MOBILIZATION OF DISSOLVED SELENIUM IN THE MANCOS SHALE AND ASSOCIATED ALLUVIUM IN THE IRRIGATED GRAND AND UNCOMPAHGRE VALLEYS, WESTERN COLORADO

ABSTRACT

By Winfield G. Wright, U.S. Geological Survey, Water Resources Division, Grand Junction, Colorado and, Larry M. Fukui, Chem-Nuclear Geotech, Grand Junction, Colorado

Distribution of dissolved selenium in ground water of the irrigated Grand and Uncompahgre Valleys is affected by the aqueous geochemical environment of the shallow ground-water system that is comprised of alluvium and shale residuum. Detectable selenium concentrations range from 3 to 1,300 micrograms per liter in water from shallow wells. Selenium and uranium are correlated in ground-water samples, but selenium and sulfate are not well correlated. Sulfur-isotope values for ground-water samples from the Mancos Shale range from +6 to -26 per mil, the lighter values indicating sulfide sources for dissolved sulfate. Sulfur-isotope values in water from 8 out of 12 wells are in the -15 to -18 per mil range which probably represents an average of sulfur-isotope values from sulfide sources. Possible original sources for selenium include disseminated selenium-bearing sulfides that may have been originally associated with ash layers in the Mancos Shale. Prior to irrigation, selenium and other trace elements may have been leached from the Mancos Shale, transported, and deposited in alluvium and residuum in association with H_2S reduction. Current infiltration of irrigation water provides oxidizing conditions for leaching of selenium and transport out of the system. Where oxygen has been depleted from ground water, dissolved nitrate may be an oxidant for mobilization of selenium.

Future Water Resources in Southwestern Colorado: An Historical Analog Scenario. Elizabeth Law-Evans and Dana Stright, Department of Earth and Atmospheric Sciences, Metropolitan State College of Denver, Campus Box 22, P.O. Box 173362, Denver, CO 80217-3362. SUPERNET: LAWEVANS@ZENO.MSC.COLORADO.EDU.

A major drawback to the application of global climate models to the prediction of regional water resources is the current lack of spatial resolution. An alternative to models is the historical analog method, which offers better spatial resolution but is limited by the quantity and quality of historical meteorological and streamflow data.

This study compared precipitation, streamflow, and snowpack, and temperature 30-year averages to averages for the globally warmest decade on record, 1980-1989. While it is impossible to predict conditions under a doubled-CO2 regime since global temperatures of the predicted warmth have not occurred in the historical record, the scenario method offers interim indications of climate and water resources.

Results of the application of the historical analog method to sites in Southwestern Colorado suggest that under globally warm conditions, monthly streamflows are higher. Monthly precipitation totals and lower-elevation (7500-9000 feet) snowpack are normal to slightly higher while wintertime monthly average minimum temperatures higher. These results suggest that increased streamflows are due to somewhat increased precipitation and snowpack. These results show the local climatic changes which have occurred under historically globally warm conditions.

While the historical analog method of climatic scenario construction is obviously based upon limited historical data, it provides a degree of spatial resolution far more detailed than current global climate models. This study was undertaken as a test of the historical analog method. The authors have proposed to apply the method to western North America as a preliminary evaluation of water resources under globally warmer conditions.

GEOMORPHIC AND PALEOFLOOD STUDIES ASSOCIATED WITH THE GUNNISON RIVER BASIN GLOBAL CHANGE PROGRAM

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ABSTRACT: A study is being conducted in the Gunnison Gorge, the lower 22-kilometer reach of the Black Canyon of the Gunnison River, to evaluate the potential effects of climate change on bed-material entrainment and fluvial geomorphology in a canyon/river system. Since the mid-1960's, upstream reservoirs have altered the timing and decreased the magnitude of snowmelt flood peaks, resulting in a decrease in bed-material entrainment and changes in fluvial geomorphology. Bed-material entrainment, a process dependent on streamflow regime, may be affected by climate-induced hydrologic changes in several reaches of the Gunnison Gorge. River reaches with the greatest potential for change in bed-material entrainment are those where shear stress from regulated or drought-diminished streamflows is insufficient to mobilize the larger-size bed-material particles. Reaches downstream from tributary confluences are especially sensitive because of the proximity to periodically-supplied, coarse debris-flow materials. Hydraulic, sedimentologic, and geomorphic changes due to reservoir operation in normal and below-normal runoff periods may provide some indication of potential climate-induced changes in the Gunnison Gorge and other canyon/river systems. Historical streamflows, measured channel hydraulic properties, and quantitative bedload-transport equations are being used to estimate potential effects on bed-material entrainment and fluvial geomorphology.