to extensive validation studies, has led to robust retrieval algorithms of geophysical parameters (i.e., vegetation and soil moisture) supporting global change monitoring efforts. The newly launched Aqua satellite will allow global coverage of these surface parameter estimates. In order to best simulate the surface properties using satellites, it is necessary to combine several temporal and spatial resolutions. Given that sensors have varying frequencies, spatial/temporal resolutions and sensitivities to vegetation and surface roughness, proper methods for accounting for these differences are required for algorithm development.

This work will emphasize an analysis of soil moisture and vegetation parameter retrievals using a)Satellite (Landsat Thematic Mapper) data, b)Aircraft (Passive/Active L/S Band instrument (PALS) data, and the Polarimetric Scanning Radiometer (PSR) data), c)In-situ data acquired during the 1999 Southern Great Plains experiment (SGP99). The temporal and spatial co-location of these instruments enables an assessment of remote sensing capabilities combining multiple wavelengths, active/passive/optical data, and polarization ratios/frequency indexes for optimum parameter estimation.

H72A-0845 1330h INVITED POSTER

The Hydrosphere State (HYDROS) Mission Approach to High Resolution and Frequent Revisit Data Products for Hydrometeorological and Hydroclimatological Applications

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The design and expected characteristics of the Hydrosphere State (HYDROS) Mission space-borne system for high-resolution mapping of surface soil moisture and landscape freeze/thaw dynamics are outlined. The HYDROS proposal has been selected by NASA as the alternate mission in the current set of three approved Earth System Science Pathfinder (ESSP) projects. The unique approach of the HYDROS mission is to combine active and passive sensor observations. The radiometer instrument on board the satellite provides polarized brightness temperature fields at 1.4 GHz across a wide swath (900 km) at a resolution of 40 km. The radar operates at 1.2 GHz (VV, HH, and HV) and is capable of high-resolution mapping (<3 km) over 70 precent of the swath and low-resolution across the remainder. All terrestrial land regions are revisited within 2-3 days. The microwave approach allows estimating soil moisture and surface freeze/thaw in nearly all weather conditions and regardless of solar illumination. The active and passive measurements are used to develop land hydrology products. Soil moisture and its freeze/thaw state are critical determinants of the rates of water, energy, and carbon cycles over the continents because they are key controls on land-atmosphere flux exchanges. Significantly, the data products address science questions about processes that link these cycles. In this presentation it is shown that combining active radar and passive radiometer sensor measurements result in land hydrology data products with resolution and accuracy that are not possible when only once sensor measurement is used. The heritage and performance of the algorithms and algorithm components over diverse surface conditions and based on ground and airborne field campaign data are summarized.

H72A-0846 1330h INVITED POSTER

Global River and Lake Monitoring from Satellite Altimetry

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A series of satellite altimeter missions has gathered data over the earths oceans. Several of these instruments have also acquired data over land. Of particular relevance, both Topex and ERS1&2 have now amassed a continuous time series over ten years of echoes from both ocean and land surfaces, including inland water. However, data from varying topographic surfaces are generally complex and difficult to interpret.

Echoes from large lakes can often be successfully processed using the existing ocean processing algorithms; however, river echoes present problems except in the widest estuaries, as land contamination complicates the echo shape. By developing a suite of algorithms to reprocess non-ocean echoes, river data can now be successfully retracked to yield good heights.

This paper presents results of an extensive study over the earths major river systems, using both ERS and Topex data. The tracking advantage of ERS ice mode is discussed, together with an assessment of the benefits and drawbacks of different repeat patterns for recovery of time-varying signals.

The global applicability of these automated techniques for river height extraction means that it is now possible to create a decadal time series of global river heights, and hence to estimate the global hydrology runoff budget. This valuable time series is being continued by ENVISAT and Jason-1.

H72A-0847 1330h POSTER

QuikSCAT/SeaWinds Monitoring of Large Seasonal Wetlands

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Polarization ratio measurements of the SeaWinds radar backscatter are sensitive to surface water area expansions and contractions in large seasonal wetlands (areas greater than 10,000 sq km). Examples include the Sudd, in the upper Nile Basin, the Barotse Plain and Chobe Swamp in the upper Zambezi, the Llanos de Mojos in Bolivia, and the Rio Araguiaia floodplain in Brazil. QuikSCAT provides new information on a near-daily basis but at relatively coase spatial resolutions (tens of km at best). We use multispectral classification techniques on MODIS optical data at resolutions of 250 m or 500 m to locate and accurately measure surface water areas when cloud cover allows. This allows calibration of the radar polarization information to water surface area. The moisture status of these evapotranspiration sources can thereby be re-evaluated with each new QuikSCAT pass. Because the wetlands play a large role in the associated river basin moisture mass balances, radar monitoring should facilitate improvements in river discharge prediction within these basins.

URL: http://www.dartmouth.edu/artsci/geog/floods/wetlands/Wetlands.html

H72A-0848 1330h POSTER

Comparison of evapotranspiration estimates from the Surface Energy Balance Algorithm (SEBAL) and flux tower data, middle Rio Grande Basin

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Evapotranspiration (ET) is one of the most important components of the water balance, but also one of the most difficult to measure. Field techniques such as soil water balances and Bowen ratio or eddy covariance techniques are local, ranging from point to field scale. SEBAL (Surface Energy Balance Algorithm for Land) is an image-processing model that calculates ET and other energy exchanges at the earths surface. SEBAL uses satellite image data (TM/ETM+, MODIS, AVHRR, ASTER, and so on) measuring visible, near-infrared, and thermal infrared radiation. SEBAL algorithms predict a complete radiation and energy balance for the surface along with fluxes of sensible heat and aerodynamic surface roughness (Bastiaanssen et al, 1998; and Allen et al. 2001). We are constructing a GIS based database that includes spatially-distributed estimates of ET from remote-sensed data at a resolution of about 30 m. The SEBAL code will be optimized for this region via comparison of surface based observations of ET, reference ET (from windspeed, solar radiation, humidity, air temperature, and rainfall records), surface temperature, albedo, and so on. The observed data is collected at a series of tower in the middle Rio Grande Basin. The satellite image provides the instantaneous ET (ET_inst) only. Therefore, estimating 24 hour ET (ET_24) requires some assumptions. Two of these assumptions, which are (1) by assuming the instantaneous evaporative fraction (EF) is equal to the 24-hour averaged value, and (2) by assuming the instantaneous ETrF (same as crop coefficient, and equal to instantaneous ET divided by instantaneous reference ET) is equal to the 24 hour averaged value, will be evaluated for the study area. Seasonal ET will be estimated by expanding the 24-hour ET proportionally to a reference ET that is derived from weather data.

References:

Bastiaanssen,W.G.M., M.Menenti, R.A. Feddes, and A.A.M. Holtslag, 1998, A remote sensing surface energy balance algorithm for land (SEBAL): 1. Formulation. J. Hydrology 212-213, p. 198-212.

H72B MCC: Hall C Sunday 1330h

The Science and Uncertainty of River Management and Restoration II Posters *(joint with B, T, PA)*

Presiding: **A Collison,** Philip Williams and Associates**; S Darby,** University of Southampton**; P Downs,** Stillwater Sciences**; D Sear,** University of Southampton

H72B-0849 1330h POSTER

Challenges in Assessing the Effects of Experimental Flow Regimes from Glen Canyon Dam on Fine Sediment Storage and Native Fish Populations in the Colorado River in Grand Canyon

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The Colorado River ecosystem between Glen Canyon Dam (GCD) and upper Lake Mead, Arizona, provides a unique opportunity to test various ideas about river management and the use of adaptive management experiments to help resolve scientific uncertainties about best management practices. Beginning in the early 1990's, a variety of experimental discharge regimes from GCD have been implemented including the well-publicized 1996 controlled flood and the costly 2000 steady flow experiment (ca. $21 million in lost power revenues). The experimental flows and the extensive monitoring, research, and modeling efforts have focused on quantifying the effects of flow on the storage of fine sediment in the Marble and Grand Canyon reaches of the Colorado River and on the survival and growth of native fish, with an emphasis on the endangered humpback chub (Gila cypha). Analysis of sediment and flow discharge data from natural hydrologic events and experimental flows has been more helpful in formulating current flow management regimes focused on sediment retention than results from single and multi-dimensional sediment transport models. Inferences from historical analyses have been limited by the resolution of sediment transport data, while inferences from multi-dimensional models have been limited by difficulties in scaling-up site specific results to reaches that are 10's to 100's of km long. Evaluation of the status and trends of exotic and native fish populations in Grand Canyon is highly uncertain because of the difficulties of conducting representative catch-per-unit-effort sampling in a large and turbid river with very difficult access, and because of multi-year delays associated with mark-recapture data. Application of stock assessment modeling procedures, originally developed for managing commercial fisheries, has been helpful for estimating population trends from the historical fisheries data, but not sufficient to resolve whether declines in native fish populations have been caused by the increasing abundance of exotic fishes, dam operations, or a combination of the two. Our ability to detect fish population responses to future experimental flows is weak in spite of the lessons learned from stock assessment modeling and expanded monitoring efforts. In contrast, near-term experimental flows proposed for 2002 through 2004 will likely be highly informative for

distinguishing among alternate hypotheses about the response of sediment storage to dam operations.

H72B-0850 1330h POSTER

The significance of discharge in the replenishment of sand bar deposits along the Colorado River through the Grand Canyon

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Topographic sandbar surveys, recovered scour chains, analysis of aerial photos, and modeling of sand deposition demonstrate that releases from Glen Canyon Dam greater than power-plant capacity (PPC; about 900 cubic meters per second) are significantly more effective than PPC-limited releases at redistributing sand from the channel bed to higher elevations along the channel margin. A release of 1,270 m^3/s (1.4 times the PPC) for 7 days in 1996 tested the effectiveness with which sandbars could be restored by the manipulation of dam releases aimed at redistributing a limited sand supply. This high flow generally resulted in substantial increases in bar size, although some sandbars close to the dam eroded. Since 1996, releases for bar building and habitat maintenance (a 2-day release in 1997 and two 4-day releases in 2000) have been limited to PPC.

Field measurements indicate that the 1996 release of 1,270 m^3/s significantly increased the area and volume of sand deposits at elevations greater than the stage reached during typical post-dam flows. Minor aggradation occurred during the PPC flows. In 1996, the relative extent of erosion and deposition changed longitudinally downstream as evidenced by the area of substantial deposition exceeding that of erosion at sites further downstream. The number of bars that were substantially reworked, as measured by the number of bars that significantly increased or decreased in area at the elevation range of normal dam operations, was much greater at 1,270 m^3/s than at 900 m^3/s. Deposition from the 1,270 m^3/s release persisted at many sites on a multi-year scale whereas deposition resulting from the PPC flows only lasted a few months. Minor deposition during PPC flows in 1997, however, was greatest in upstream reaches where bar erosion during normal flows had been more extensive. These observations show that deposition is sensitive to flow magnitude and depth of inundation as well as sand supply.

Flow, sand transport, and bed evolution were modeled for conditions that occurred during PPC flows and at higher discharges, such as those that occurred in 1996. Modeling results show that discharges greater than PPC form larger, higher-elevation deposits than are possible at discharges less than PPC. A key requirement for substantial deposition of new sand along the sides of this narrow, deeply incised river is the availability of depositional sites. PPC flows fail to increase stage sufficiently to create space to accommodate new deposits. The inefficiency of PPC releases at building substantial sandbars is compounded by the efficiency with which channel-bed sand is exported during PPC flows, as shown by sand-transport data collected from 1997-2000. Results to date indicate that restoration and maintenance of sand bars will likely require releases greater than PPC more frequently and of shorter duration than anticipated in the past.

H72B-0851 1330h POSTER

Modeling Subsurface Heterogeneity and River Aquifer Interactions in an Alluvial Fan System - Implications for River Flow Restoration

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Diminishing fall flows in the Cosumnes River in Sacramento County, California have led to declining fall runs of endangered Chinook salmon. Severe overdraft of the regional aquifer over the last 60 years has drawn down groundwater levels below the elevation of the channel over extended reaches of the river, practically eliminating baseflows. Efforts to restore Chinook salmon fall runs have led to investigations of river aquifer interactions along the lower Cosumnes River with the aim of building simulation models of river aquifer interactions that can guide the development of management strategies to restore fall flows.

Simulations of regional groundwater flow indicate that large reductions in groundwater pumping over extended time periods would be necessary to reconnect the channel with the regional aquifer. Surface flow augmentation and artificial recharge could provide alternative short and long term measures to enhance fall flows. Field measurements suggest complex interactions between the river and the subsurface, including the formation of perched aquifers above the regional water table, that are not captured by the coarse regional model. Subsurface heterogeneities in the alluvial aquifer system, which is characterized by a large proportion of fine-grained sediments, seem to exert important local and intermediate scale controls on the exchange between the river and aquifer. Subsurface heterogeneities in a 420 sqkm area around the river, are simulated with a transition probability / Markov-Chain based three dimensional geostatistical model. Results from the geostatistical model are used as a basis for simulations of river aquifer interactions including variably saturated flow below the river channel. Results will quantify the role of subsurface heterogeneity on river aquifer exchange in a river aquifer system that is disconnected by an unsaturated zone and could provide guidelines for fall flow restoration in the Cosumnes River.

H72B-0852 1330h POSTER

Numerical Simulation of Flow in Compound Channels

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Compound Channels are often constructed in restoration projects on streams that have been channelized or are deeply incised. The compound channel design allows for flow over a wider cross-sectional area and is supposed to reduce flow velocities and bed shear stresses in the channel during high flow events. The reduction in channel velocities helps to reduce further incision and establish a more natural flow regime under high flow conditions.

In river restoration projects, compound channel designs are often based on one-dimensional numerical simulations. However, one-dimensional numerical models are not always suitable for simulating the complexity of compound channel flows and can produce erroneous results. We will present a comparison of simulation results for a pre-restoration incised channel and a post-restoration compound channel using one-dimensional and three-dimensional numerical models. We will focus on the limitations associated with these models and address their suitability for use in the design of compound channels in river restoration projects.

H72B-0853 1330h POSTER

Defining Successful Dam Removal and Shifting the Focus of Restoration; A Midwest Perspective.

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The number of dam removals in the US has increased in the last decade because design lives are being exceeded for an increasing number of dams, and because interest groups have pushed for removal as part of attempts to restore river ecology. Large numbers of small dams have been removed, despite the paucity of information regarding the physical and biological impacts of removal. Here we offer a Midwestern perspective on dam removal, based on issues endemic to rivers of this region. In the absence of comprehensive national studies of dam removal, regionally specific studies provide a starting point for the debate over the efficacy of dam removal as a river restoration tool.

Three of the most important issues in Midwestern river management are; excessive nutrient export, endangered mussel populations, and high sediment inputs. Some of the most diverse assemblages of freshwater mussels reside in the Midwest. These populations have been historically impacted by over-harvesting and increased sediment inputs to lotic environments. Dam removal results in two impacts that operate against mussel populations. First, the rapid dewatering of the upstream reservoir can cause nearly total mortality of the upstream (impoundment) community. Second, large volumes of sediment are released and deposited into downstream reaches, effectively smothering downstream communities. Sediment deposition downstream exacerbates the well-documented negative impacts that years of poor land use have had on stream and river biota, thus not only does deposition impact mussel communities, but interferes with all aquatic communities. Closely related to the movement of sediment out of the former impoundment is the export of nutrients. Issues of eutrophication have been documented in water bodies ranging from small receiving lakes to the Gulf of Mexico. Removing a dam releases nutrients that have been stored for the duration of the dams existence, allowing them to flow downstream in a concentrated release that can last long after the initial removal.

All three key Midwestern river management issues are directly impacted by the removal of dams. Though few comprehensive studies have quantified specific impacts following removal, information from chance failure observations and unpublished documentation can be used to support the argument that dam removal evaluation should move away from perceived needs, such as restoring connectivity and opening up habitat for non-endangered aquatic species, toward other relevant regional issues. Given the importance of excessive nutrient export, endangered mussel populations, and high sediment inputs, they should be substantial components in defining the potential success of removal as a restoration option in the Midwest, and possibly other areas of the US.

H72B-0854 1330h POSTER

Riparian Dis-connectivity and Changes in Hydrologic Regime by Dams

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Dams have major impacts on river hydrology and ecology, primarily through changes in the timing, magnitude, and frequency of both low and high flows ultimately producing a hydrologic regime differing significantly from the pre-impoundment natural flow regime. Using both the National Inventory of Dams (NID) and USGS gages, we analyzed the hydrologic changes due to dams covering the spectrum of hydrologic regimes across the US. We apply flood frequency analysis and a hydrologic model, the Indicators of Hydrologic Alteration (IHA), to 21 dams ranging in watershed contributing drainage of four orders of magnitude in order to document the type, magnitude, and direction of hydrologic shifts due to impoundment. For most large dams in the U.S., irrespective of region, contributing watershed size, or primary function, the bankfull 2-year flood, which maintained natural channel dimensions and sediment transport capacity before the dam, was reduced on average 60 percent following impoundment, and in almost half the cases was never attained. In addition, floods greater than bankfull, which are necessary for successful recruitment and persistence of distinct riparian biotic communities, have been essentially eliminated by dams, completely disconnecting the riparian zone from riverine influence. Our analyses suggest that a critical threshold of riparian dis-connectivity exists and corresponds approximately to the pre-dam 5-yr flood. Results from IHA indicate that the most significant changes across these sites occur in minimum and maximum flows over different durations. For low flows, the 1-day through 90-day minimum flows increased significantly following impoundment and baseflows also increased. The 1-day through 7-day maximum flows decreased significantly across the sites. At monthly scales, April and May mean flows tend to decline while August and September mean flows increase. Other significant adjustments include changes in annual hydrograph conditions, primarily in the number of hydrograph reversals that have increased dramatically for all sites following impoundment. The number of high pulses has increased following impoundment but their average length declines. The mean hydrograph rise rate and fall rate has declined significantly. These results indicate that the ma-

jor pulse of dam construction during the previous century has affected hydrologic regimes on a nation-wide scale, for both large and small rivers.

URL: http://www.dartmouth.edu/~fjmagill

H72B-0855 1330h POSTER

The Use of Spatial Complexity in a Spawning Gravel Rehabilitation Project

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A shortage of spawning habitat on dammed and regulated rivers has led to the popularity of gravel augmentation and spawning habitat restoration projects among river managers. Spatial complexity has been cited as an important feature of aquatic ecosystems, but has yet to be widely adopted in the design of spawning habitat rehabilitation projects. Spatial complexity in rivers is formed by geomorphic and hydrodynamic processes, and its importance reflected in habitat utilization. In August of 2002, over 2,786 metric tons of spawning gravels and 7 large boulders were placed in a 155 meter reach comprised of a short (22 m long) riffle, long (95 m long) glide and second riffle (38 m long) on the Lower Mokelumne River, California. Spatial complexity was incorporated into the design as part of a new, integrated, scientifically based spawning habitat rehabilitation approach developed and implemented over the past two years. At the reach scale, gravels were used to elevate the bed and increase slopes over newly constructed riffles from 0.0012 to 0.004. At the geomorphic unit scale (sub-reach), flow was routed through a complex assemblage of geomorphic units including three broad riffles (to encourage divergent flow and deposition of gravels at high flows), three small pools (whose widths were constricted by bars to encourage convergent flow and scour at high flows) and three boulder complexes. Boulder complexes were used to encourage localized scour and create shear-zones, channel constrictions, pour-overs and standing waves. Pool exit slopes at pool-riffle transitions were shaped to promote intragravel flow and encourage concentrated flow to diverge across riffles. Although optimal spawning habitat is generally found in riffles, proximity of optimal spawning habitat to pools, large woody debris, boulder clusters and overhanging cover provides equally important refuge from predation and holding areas where the female can quickly move between the redd and refugia without leaving the nest unprotected. Incorporating such complex features into a design can improve the quality of habitat beyond the predictive capability of models that use numerical habitat suitability indices. Such models can constrain the uncertainty of a design but need to be combined with conceptual models and practical limitations of construction to achieve spatial complexity. Results are presented to illustrate the exploitation of complexity as a component of an integrated approach to constructing spawning habitat rehabilitation projects.

URL: http://lawr.ucdavis.edu/faculty/gpast/shira/shira_contents.htm

H72B-0856 1330h POSTER

Incorporating Large Woody Debris Into River Restoration and Management Plans for Low-energy Streams

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The use of large woody debris (LWD) as a restoration tool has burgeoned in recent years, but little is know about its influence on fluvial processes in low-energy alluvial streams. This gap in knowledge is increasingly being met by demands for low-energy river management and restoration projects that incorporate LWD in a more scientifically-based and geomorphologically correct manner. A field experiment has been conducted to investigate the influences of LWD a low-energy meandering stream in northern Illinois. The results of this study show that LWD obstructions systematically, yet diversely, influence the three-dimensionality of flow and sediment particle size distributions in meander bends. Results also show that rates of bank erosion and meander development are very low in the study bends, indicating that LWD does not readily induce rapid planform change in the system. Given the results of this study, it appears that LWD may influence the in-channel fluvial dynamics of low-energy meandering rivers in a number of different, yet equally significant, ways that do not commonly induce rapid planform development.

H72B-0857 1330h POSTER

Hydrogeomorphic Classification of Western Streams for Ecological Assessment

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Geophysical controls such as climate and geology interact with human activities to shape the fundamental drivers (e.g. flow regime, thermal regime, pollutant stressors, habitat structure) that make fluvial systems similar or different ecologically. These fundamental drivers are manifested differently across watershed, valley bottom, reach, and local spatial scales. Although geophysical setting is a fundamental determinant of variation in aquatic communities, physical habitat assessment techniques and popular, existing geomorphic classifications of streams do not necessarily provide an adequate multi-scale description for assessing ecological condition. In particular, the integration of hydrologic and geomorphic classifications at the reach, valley, or watershed scale does not exist, despite the fact that such integration may be a powerful way to stratify stream habitats, as has been shown for wetlands. We are developing a hierarchical classification framework for stream environments in the western US that integrates geologic context, a hydrologic regionalization approach, and analysis of drainage network structure with traditional reach-scale geomorphic classification. Extensive physical and biological data from over 300 first through fourth order streams across six ecoregions in Colorado, Oregon, and Washington and a comprehensive matrix of multi-scale hydrogeomorphic descriptors are being analyzed to link the classification with expectations of taxa distribution. For example, in the Cascades Ecoregion in Oregon, up to 72 percent of the variation in macroinvertebrate genus richness at a site can be explained using no more than four geophysical descriptors from both the reach and watershed scales. Given the current emphasis on ecoregional and local scales in biomonitoring, this approach is providing essential information on how geophysical factors measured at scales intermediate to ecoregions and stream reaches can be used to further understand and predict biotic condition at individual sites distributed across the landscape and the costs and benefits associated with different spatial resolutions of geophysical data in ecological assessment.

H72B-0858 1330h POSTER

Controls of channel response to cattle-grazing exclosures on five streams in the Blue Mountains of eastern Oregon

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Riparian-corridor fencing has been shown to be effective in allowing streams to recover from grazing pressure, but relative response of different stream types is poorly understood. This study compares processes of geomorphic response of five mountain streams to removal of cattle-grazing pressure. The streams differ in basin size, type of bed material and suspended sediment, vegetation type, channel slope, sinuosity, age of cattle fencing, and previous grazing history. The relative ability of each stream to adjust by depositional processes, such as construction of gravel bars and in-channel sedge benches, vertical accretion, and trapping of sediment by woody debris, was analyzed in terms of the controls.

Cross-section resurveys were used to document large changes in channel geometry, and mapping based on field evidence was used to identify dominant processes and capture more localized areas of deposition and erosion. Dynamic segmentation in GIS was used to construct channel maps for visualization of adjustment processes relative to channel planform and geomorphic surfaces. Frequency of mobilization of bed material was estimated using particle entrainment calculations for each stream.

The streams that appear to adjust by multiple processes show evidence of adjustment along the greatest percentage of their length. Lower-gradient streams with the largest drainage basins show the most evidence of both bar development and erosion on outsides of bends, while frequency of vertical accretion and development of sedge benches may be less related to stream size. Sedges and rushes appear to be effective in promoting and stabilizing low depositional surfaces (sedge benches) at sites with fine sediment availability. Large wood influences deposition on up to 12% of the length of some sites, but may not be as important as in streams west of the Cascades. Bar development may be most important in controlling response rate, and appears to associated with larger streams, higher sinuosity, more bedload, and higher competence.

H72B-0859 1330h POSTER

Controls of the Geomorphic Effectiveness of Passive Restoration Projects in the Interior Columbia River Basin, Oregon, USA

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Low-order montane tributaries in watersheds of the interior Columbia River Basin historically were highly productive habitat for anadromous and resident salmonids, now greatly reduced in numbers and listed under the Endangered Species Act. Historical impacts, including cattle grazing, other land use activities and direct channel modification, have resulted in loss of streamside vegetation, and channel widening and simplification. Over the past fifteen years, many stream restoration projects have been completed, using both active (instream structures) and passive (cattle grazing exclosure) approaches. The implicit goal of most projects has been to restore multiple structural and functional characteristics, with the ultimate goal of increasing salmonid populations. Very little evaluation of effectiveness of these projects has been done. Previous work has suggested several hypotheses concerning restoration effectiveness: 1) channel narrowing may be driven by increased vegetation cover in response to treatment; 2) adjustment of bed morphology may be controlled by stream power and competence, or channel constraint; 3) response to restoration may require several years.

We selected eleven passive restoration sites and measured vegetation and channel morphology at adjacent paired reaches (grazing exclosure vs. grazed reach). All sites were gravel-bedded, <100 km2 drainage area, moderately to highly sinuous; all except one had channel gradients <0.0015. Exclosure age was 2 to 36 years. We used statistical analysis and data visualization to test the hypotheses discussed above. Overall, exclosure reaches were narrower, deeper and had more pool area than comparable grazed reaches. Most exclosure reaches had more sedge cover and riparian shrub cover, and less bare ground. Degree of narrowing was not strongly related vegetation cover, but young sites that did not show vegetation response also failed to show channel narrowing. Adjustment of bed morphology was limited, at different sites, by power/competence, constraint and treatment age. Understanding such controls may lead to better selection of restoration projects in the future.

H72B-0860 1330h INVITED POSTER

Recent Innovations in Monitoring Suspended-Sediment Mass Balance of the Colorado River Ecosystem Below Glen Canyon Dam: A laser-Based Approach

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Intensive monitoring of suspended-sediment in the Colorado River ecosystem below Glen Canyon Dam is a priority for environmental management. Historically, the program has been logistically complicated, costly and limited in spatial and temporal resolution.

These elements have contributed to relatively large uncertainties in mass-balance estimates of sediment export. To improve mass-balance estimates, the Grand Canyon Monitoring and Research Center is field testing new and existing technologies to develop a continuous suspended-sediment transport protocol.

A recent innovation includes use of optical forward-scattering instruments, LISST, in combination with programmable pumping samplers. The LISST-100 (Laser In-Situ Scattering and Transmissometry) is both a particle-size analyzer (size range 2.5 to 500 microns) and a transmissometer capable of measuring variable concentrations, depending on particle size. A second innovation, the LISST-25X, is a recently developed variation of the instrumentation that allows sand to be measured separately from finer particles. This is achieved by use of shaped focal plane detectors that compute 2 distinct weighted sums of angular scattering by suspended particles. The LISST-25X currently collects volume-concentration and grain size (Sauter-mean-diameter) data for suspended particles at four sites below the dam. Unit values are derived by averaging 1000 individual measurements every 15-minutes (sampling about 1.1 liters of water per hour). The volume-to-mass conversion is made once average particle density has been gravimetrically determined through conventional methods.

During high-concentration conditions, laser-transmission values (T) can fall outside of the user-defined minimal threshold (20<T<99 is acceptable range). During these periods, the LISST-25X is designed to electronically enable its pump-sampler counterpart, ensuring that point samples are physically collected when the LISST detectors are subject to bias from multiple scattering caused by the abundance of fines. As with any point-data set, the LISST point values must be calibrated to cross-sectionally integrated samples collected using isokinetic samplers. The increased temporal and spatial resolution, and continuous nature of these in-situ measurements, is a significant advance over previous methods for monitoring suspended-sediment mass balance of the Colorado River.

Recent work by Rubin and Topping (2001), has shown that suspended-sediment concentration and grain-size data can be used to back-calculate grain size of sediment on the bed upstream (a surrogate for how enriched the river is in fine sediment, and thus an indirect measure of the mass balance). Preliminary results indicate that bed-sediment grain size mimics the sediment balance (fining during depositional events and coarsening by winnowing during intervening periods). Results also suggest that LISST data will be suitable for tracking beta values in real time. Field testing of these combined technologies and others is scheduled to continue through 2004.

Rubin, D.M., and Topping, D.J., 2001, Quantifying the relative importance of flow regulation and grain size regulation of suspended sediment transport (*alpha*) and tracking changes in grain size of bed sediment (*beta*): *Water Resources Research* vol. 37, no. 1, p. 133-146.

H72B-0861 1330h POSTER

Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters

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The next time you open a bottle of spring water, consider that it may have come from a well that is drying up a blue-ribbon trout stream. The next time you super-size a meal at McDonald's, note that the fries are all the same length. That's because the potato farmers irrigate their fields with groundwater from wells, some adjacent to nearby rivers. The next time you purchase gold jewelry, consider that it may have come from a mine that has pumped so much groundwater to dewater the gold-bearing rock that 60 to100 years will pass before the water table recovers. The next time you water your suburban lawn, pause to reflect on what that's doing to the nearby wetland. And the next time you visit Las Vegas and flip on the light in your hotel room, consider that the electricity may have been generated by a coal-fired power plant supplied by a slurry pipeline that uses groundwater critical to springs sacred to the Hopi people.

These and countless other seemingly innocuous activities reflect our individual and societal dependence on groundwater that is hydrologically connected to surface water. Hydrologists understand that ground and surface water are interconnected, but frequently the legal rules governing water distinguish between ground and surface water. This has led to groundwater pumping that has dried up many rivers, particularly in the arid West. In Arizona, many once verdant streams have become desiccated sandboxes as city, mines, and farms pumped groundwater to such an extent that surface flows were totally depleted.

The problem of the impact of groundwater pumping on the environment, however, is not confined to the arid West. It is an enormous national, indeed international problem. This presentation will focus on the United States and illustrate with examples from around the country the array of environmental problems caused by excessive groundwater pumping. The locations of these case studies range from Maine to California, from Minnesota to Florida, and from Texas to Massachusetts. Indeed, a river in Massachusetts - the Ipswich River - has gone dry in three of the last six years due to groundwater pumping.

This presentation will also explore our cultural uses of water and supposed "solutions" that can actually worsen environmental consequences. It will also offer alternative solutions that would prevent some of the most severe environmental consequences. One problem, is as a matter of public policy, we have treated water as a public resource that is free for the taking, creating what economists call the tragedy of the commons. It is essential that we begin to price water more in line with its true economic value. Any meaningful reform must combine principles of water marketing together with meaningful government regulation. This presentation will outline the steps that states should take if we are to prevent further degradation of our rivers, streams, wetlands, and estuaries.

URL: http://www.islandpress.org/Water

H72C MCC: Hall C Sunday 1330h

Isotopic and Chemical Tracers of Groundwater Susceptibility: Linking Science Understanding to Policy Needs Posters *(joint with B, PA)*

Presiding: **T Bullen,** U.S. Geological Survey**; K Thomasberg,** Monterey County Water Resources Agency

H72C-0862 1330h POSTER

The Effect of 1999 Chi-Chi Earthquake on the Groundwater Flows of Choshuichi Alluvial Fan, Taiwan

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The 1999 Chi-Chi (Mw=7.5) earthquake in central Taiwan stands as one of the most important hydrogeological events in the past century in Taiwan. It has produced profound impacts for the local groundwater hydrology. The monitoring network that completed its emplacement in 1997 in the Choshuichi Alluvial Fan has recorded for the first time detailed and complex variations of groundwater levels of various aquifers during and after the Chi-Chi earthquake. In addition, hydrogen and oxygen isotope compositions for the same set of monitoring wells have been measured in 1999 and 2000 to elucidate the groundwater flow patterns and interactions among aquifers before and after the Chi-Chi earthquake. In general, water levels exhibited relatively higher positive anomalies in the northern (Changhua) section than those of the southern (Yunlin) section during the Chi-Chi earthquake. The water levels showed larger affected area for the lower confined aquifer III and the affected area diminished toward upper unconfined aquifer I. Stable isotopes identified three sources responsible for the groundwater recharging in the Choshuichi Alluvial Fan: the northern Pakua Terrace, the central Choshuichi river and the southern Touliu Terrace. During the Chi-Chi earthquake, the central Choshuichi river expanded its recharging extents primarily in a horizontal propagating way for confined aquifers and mainly flowed toward the northern section. Minor vertical mixing among aquifers were also observed for some monitoring wells implying the ruptures of aquitards. The Choshuichi Alluvial Fan eventually resumed their pre-earthquake groundwater flow patterns in the summer of 2000. We suggest that the expansion of the Choshuichi river recharge following the Chi-Chi earthquake may be due to enhanced permeability by the earthquake. The eventual resumption of groundwater flow to the pre-earthquake pattern may signify the return of the permeability to its pre-earthquake value.

H72C-0863 1330h POSTER

Quantification of Natural and Anthropogenic Components in Karst Aquifer Discharge Under Variable Flow Conditions: A Case Study of the Classical Karst (Kras), Southwestern Slovenia

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The groundwater resurgence of the Classical Karst (Kras) aquifer is an internationally shared water resource. The springs of the resurgence zone are located in Italy, while the majority of the recharge area is within Slovenia. In this study, measurements of chemical (Ca^{2+}, Mg^{2+}, Cl^-, $SO_4{}^{2-}$, electrical conductivity) and stable isotopic ($\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C_{DIC}$) parameters of the groundwaters were made in an effort to quantify the contributions of multiple sources to the aquifer discharge under changing hydrologic conditions. Principal components analysis (PCA) and end-member mixing analysis (EMMA) were employed to estimate mixing proportions among three end-members: allogenic surface water recharge from the sinking Soča River, autogenic recharge from local precipitation, and an anthropogenic component characterized by 1) anomalously high Cl^- and $SO_4{}^{2-}$ concentrations, and 2) a Cl^-/ Br^- ratio of 460. Water samples were collected on a monthly basis for two years, and daily during storm events. Hydrograph recession analysis of the major spring flow was used to identify four hydrologic flow regimes of the aquifer resurgence. The PCA/EMMA was performed on the mean chemical compositions of the four flow regimes, as well as on the data obtained from the storm sampling.

The results indicate that the three end-member sources mix in varying proportion to give rise to 4 groups of groundwaters. For all of these, the Soča River water is the largest component of flow under all flow conditions. The river provides the majority of the aquifer discharge at low flow, while during high flow there is an increased contribution from autogenic recharge. In addition, an anthropogenic component significantly affects the aquifer discharge under high flow conditions. It affects most the water supply well at Klariči, providing as much 28% of the well discharge under conditions of elevated hydraulic head during storm events.

H72C-0864 1330h POSTER

Physical and Hydrochemical Evidence of Lake Leakage and Assessment of Karst Features in the Vicinity of Lake Seminole, Southwestern Georgia and Northwestern Florida

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Lake Seminole is the surface manifestation of an interconnected aquifer-stream-reservoir system characterized by a constructed impoundment emplaced in the karst terrain of the lower Apalachicola-Chattahoochee-Flint River Basin. Physical, chemical, and isotopic constituents of water samples indicate surface water mixing with ground water of the underlying Upper Floridan aquifer, lake leakage beneath Jim Woodruff Dam, and karstic dissolution of the limestone aquifer matrix.

Major ions, nutrients, radon 222, and stable isotopes of hydrogen and oxygen collected in 2000 from 30 wells, 7 lake locations, and 5 springs indicate that in-lake springflow evolves chemically and isotopically along ground-water and surface-water pathways. Although mixing ratios of ground water to surface water in springs varied with location and season, springflow from May to October exhibited more ground-water-like qualities (higher specific conductance, dissolved oxygen, and lower temperature) than surface water. Ratios from November to April were difficult to quantify due to rapid mixing of spring and lake water during sampling and reduced flow from springs.

Lake leakage is evidenced in the bottom of the Apalachicola River about 300 yards downstream of the dam, where lake water boils up from a limestone ledge at rates of about 140-220 cubic feet per second. Dye tracing by the U.S. Army Corps of Engineers indicates that the river boil also receives water from a similar boil on land, which discharges to a sinkhole adjacent to the river. Isotopic data indicate about a 13 to 1 mixing ratio of lake water to ground water.