Assessing the Effectiveness of Water Trading by an Efficient Smart Market in Maximizing the Economic Benefits While Assuring the Environmental Constrains of the Ecosystems: The Case of Lake Urmia Basin in Iran - Ahmad Abrishamchi, Sharif University of Technology, Tehran, Iran (co-authors: M. Hassanzadeh, M. Tajrishy)

Lake Urmia is located in northwest of Iran and west of the Caspian Sea. It is the largest inland lake in Iran and the largest permanent salt lake in the Middle East. Urmia Lake and its surrounding freshwater wetlands are one of the most important and valuable aquatic ecosystems in Iran. The lake has been shrinking for years due to the anthropogenic pressures (e.g. population and urbanisation growth in the ecologically sensitive area around the lake, land use change, and climate change) and natural pressure of climate variability (extended drought). In effect, the salinity of water has increased leading to crystallization of salt. This situation has created many environmental problems. Due to the fact that agriculture is the biggest water user in this region, effective management of surface and ground water resources plays an important role in management of Urmia Lake’s condition. In this situation, “water trading” by designing an efficient "smart market" seems to be a viable option; a market with lower transaction costs which can be adaptable to changing demands and being able to optimize economic benefit within the environmental constraints. This market works by reallocating water among users and using water for high-value products. The proposed smart market is a computer aided auction that is cleared through the use of a linear program. It is developed by stylizing three components: 1) a hydrological model with fixed environmental constraints, 2) user’s demand curves for water versus price by applying Water-Crop Production Functions and 3) a linear program that optimizes the economic value of water. Due to the severe agricultural water scarcity in East Azerbaijan (one of the provinces located in the basin), this province is selected for the proposed water market. Since there are unconnected rivers in all around the province, the water trade is done independently along each river. Furthermore, any watershed along each river is considered as a user and the main agricultural product in each subbasin is considered as each user’s product. Trades are not bilateral (one to one) but rather from or to a pool along the river. If there is any availability of ground water for each user, this fact is seen in the model. The main aim of this research is to assess the efficiency of a smart market at maximizing the economic benefits of the province while the environmental constrains of Urmia Lake is assured.

Hydrochemical Processes and Metal Composition of Ain Umm-Sabah Natural Spring in Al-Hassa Oasis Eastern Province, Saudi Arabia - Ahmed. A AL-Naeem, Saudi Arabia, Al-Hassa

This study was carried out to determine the hydro-chemical processes and the metal concentration of spring water to evaluate its suitability for irrigation and other purposes. A total of 10 water samples
were collected from Ain Umm Sabah at different times and from different locations from the spring basin. EC (dS m-1), pH, temperature, total cations (Na+, Ca+2, Mg+2, K+) and anions [Cl-, CO3-2, HCO3-1, SO4-2, NO3-1, Fluoride (F+)] were determined. Some trace and heavy metals (Al, As, Ba, B, Br, Mo, Ni, Si, Cd, Cu, V, Fe, I, Pb, Mn, Zn, Sr, Se, Sb, La and Se were determined. The Spring water is classified as C4-S2 (high salinity with medium sodicity problem water). Chloride (Cl) and nitrate (NO3) concentrations were higher than the permissible limits according to World Health Organization. Standards (WHO, 1993). The Ain Umm Sabah water is Na-Cl dominant water and can create soil sodicity problems and cause Na and Cl ion toxicity to plants if used for irrigation of sensitive crops. The spring water is under-saturated (negative SI) with respect to calcite, dolomite, gypsum, anhydrite, halite, fluorite and aragonite and oversaturated (positive SI) with respect to goethite, siderite and hematite minerals. The concentration of all the estimated trace metals was within the permissible limits for its use as drinking water and other purposes according to WHO, 1993. Since the spring water contains high concentration of NO3, hence cannot be used for drinking purposes without prior treatment. The study findings suggest careful use and pumping of water from the spring. Further studies are required on regular basis to monitor the depletion in the spring water level and the temporal change in water salinity.

Farm Water Use Efficiency Assessment for Smallholder Pumped Irrigation Systems in the Arid Areas of Saudi Arabia - Abdullah Aljughaiman, King Faisal University, Saudi Arabia

Abstract: Water use efficiency for irrigated agriculture still remains low. This presents a risky trend in the near future due to diminishing water resources as well as rising population demanding increased food supplies. The objective of the study was to investigate pumped irrigation methods used by smallholder farmers in the arid land environments as well as assess the water use efficiency during crop production under usual farmer management. The study was carried out in Alhassa location of Eastern Province, Saudi Arabia. Observational study during the field transect walks in the study sites identified methods of irrigation used by the smallholder farmers, water conveyance as well as application methods and the soil physical properties. Questionnaires were developed and administered to 80 farmers in order to find out the socio-economic status of the people and the agricultural practices carried out. A detailed study was carried out in 10 experimental plots set in the study areas. Water losses during conveyance and application were assessed in the experimental plots. Of the five farms where water conveyance was through secondary canals, the mean water conveyance efficiency was found to be 81.4%. Water application efficiency in the ten blocks under different crops grown i.e. baby corns (Zea mays L.), French beans (Phaseolus vulgaris L), tomatoes (Lycopersicon esculentum L) and water melon (citrullus lanatus in the months of April to July 2012 was assessed. On average, water application efficiency ranged from 19.5% to 30 % for the crops assessed which was far below the recommended range of 65% for surface irrigation methods. The study hence shows that there is a need to improve water use efficiency in smallholder irrigated agriculture in order to conserve water and ensure no shortages of water during the times of high water demand.

Effect of Re-Utilization of Drainage Water on the Growth, Gas Exchange Rate and Ion Content of Faba Bean (Vicia Faba L.) - Sami Althabet, King Faisal University, Alhassa, Saudi Arabia

The re-utilization of drainage water (about 66 mol m-3) in Al-Hassa Oasis is one of the alternate strategies examined in this study with faba bean cultivars. Vicia faba plants were grown in sandy loam in greenhouses and salinity treatments were applied from seedling stage to flowering. Plants treated with NaCl, in general, induced a significant effect on growth parameters at the growth period. The results indicate that fully expanded leaves maintained higher Na+ than expanding leaves, whereas maintenance of low concentrations was observed for K+. Net photosynthesis rate decreased significantly with
increasing external salinity concentration and also as leaves aged. Decreases of stomatal conductance, increasing the concentration of Na+ in the leaves, and the lack of carbohydrate utilization due to salinity contributed to the low photosynthesis rate

**Collaborative Assessment of Transboundary Aquifer Systems: case studies, the Santa Cruz (Mexico-United States) and the Chateauguay (United States-Canada) - Pablo Alvarez Tostado, Oregon State University, Corvallis, OR**

Groundwater is the most extracted natural resource. Humans have extracted groundwater for thousands of years. Today, around fifty percent of the world's population relies on groundwater to meet its drinking water needs. Computer models and numerical models are powerful tools that allow the analysis and understanding of aquifers. However, groundwater systems are inherently hidden and uncertainty in characterizing them remains. Political boundaries add complexity to an already complicated system, and often countries find themselves with different interpretations of the aquifer. That is the case of the Santa Cruz Aquifer, shared by the American state of Arizona, and the Mexican state of Sonora. Despite collaborative language and discussion forums a joint assessment has not been completed. In order to adequately manage groundwater it is imperative to know and understand the aquifer. I will conduct assessment of three Transboundary Aquifer Systems (TAS), the Santa Cruz Aquifer, the Chateauguay River Aquifer, and a third system that is being selected at the moment. The assessment framework is being developed specifically for this study, beginning with some conflict assessment theory the framework contains the following categories: context, institutions hydro-hegemony (Zeitoun, 2008), values, and goals. The framework will provide an in depth scope of every case study; and allow for the comparison between the three case studies. This study follows the principles of the UN Resolution 63/124 (The Law of Transboundary Aquifers) learning from selected cases, and promoting cooperation. The analysis of the case studies will highlight important aspects that allow or impede effective collaboration in assessing and managing TAS.

**Designing Structures in Highly Dynamic Streams: Managing a Surface Water System in Post-Earthquake Haiti – Mark A. Anderson, CH2M Hill, Portland, OR (co-author: M. Ruark)**

Changing climate patterns, extensive deforestation, and new urban and agricultural land use in the Riviere Grise basin of southern Haiti have dramatically affected the watershed, producing a system prone to flash flood events and excessive sedimentation. While this basin is a unique case study, designers of in-stream structures in watershed settings that can include forest fires, intensive logging, dam removal, volcanic eruption, or rapid urbanization may recognize similar challenges. The Riviere Grise is relied on for agricultural water supply and gravel mining, as well as drinking and bathing water for nearby communities. A new diversion structure and repair of the canal headworks are planned at Dumay, near Croix des Bouquets. This system would replace an earlier structure built in the 1950s, which has since filled in with sediment. Subsequent attempts to relocate the headworks upstream have had only temporary success. Extreme storm events of increasing intensity and frequency challenged the designers and design efforts. Tropical Storm Isaac and Hurricane Sandy both affected the basin significantly in 2012. Since the basin has been rapidly deforested, these events now produce extensive bank erosion near the site and result in regular changes to the course of the river. Additionally, the steep gradient of the river as it exits the uplands immediately upstream of the project site, combined with the amount of sediment the stream is transporting, produces stream aggradation and siltation in the adjacent irrigation canal. Finally, the poor condition of existing infrastructure and the extreme poverty of the area require a structure with minimal maintenance requirements. The designers have attempted to address these challenges by planning a low-head barrage with a gravel notch to maintain
sediment transport within the stream. A manually-controlled overflow gate, along with a sedimentation basin and a side channel spillway, have been planned to reduce siltation in the irrigation canal and to cut off large flows due to extreme storm events. The banks on both sides of the river will be anchored by a system of spurs, designed to maintain flow in the main channel of the river near the canal headworks and to reduce bank erosion. Site visits, survey, and photo documentation were used to determine the bed material, locate the previous barrage (5 to 6 meters below the current river bed), and observe the extensive bank failure, as well as siltation in the canal, and other storm impacts after each major event. This work was financed by the United States Agency for International Development (USAID). The opinions expressed are the authors’ and not those of USAID.


The use of inorganic nitrogen (N) fertilizers has become an essential part of modern agriculture and has helped increase yields to keep pace with an ever growing population. N is the most dynamic nutrient in nature, and biological activity can transform it into several mobile forms. Nitrate (NO_3^–) is the most mobile form of N and is highly susceptible to transport to ground and surface waters. The purpose of this study is to observe the storm flow dynamics of N in three agricultural watersheds. Specifically, the study focuses on the mode of delivery of N to ephemeral streams in an agriculture field of moderate relief in the absence of tile drainage. The study is being conducted in a ninety-seven hectare agriculture field in Macon, County Illinois. The study site is divided into three watersheds, with four plots per watershed, and three topographic positions per plot. Volumetric water content (VWC) is being measured continuously in each of the three topographic positions. In each watershed, stream stage collected over storm hydrographs using automated water samplers will be compared to volumetric water content in each topographic position. Four 6.1m groundwater monitoring wells and eight vacuum lysimeters in each watershed are being monitored to determine the fate and transport of N to soil water and groundwater. Soil sampling was completed on a 0.4 hectare field over the entire field during the Spring 2010, Fall 2010, Fall 2011, and Fall 2012. Samples were analyzed for total N and NO_3^– concentrations to compare N concentrations with topographic position. Preliminary results show that NO_3^– concentrations are highest in soil water, followed by groundwater, and lastly surface runoff. Data from the June 15, 2011 storm showed that on the falling limb of the hydrograph VMC decreased on hill slopes and shoulder slopes, while VWC on foot slopes increased. This is indicative of a variable source area controlled watershed where the near stream zones undergo prolonged saturation from the subsurface drainage of the shoulder slopes and hill slopes. A possible management implication from this study is that fertilizer management could be based on elevation and hydrology instead of expected yield.

**Low Cost Electrofiltration/Coagulation Technique in the Provision of Quality Drinking Water - Emmanuel Asapo, Lagos State University, Lagos, Nigeria**

Water is generally perceived as a free social commodity in developing countries. This paper presents the challenges being faced by households in meeting quality drinking water in Lagos State, Nigeria. With 98 L/c. d as the average water consumed in a peri-urban setting in Lagos, Nigeria, and the inability of the state owned water supply agency to meet daily water supply, alternate water supply sources have been explored. The major source of water is now groundwater through drilled boreholes available in approximately 75% of the houses with an average of 6 people and a family income range between $800 and $1500. Analysis of the water quality from these boreholes showed that the organoleptic parameters require urgent attention in meeting known standards. Physico- chemical parameters showed that the
water samples contained more than 0.5 ppm of Iron and pH was slightly acidic. Survey results showed that no treatment method exist in most privately owned water supply facility. However it was highly desired. The research finally presents a low cost drinking water technology with efficient removal of the organoleptic and the physico-chemical parameters of water in Lagos State, Nigeria. This technique will combine water supply for 10 to 12 household reducing storage and maintenance costs.

**Inventory and Monitoring of Groundwater-Dependent Ecosystems on National Forests and Grasslands**

– Leslie Bach, The Nature Conservancy, Portland, OR (co-authors: C. Carlson, J. Gurrieri, A. Aldous)

Groundwater-dependent ecosystems (GDEs) are located across the landscape in every ecoregion of the United States. Although largely unrecognized, GDEs play an important role for both ecological and human communities. Groundwater-dependent ecosystems support a diversity of species, including a suite of rare biota, and habitats, often serving as critical refugia during extreme climatic conditions. In addition to being ecologically important, GDEs provide key services to society, including high-quality water for human consumption, agriculture, and industry, support for fisheries, and production of specialty commodities.

The Forest Service, in cooperation with The Nature Conservancy, has produced a set of Field Guides for inventory and monitoring of GDEs (GTR-WO-86a (Level I) and GTR-WO-86b (Level II), March 2012 - [http://www.fs.fed.us/geology/groundwater.html](http://www.fs.fed.us/geology/groundwater.html)). These Field Guides represent a consistent and scientifically sound approach to characterizing and monitoring groundwater-dependent resources on lands managed by the Forest Service and other entities. Rigorous field testing on several National Forests and Grasslands across the US resulted in a user-friendly product and proved that the methodology is applicable in a wide range of different ecological and climatic locations.

Several Forest Service field units across the West are using the Field Guides to address inventory and monitor GDEs, including the Humboldt-Toiyabe (NV), Ashley NF (UT), Prescott NF (AZ), and Umatilla NF (OR). In addition, state agencies in Utah and Michigan have either begun using the Field Guides to conduct inventories or are exploring their usefulness. Here we present some initial data from the Spring Mountains National Recreation Area on the Humboldt-Toiyabe National Forest in Nevada.

**The Forest Service National Best Management Practices (BMP) Program: Assessing the First Year of Implementation**


In May 2012, the USDA Forest Service (FS) initiated implementation of a new BMP Program across all national forests and grasslands. The National Program is an innovative approach to protecting water quality through a consistent national framework that spans land management activities across varying landscapes and provides for BMP monitoring. Through implementation of this program, the FS has improved consistency, comparability, and accountability in protection of water quality from ground-disturbing activities on National Forest System (NFS) lands. The National BMP Program consists of four main components: 1) the National Core BMP Technical Guide ([Volume 1, FS-990a, April 2012](http://www.fs.fed.us/geology/groundwater.html)); 2) the National Core BMP Monitoring Technical Guide (Volume 2, FS-990b, in prep, September 2014); 3) revised national direction; and 4) a national data management and reporting system. The National Core BMPs are written in broad, non-prescriptive terms that recognize the importance of existing state and tribal BMP prescriptions and provide for integration with the national program. The National Core BMP
Monitoring Protocols determine whether the National Core BMPs are being implemented as planned and whether they are effective. The first year of national BMP monitoring was completed in September 2013. Through the monitoring data and associated information and comments on program implementation, the agency will be assessing the effectiveness of the program. Monitoring results will allow the agency to demonstrate how well it is meeting its requirements for protecting water resources, improving agency credibility and validating our commitment to EPA, OMB, the States, Tribes, and other partners.

**Contaminants in Drinking Water as a Result of Private Well Homeowner Behavior - Isabella Bergonzoli, Oxbridge Academy of the Palm Beaches, West Palm Beach, FL (co-author: T. Thornton)**

In Florida, approximately one million people rely on private groundwater wells for drinking water (USGS, 2005). Like many states there is little to no regulation on the health of private well water. This lack of attention to private wells was believed to be one cause for a 2010 cancer cluster in Loxahatchee, FL. Although speculation regarding the exact source of the cancer continues to cause debate, during remediation studies it surfaced that homeowners were unknowingly creating a cancerous substance (trihalomethanes) through improper maintenance of their private water filtration systems. This ignorance of personal responsibility was confirmed in 2012 and 2013 when hundreds of high school students from three different Palm Beach County schools participated in a program called GET WET! (Groundwater Education Through Water Evaluation & Testing). They worked with local governmental representatives, ENGOs, and universities to chemically test groundwaters and to increase awareness of the need for water systems monitoring. One student decided to evaluate homeowner behavior in the Loxahatchee and Jupiter Farms area through a survey sent out to private homeowners. Behaviors regarding their knowledge, usage, and maintenance of private wells, septic systems, and filtration systems were addressed. Included in the survey were questions pertaining to what might motivate a homeowner to test their water systems. Results show that homeowners are not aware that the groundwaters may be stressed due to natural and manmade contaminants. Results also indicate homeowners do not understand how to properly maintain their systems, are uncertain of the chemicals they should test for, and are not quite sure who to contact regarding this matter. Furthermore, the results for homeowner motivation to test their systems also shows a lack of groundwater understanding.

**Summer Evapotranspiration (ET) in Eastern WA: Trends and Linkages to Regional Circulation - Nick Bond, University of Washington, Seattle, WA (co-author: K. Bumbaco)**

The summertime demands for water in agricultural regions depend on the rate of evapotranspiration (ET). Daily records of potential ET are available from the mid-1980s through the present for four stations in eastern Washington state (George, Harrah, Lind and Odessa) through the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) under the auspices of the Bureau of Reclamation. These records reveal a secular increase in the seasonal mean (June-August) potential ET over the period 1987-2012. This increase can be attributed largely to an increase in solar irradiance (from roughly 560 to 610 langleyes) over the same period. Interannual variations in seasonal mean ET are linearly related to the seasonal mean solar irradiance and air temperature with correlation coefficients of 0.76 and 0.60, respectively. Daily data for potential ET and other atmospheric variables are used to determine the regional atmospheric circulation patterns associated with periods of large water demands. Among other factors, anomalous ridging aloft centered to the west of the study area generally precedes the days with the greatest potential ET. The relationships that have been found will ultimately be used in empirical downscaling of potential ET from global climate model projections.
Carbon, Nitrogen, and Phosphorus Sequestration in the at ArcataTM's Constructed Wetlands for Wastewater Treatment: A Study of a Hyper-eutrophic Wetland System - Mary Burke, Humboldt State University / Arcata Marsh Research Institute, Arcata, CA (co-authors: R. Gearheart, B. Finney)

A better understanding of the role that emergent macrophyte species play in nutrient storage and specifically carbon sequestration is needed to guide design and management of freshwater wetlands. In this 2009 study, Typha latifolia and Scirpus acutus were studied for biomass productivity, decomposition, and the potential for nutrient storage in a 0.8 ha (1.9 acre) constructed wetland for wastewater treatment in Arcata, California, USA. The constructed wetland, sampled at one point in time after 24 years of unharvested growth demonstrated 300,000 kg/ha of biomass. Mean productivity for Typha latifolia was 30,399 kg/ha and for Scirpus acutus was 42,264 kg/ha. Of the two dominant macrophyte species, Scirpus acutus demonstrated a more recalcitrant biomass that stores carbon, nitrogen, and phosphorus. Due to the slow rates of decay, the wetland system shows accretion of 1.5 cm/yr in the peat layer and 1.4 cm/yr in the settled solids. The peat layer and settled solids contain 57% of the carbon mass, 79% of the nitrogen mass, and 34% of the phosphorus mass in the wetland system. Using the demonstrated productivity, decomposition, and nutrient concentration of the macrophytes, the treatment marsh sequesters 21,000 kg C/yr and has accumulated 120,000 kg C over 24 years. Sequestered carbon in constructed wetlands has the potential to be used by the City of Arcata to balance carbon emissions from wastewater treatment.

Assessment of Hydrologic Models for Re-Evaluating Climate Change Impacts on Portland's Surface Water Source - Tzu-Hsin Chiao, University of Washington, Seattle, WA (co-authors: B. Nijssen, L. Stickel, D. Lettenmaier)

In the Pacific Northwest, anthropogenic climate change in the 20th century has already contributed to changing hydrologic patterns, which are expected to continue in the coming decades. Hydrologic models with varying complexities and structures have been used to evaluate future hydrology based on climate forecasts. While the uncertainty in projections of future climate is well documented, uncertainty associated with hydrologic models is less well understood or even recognized. Here we describe a review of hydrologic models that may be adapted to evaluate implications of future climate change projections for the Bull Run watershed. The Bull Run watershed is the primary source of drinking water for the City of Portland and its wholesale supplies to other water providers. Although the impacts of climate change on the Bull Run were studied in 2002, the Portland Water Bureau currently does not have an operating hydrological model that would allow it to reexamine potential impacts using newer global climate model outputs. We reviewed eight existing hydrologic models for the watershed based on a suite of criteria, including the general ease of usage, past performance in climate change studies, and the ability to represent key hydrologic processes (e.g., ability to represent runoff production in transient rain/snow regimes in forested environments typical of the Bull Run watershed). Based on the screening analysis, three models were selected by the team for further investigation: DHSVM (Distributed Hydrology Soil Vegetation Model), PRMS (Precipitation-Runoff Modeling System), and VIC (Variable Infiltration Capacity). Detailed analyses of these three models were performed with respect to their ability to reproduce historic observed streamflows in the Bull Run watershed using a common set of gridded, long term climate forcings. In addition, these models were evaluated based on how well they capture inter-annual variations in past climate and the resulting streamflow variations. Specifically, this research reports inter-model variations in the climate sensitivity of various hydrologic components, including the timing of the centroid of flow, peak flow magnitude and timing, and baseflow recession. This evaluation of the climatic sensitivity of hydrologic models should contribute to a better understanding of the range of tools available to municipal water providers to evaluate uncertainties in
how climate change will affect the hydrology of mid-elevation forested watersheds like the Bull Run. The evaluation process also illustrates the benefits of co-production of useful knowledge about the impacts of climate change by building partnerships between the academic and governmental sectors.

Examining Modeling Approaches for the Rainfall-Runoff Process in Wildfire Affected Watersheds - Karletta Chief, University of Arizona, Tucson, AZ (co-authors: L. Chen, M. Berli)

Wildfire can significantly change watershed hydrological processes resulting in increased risks for flooding, erosion, and debris flow. The goal of this study was to evaluate the predictive capability of hydrological models in estimating post-fire runoff using data from the San Dimas Experimental Forest (SDEF), San Dimas, California. Four methods were chosen representing different types of post-fire runoff prediction methods, including a "Rule of Thumb", MODRAT, HEC-HMS Curve Number, and KINEROS2. Results showed that simple, empirical peak flow models performed acceptably if calibrated correctly. However, these models do not reflect hydrological mechanisms and may not be applicable for predictions outside the area where they were calibrated. For pre-fire conditions, the Curve Number approach implemented in HEC-HMS provided more accurate results than KINEROS2, whereas for post-fire conditions, the opposite was observed. Such a trend may imply fundamental changes from pre- to post-fire hydrology. Analysis suggests that the runoff generation mechanism in the watershed may have temporarily changed due to fire effects from saturation-excess runoff or subsurface storm dominated complex mechanisms to an infiltration-excess dominated mechanism. Infiltration modeling using the Hydrus-1D model supports this inference. Results of this study indicate that physically-based approaches may better reflect this trend and have the potential to provide consistent and satisfactory prediction.

An Integrated Approach to Economic Valuations of Salmon Habitat Restoration Management – Bern Dealy, University of New Mexico, Albuquerque, NM (co-author: B. Bridge)

Endangered salmon fisheries are water-based ecosystems facing numerous management challenges. While policymakers have various management tools at their disposal, each of these options face unique economic, social, cultural, legal and environmental implications. Efforts have been made to assign nonmarket values to endangered salmon habitat restoration. Some aspects of these values include existence, bequest, and recreation values. This study intends to offer a new perspective on the valuation of this important endangered aquatic habitat. Specifically, this analysis expands upon existing methods using a bioeconomic model that incorporates the unnatural concentration of a natural predator to salmon. In so doing, we derive marginal value estimates of salmon habitat restoration that are consistent with economic theory. As a case study, we look at the endangered salmon management strategies implemented within the Columbia River Basin. In this region, hydroelectric dams have had a significant impact on salmon habitats. Attempts to mitigate the impact of hydroelectric dams on salmon populations include the use of fish ladders to facilitate spawning and hatcheries to boost populations. Also, an issue of increased contention in this area is the interaction between the hydroelectric dams (a man-made threat) and one of the salmon's natural predators (pinnipeds, including the California and Steller sea lions). Despite the effectiveness of fish ladders to facilitate upstream travel for spawning purposes, these ladders create a traffic bottleneck that attracts an unnatural concentration of pinnipeds who feed on the endangered salmon. In 2007 the Marine Mammal Protection Act was amended in order to legalize the removal (both lethal and non-lethal) of a restricted number of pinnipeds. To date, these removal efforts have generated significant costs. In a modeling scenario, these costs are included with those of the existing habitat recovery programs to generate a more comprehensive measure of the nonmarket value of salmon habitat restoration. The lethal removal of endangered sea lions for the benefit of salmon habitat restoration results in an additional model outcome; an implied nonmarket
value of endangered sea lions. This may be of even greater interest due to the fact that sea lion value is exclusively nonmarket.


In 2010, the United States, the States of California and Oregon, PacifiCorp, regional Native American tribes, and a number of other stakeholder groups signed the Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA lays out the process for additional studies, including water quality improvement projects in the Klamath Basin during the interim period leading up to dam removal. PacifiCorp contracted with Watercourse Engineering, Inc. (Watercourse) to conduct a pilot-scale study to test the feasibility of hydrodynamic vortex separation technology to remove particulate organic matter from the Klamath River. A prototype continuous deflection separation (CDS) particle separator was specially constructed and tested for this study. CDS separators are most commonly employed in municipal stormwater treatment systems to remove coarser particulates, but this application is unique in that this is not a stormwater treatment application of the technology. Several studies have identified stormwater treatment technologies as an effective way of removing particulates and associated nutrients that potentially promote algae growth. However, no significant work has been completed to investigate the potential of using stormwater treatment technology to directly remove algae and organic matter. The Klamath River is nutrient-enriched, due to large loads of nutrients and organic matter to the river from hypereutrophic Upper Klamath Lake (UKL) and other upstream sources. Reductions of seasonal algae and organic matter loads emanating from UKL could provide substantial water quality improvements in the Klamath River. The technology, herein referred to as the organic matter separator, was used in this application to reduce the concentrate and reduce the waste stream. Treated water was discharged through the outlet and the waste stream discharged from the sump. The system removed a notable fraction (i.e., 25 to 72 percent) of particulate matter. The outlet/sump discharge ratio was the principal factor that determined the removal efficiencies observed from the experiments. Particulate organic matter was characterized through particulate carbon, nitrogen, and phosphorus, as well as chlorophyll a and algae species. Removal efficiency was tested at different flow rates and outlet/sump fractions. Based on these data, relationships were developed to identify different removal quantities for different operations. Overall, the 2012 pilot study organic matter removal experiment identified that such a technology could be effective for improving downstream water quality through the removal of particulate algal biomass. The study results demonstrated that removal efficiency depends on flow rate and outlet/sump ratio. These parameters in turn would affect the economics of constructing and operating a larger-scale separator system.

**Using Basin-Scale Numerical Modeling to Evaluate Ground Water Dependent Ecosystem Services for the Calapooia Watershed, Oregon - Barton Faulkner, USEPA Office of Research and Development, Ada, OK (co-author: J. Groves)**

Many states maintain public online databases for driller's logs. These logs typically contain screening level information on pumping tests, and sometimes lithologic descriptions that can be correlated with established hydrogeologic units. Although this information is at the screening level, it still can aid in constructing conceptual models for ground water flow in large watersheds where new data collection is not always feasible. The Oregon Water Resources Department maintains such a database, and the abundant information in it aided construction of a conceptual model for the hydrogeology of the Calapooia Watershed, a sub-basin of the Willamette River Valley, Oregon. We examined over 1500
driller’s logs in development of a three-dimensional numerical ground water flow model with an areal extent of 45,852 ha (the lower non-bedrock portion of the watershed). Calibrated model runs were created for both the wet and the dry seasons. Wet season flow budget errors were on the order of 2%, and total estimated seepage was 19,988 cubic meters per day. In the dry season, flow budget error was about 11% with total basin wide seepage computed to be 5838 cubic meters per day. The results are quite consistent with observed stream network expansion in the region due to seasonal rainfall patterns, and highlight the importance of ground water for maintaining ecosystem function in streams and wetlands. This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.

The Use of Pfafstetter ‘Ottobacias’ as Innovative Technique for Integrated Water Resources Management - Carlos Gallego, COBRAPE - Cia Brasileira de Projetos e Empreendimentos, Rio de Janeiro, RJ, Brazil (co-authors: R. F. Tozzi, C. Taschemayer, B. Miró Tozzi, C. V. S. Fernandes)

The purpose of this article is to demonstrate the application of the watersheds coding methodology developed by Otto Pfafstetter as innovative techniques to support the Integrated Water Resources Management (IWRM) in Brazil. The methodology was originally proposed by the engineer Pfafstetter in the 80s, and is based on the ranking of watersheds, dividing and codifying its tributaries in numbers. Initially, the methodology was applied in South America, assigning a numeric code, ranging from 1 to 9, to the main river basins identified on the continent. The division of the sub-basins in the lower level depends directly on the river system and its relief, i.e., the coding continuity is associated to the tributaries of each river basin analyzed. It is noteworthy that the codes of the original basins, which were divided, remain - this ensures the method hierarchical recursiveness. The use of this methodology, named "ottobacias", to support the management of water resources in Brazil started in the late 90's, with the creation of the Federal Law No. 9.433/97, which established the National Policy of Water Resources and created the National System of Water Resources Management. This law set the watershed as a territorial unit for the implementation of the National Policy of Water Resources, and proposed State Water Resources Plans and Watershed Plans as management tools. For the execution of these plans, the methodology Pfafstetter started to be used. The first study to use of the methodology was the Water Resources Plan of the State of Tocantins (PERH/TO), conducted in 2008. During its development, it was found that the application of the methodology ottobacias in conjunction with other current tools, such as Geographic Information System (GIS), enabled the creation of a georeferenced database, composed by relevant information to the water resources management system, which could be used as a decision support systems by the governing, due to its ease of gathering the information at different levels of regionalization. The study results were very satisfactory and served to consolidate the implementation of the methodology ottobacias as a tool for the management of water resources. After the completion of PERH/TO, other studies were developed using the methodology ottobacias, highlighting the Water Resources Plan of the State of Minas Gerais (PERH/MG) and the Water Resources Plan of Paraíba river basin (PRH-Paraíba). In the case of PRH-Paraíba, the construction of the georeferenced database used the ottobacias at level 12, which resulted in 4,682 cells, ranging between levels 6 and 12. As a conclusion of the study, it was observed that the use of ottobacias turned up very interesting when applied to management tools used for planning.

Current State of the Hydrological Monitoring Industry - USA versus Global Trends - Stu Hamilton, Aquatic Informatics Inc., Vancouver, BRI, Canada

The hydrological monitoring industry is undergoing rapid evolution worldwide! In the past decade, a paradigm shift in environmental monitoring technologies, standards, and practices has transformed the
industry. Is the United States leading or lagging? How can today's monitoring agencies keep pace?
Answers will be provided in the presentation "The Current State of the Hydrological Monitoring Industry - USA versus Global Trends," which will reveal the most comprehensive and up-to-date information on the water monitoring industry. Over 700 water professionals (including AWRA members) participated in a global survey in the fall of 2012, providing deep insight into the current state of the industry. By benchmarking their programs against those of peers, water professionals can better plan future investments as they modernize their programs in response to rapidly evolving expectations and emergent technological opportunities. What is driving all this change? The growing global population is placing unprecedented burden on water resources, needed not only for safe drinking water, but also to support agriculture, energy, transportation, manufacturing, and civil infrastructure. Increasing climate uncertainty invalidates many historic assumptions, creating a need for new information for water management. Regulations and water rights are growing in complexity. Water resource managers, hydrologists, and scientists are facing enormous pressure to meet mounting stakeholder expectations for high-quality, real-time information. The days of publishing raw gauge data have passed. Quality-controlled data are expected to be published sooner, in fact, by 2022, 46% of respondents forecast that they will be publishing daily means and unit values dynamically. Demand for metadata and higher-level analysis has increased, while tolerance for data faults in dynamic data has declined. Water resource managers are responding by adopting continuous monitoring hardware, real-time communications technologies, and specialized hydrological data management systems. Today, over 70% of respondents use digital multichannel data loggers; 67% percent use solid state electronic sensors; and 61% use multi-parameter water quality sensors. For real-time data transmission, respondents are using digital data retrieval (e.g., logger files) for 63% of stations. Find out which technologies are forecast to be most popular by 2022. Water resource professionals today are producing, collecting, and processing unprecedented volumes of complex hydrological data! Naturally, they are concerned with ensuring data quality, defensibility, and interoperability, and they are taking action. 62 percent of respondents reporting having adopted "clearly communicated objective(s) for data quality." 66 percent use, or plan to start using, the USGS accepted standard operating procedure reference documents. Water resource professionals depend on data management systems to capture, store, correct, derive, analyze, visualize, and report on massive volumes of environmental data from disparate sources. Microsoft Excel is still the most common tool, used by 35 percent of respondents as their primary data management system. Other systems in use include custom solutions and integrated environmental systems. Additionally, 28 percent of respondents reported using commercial hydrological data management software. Learn which systems are most effective in meeting stakeholder expectations for real-time information, metadata availability, higher level analysis, and timely reporting and publishing. Everyone who attends will receive a FREE copy of the 30-page report.

North American Stream Hydrographers (NASH) - Stuart Hamilton, Aquatic Informatics, Vancouver, Canada (co-authors: R. Andrishak, R. Boals, A. Bouchard, S. Dery, P. Pilon, P. Whitfield)

NASH is a society that brings researchers, practitioners and hydrometric data-users together in a community of practice for advancing the science of hydrometry to better resolve - and communicate - best practices and innovative solutions for the challenges of streamflow monitoring. There are currently six active working groups in NASH covering the themes of: Uncertainty Frameworks; Common Data Access Frameworks; Network Design; River Ice; Streamflow Reconstruction; and, Standards and Training. NASH is effective as a result of facilitating a collective approach to problems that members are interested in solving. This 'stone soup' approach minimizes organizational overhead so the primary focus can be on interesting questions and problems rather than policy, procedures or governance issues. The
NASH collaboration with AWRA, and the opportunities for AWRA member to engage in these working groups are explained.

More Than an Organized Toolbox: Fostering Innovation and Adaptation with the Carpe Diem West Academy - Holly Hartmann, University of Arizona, Tucson, AZ (co-authors: K. Morino, K. Teige, K. Wiltshire)

Resource managers face a confusing and often overwhelming plethora of evolving tools and methods for considering climate change in planning and management. Many tools require substantial investments in data gathering, analysis, or stakeholder engagement. Many address only pieces of the climate change adaptation challenge without clear interconnection. Irreducible uncertainties associated with climate change call for an iterative approach to risk management using a mix of tools and methods matched to the stage of risk management being addressed, the specific issues and time scales of relevance, the resources available for planning, desired characteristics for stakeholder engagement, and decision making roles. We integrated several organizing frameworks into an interactive 'toolbox', the Carpe Diem West Academy (carpediemwestacademy.org). It reviews and characterizes over 250 tools and training resources, developed by others, that are useful for water resources planning and management, including consideration of interconnections with other resources such as energy and ecosystem services. Academy users are supported through a variety of approaches, at a scale that is practical to sustain, that fosters shared learning about tools and their application in adaptation efforts, and that can support establishment of best practices for incorporating uncertainty and climate change. The Academy's webinar series connects water resources practitioners, methodology experts, tool designers, and webinar participants in candid discussion about specific management challenges, best practices, communication of results to executive boards and the public, costs and effectiveness of analysis efforts, and first steps to getting started. Topics covered over our two-year series include: iterative risk management, robust decision making, vulnerability assessment, scenario planning, downscaling climate projections, watershed valuation, and effective messaging. We use "Tool Time" to incentivize submission of questions for webinar discussion. Tool Time provides an extended consultation with a practitioner and staff within their organization, to match their needs with specific tools in the Academy compendium. The webinar discussions and Tool Time consults provide a unique perspective about the challenges facing western water resources practitioners, opportunities for innovative and effective responses, needs for tools and training, and establishment of best practices.

Seasonal Climate Outlooks and Water Management: Using the New Dynamic Probability of Exceedance Outlook Tool - Holly Hartmann, University of Arizona, Tucson, AZ (co-authors: E. O'Lenic, D. Hammond, S. Marquardt, M. Charles, D. Unger)

The National Weather Service Climate Prediction Center has long provided maps for their probabilistic seasonal climate outlooks of temperature and precipitation. The maps are necessarily limited in their depiction of probabilities associated with tercile classes. The maps have been supplemented by probability of exceedance (POE) outlooks that show the seasonal outlooks as cumulative density functions (cdfs). The cdfs enable users to identify probabilities for temperature or precipitation thresholds and intervals that are not limited to the tercile classes. However, these POE outlooks have proved nearly intractable for users to interpret, even though they contain substantial ancillary interpretive information. To improve the usefulness of the POE outlooks, we developed an interactive version, the Dynamic POE Outlook Tool. The tool allows users to view the seasonal climate outlooks as POE, probability of non-exceedance, or probability density graphs, and to extract outlooks for specific thresholds or intervals, identified on the basis of the variable or the probability. It also provides simple
statements about the customized outlooks, including comparisons to the climatological reference period. Field-testing for reliably correct interpretation by water resources practitioners indicated that the dynamic POE leads to higher user comprehension of the climate outlook's information content. We demonstrate use of the tool for several water management applications.

**Estuarine Conditions and High Tides for a 4 Year Period at Beaver Creek, Oregon - Glen Hess, U.S. Geological Survey, Portland, OR**

Plans to restore Beaver Creek estuary, on the Oregon coast, includes habitat for native plants and native fish such as coastal coho salmon and steelhead. For a successful restoration, planners and managers need an understanding of tidal, storm-surge, and water temperature dynamics in the Beaver Creek estuary, which extends from the mouth of Beaver Creek at the Pacific Ocean, upstream approximately 4 river miles. The objective of this USGS study was to collect baseline hydrologic data at representative sites for the 4-year period of 2010-2013 to improve our knowledge of the hydrology of the Beaver Creek estuary. The collection and analysis of data by the USGS provided an initial hydrologic understanding of the estuary/wetland system. Monitoring of stage and specific conductance, a surrogate for salinity or seawater intrusion, at the four locations recorded the number of events and duration of events when storm surges affect stream water quality. These data show that a sand bar near the mouth of Beaver Creek controls the frequency and magnitude of intrusion of ocean water into lower Beaver Creek. The pattern of streamflow and water-level fluctuation, coupled with the salinity, temperature, and tidal data, provided an indication of the predominant source of water to the estuary. Periodic streamflow measurements at four sites upstream of tidal influence during periods of relatively stable streamflow identified the flow contributions to the estuary from upland sources. Oregon State water temperature standards stipulate that a 7-day moving average of the daily maximum temperature shall not exceed 64 degrees Fahrenheit or 18 degrees Celsius. The 7- day moving average of maximum water temperature exceeding that standard during 2010-12 at the three sites indicate the upper basin site had 0% of days exceeding the standard, while lower basin sites had 20-25% of days exceeding standards. High specific conductance is an indicator of seawater intrusion in the Beaver Creek estuary. Typically, seawater specific conductance is about 20,000uS/cm. High specific conductance in water at the Beaver Creek at Hwy 101 site resulted from storm surges on 13 occasions during September-May in 2011, when seawater overtopped the sand bar near the creek mouth. Events of high specific conductance at the Hwy 101 site correlated with tides above 9.5 feet measured at the NOAA tidal stage gage at nearby Yaquina Harbor. Thus, the 9.5-foot value at the NOAA tidal stage gage can serve as a useful indicator of seawater-intrusion events.

**Large River Floodplains and Ecosystem Services: Benefits of Increased Hydrologic Connectivity - Laura Hockenbury, USEPA Region 10, Seattle, WA (co-authors: B. R. Faulkner, K. J. Forshay, J. Brooks)**

Large river floodplains present diverse benefits to communities, yet management strategies often fail to consider the broad suite of ecosystem services provided by these systems. The U.S. Environmental Protection Agency (EPA) is evaluating the benefits associated with restoring large river floodplains, specifically levee setback and revetment removal. This effort will provide scientific support for community-based environmental decision making within our study area on the McKenzie River, a tributary to the Willamette River in Oregon, and support emerging restoration efforts along the Yakima River in Yakima, Washington, and across the nation. The EPA is working with the McKenzie River Trust, the City of Yakima, and the Washington Department of Transportation. We hope to bring a more holistic approach to enhance sustainability, with consideration of the ecosystem services offered by dynamic river systems. Restoring hydrologic connectivity in floodplains can enhance the overall ecological
condition of riparian systems. We have examined groundwater flow patterns, denitrification rates, and water isotopic signatures for identifying water sources at Green Island, a 1,055 acre restoration effort located at the confluence of the McKenzie and Willamette Rivers in order to identify specific benefits of increased hydrologic connectivity. The Yakima River, which winds through a highly productive agricultural valley, has been identified as having high potential for successful restoration and increased floodplain connectivity. The EPA is undergoing research to assess groundwater flow and denitrification rates occurring within the Yakima River floodplain. With these two case studies, the EPA will present a scientific review of the issues and benefits associated with restoring large river floodplains through levee setback and the influence of hydrologic connectivity. This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.

**Water Transactions: Instream Flow Monitoring Protocols to Evaluate the Benefit of Water Right Transfers - Rankin Holmes**, Farm Stream Solutions, Missoula, MT (co-authors: A. Willis, A. Nichols, M. Deas)

The National Fish and Wildlife Foundation (NFWF), utilizing market mechanisms throughout the western U.S., has been one of the primary leaders in funding flow transactions, attempting to address stream system dewatering, fish habitat and water quality impairments; however, without a standardized instream flow monitoring method, it has proven challenging for stakeholders and funders alike to fully understand the environmental benefits and potential opportunities of this work. With support from a Natural Resource Conservation Service (NRCS) Conservation Innovation Grant (CIG), NFWF has been working to develop a monitoring framework to quantify the ecological benefits of these flow restoration activities (i.e., transferring a traditional consumptive-use water right to a non-consumptive-use instream for environmental purposes). NFWF has selected the Klamath Basin to test and develop the "Instream Flow Monitoring Protocols", to better track and account for leased or acquired surface water rights. Results from these experiments were analyzed to assess benefits to streamflow volumes, aquatic habitat, and water temperatures. The findings help support the scope and methodologies presented, and support science-based assessments of flow transactions.

**Modeling the Effect of Climate Change on Reservoir Water Quality Using the Projections of Multiple General Circulation Models and Bayesian Model Averaging - Yongtai Huang**, The City University of New York, New York, NY (co-authors: D. Pierson, E. Schneiderman)

A number of general circulation models (GCMs) have been developed to predict future climate change, and these data are widely used to predict the effect of climate change on hydrology and water quality. However, the reliability of future predictions is uncertain. The objective of this study is to investigate the effects of climate change on the nutrient and trophic status of Cannonsville Reservoir (one part of the New York City water supply system) using the projections of multiple GCMs and Bayesian Model Averaging. Future climate scenarios are simulated using a watershed model coupled to a reservoir model. These models are driven by meteorological scenarios created from historical measured meteorological data and the outputs of the GCMs contributing to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4), under a range of emission scenarios (20C3M, A1B, A2, and B1 scenarios). Output for the 20C3M scenario from the watershed and reservoir models are used to calculate the probabilistic likelihood using the generalized likelihood uncertainty estimation (GLUE), while output for the other scenarios are then processed using Bayesian Model Averaging which is a statistical procedure that infers a consensus prediction by weighing individual predictions based on the probabilistic likelihood measures obtained by GLUE, with the better performing predictions receiving higher weights than the worse performing ones. The results of the BMA scheme have the advantage of
generating more reliable predictions than using original GCM data. The findings will be beneficial to the management of the water resources of NYC water supply.

Assessment of Conservation Practices for Controlling Nonpoint Sources in a Rapidly Urbanizing Agricultural Watershed - Jaehak Jeong, Texas A&M AgriLife Research, Temple, TX (co-authors: J. Osorio, N. Kannan)

The Arroyo Colorado flows through Hidalgo, Cameron and Willacy Counties in the Lower Rio Grande Valley of Texas into the Laguna Madre. Because of low dissolved oxygen levels, the tidal segment of the Arroyo Colorado does not currently support the aquatic life use designated by the State of Texas and described in the Water Quality Standards. This has been the case for every 303(d) List prepared by the State since 1986. There have also been concerns about high nutrient levels in this stream as documented on every 305(b) Assessment prepared by the State since 1988. A model setup of the Soil and Water Assessment Tool (SWAT) watershed model was developed to simulate flow and selected water quality parameters for the Arroyo Colorado watershed in South Texas. The model simulates flow, transport of sediment and nutrients, water temperature, dissolved oxygen, and biochemical oxygen demand. The model can also be used to estimate a total maximum daily load for the selected water quality parameters in the Arroyo Colorado. The model was calibrated and tested for flow with data measured during 2000-2009 at two streamflow-gaging stations. The flow was calibrated satisfactorily at monthly and daily intervals. In addition, the model was calibrated and tested sequentially for suspended sediment, orthophosphate, total phosphorus, nitrate nitrogen, ammonia nitrogen, total nitrogen, and dissolved oxygen, using data from 2000-2009. The simulated loads or concentrations of the selected water quality constituents generally matched the measured counterparts available for the calibration and validation periods. Two watershed scenarios were simulated for the years 2015 and 2025 after estimation of land cover maps for those years, which mainly address a rapid expansion of urban lands (12%). The scenarios were intended to identify a suite of best management practices (BMPs) to address the depressed dissolved oxygen problem in the watershed. Calibrated/validated parameters were transferred to these projected datasets and BMPs requirements were assessed with which the water quality meets the DO requirement under the projected land use change.

Human Induced Changes on Land Surface Temperature and Convective Rainfall in South Florida - Hari Kandel, Florida International University, Miami, FL (co-author: A. Melesse)

Increasing anthropogenic activities in south Floridan wetland since early 20th century, such as extensive water management structures, urban expansion, crop cultivation and pasture use have resulted changes in its surface water hydrology and land surface temperature. South Florida comprising a vast wetland system, the Everglades, a unique ecosystem in the world, offers habitats for diverse flora and fauna. Levees and canals built by Central and South Florida flood management project coupled with the development of Everglades Agricultural Area restricted the free flow of surface water from Lake Okeechobee to southern Everglades. Urbanization and agricultural practices have replaced evapotranspirative, higher albedo- wet and vegetated surfaces by impervious low albedo construction and bare soil materials magnifying the absorption of solar radiation and altering the dominant energy flux from latent to sensible heat. Observational weather station records and Landsat and radar based remote sensing approaches were used to study spatial and temporal changes on land surface temperature and convective rainfall in south Florida. An increase in land surface temperature as much as 2°F as well as enhancement in thunderstorm frequencies have been noticed which are associated with land use/land cover change.
Analysis of Monitoring Needs and Redundancies of the Upper Colorado River Basin for Salinity Prediction using SPARROW - Jongho Keum, Utah State University, Logan, UT (co-author: J. J. Kaluarachchi)

The surface water quality model developed by U.S. Geological Survey, SPARROW (SPAtially Referenced Regressions On Watershed attributes), can predict salinity generation from natural geologic media and from managed irrigated lands. SPARROW is calibrated using monitored salinity data. Analysis of available monitoring stations in the Upper Colorado River Basin (UCRB) indicated that the number of stations have reduced in the past two decades. In 2011, only 66 stations were available for model calibration compared to 218 stations available in 1991 for the first calibration of SPARROW. Scarcity of observations may cause increase of uncertainty followed by unreliable model calibration. In addition, SPARROW may not converge if there is insufficient number of observations given the model is a nonlinear regression analysis. On the other hand, optimal monitoring is important not only for model calibration, but also cost management. Redundant or improperly located monitoring stations may result in increased monitoring costs. In this research, a method to find the optimal number of monitoring stations and its locations at watershed- scale is developed. Here an index called, station ratio (SR), which represents the relationship between the number of monitoring stations and incremental salinity load within a watershed, is proposed. If SR of a watershed is greater than a given threshold SR, the watershed may have redundant monitoring stations, and vice versa. The use of this SR index together with SPARROW modeling suggest that watersheds near Colorado River headwaters have redundant monitoring stations, and the watershed including Grand Valley, Colorado near the confluence of the Colorado River and the Gunnison River requires additional monitoring stations. The results of this work shows that SR is a practical indicator of monitoring redundancy and/or needs in a large basin such as the UCRB.

Evaluating Groundwater / Surface Water Exchanges in the Catherine Creek Watershed of the Upper Grande Ronde Basin - Jonathan La Marche, Oregon Water Resources Department, Bend, OR (co-authors: K. Wozniak, J. Hackett, S. Hattan)

In 2011 the Oregon Water Resources Department (OWRD) initiated a study of groundwater / surface water (GW/SW) exchanges in the Catherine Creek watershed near LaGrande, Oregon. The purpose of the study was to quantify GW/SW interactions in the Grande Ronde Valley (GRV) where irrigation withdrawals severely deplete streamflow in Catherine Creek, a critical salmonid bearing tributary to the Grande Ronde River. This knowledge is needed to evaluate the likely success of a proposed aquifer storage and recovery project, located several miles upstream from the GRV in the upper watershed that would augment low summer flows by pumping groundwater directly into the creek. In the fall of 2011 stream stage gages and nested piezometers were installed at three monitoring sites along Catherine Creek to evaluate hydraulic head gradients between the stream and the alluvial aquifer in the upper, middle, and lower portions of the GRV. The piezometers were installed in shallow (10 foot) and deep (25 foot) pairs, along the left and right banks of the creek at each site. GW/SW exchanges were quantified during an October 2011 seepage run which consisted of a series of stream discharge measurements on Catherine Creek, and all tributaries and diversions during a two day period. Additional periodic stream flow measurements were made at a subset of these sites in 2012. The seepage run indicated that GW/SW exchanges in the upper and middle reaches of Catherine Creek were relatively minor, while groundwater increased streamflow in the lower reaches. The groundwater head gradient was towards the creek at the lower monitoring site, and away from the creek at the upper and middle monitoring sites at the time of the seepage run. This result indicates that the head gradient was sufficient to cause gains in the lower reach, but insufficient to cause losses in the middle and upper reaches at the time of
the seepage run, given the underlying streambed and aquifer properties in each area. The WY 2012 stream flow measurements and piezometer data indicated seasonal changes in both the head gradient and resulting GW/SW exchanges in the upper, middle, and lower reach of Catherine Creek. The head gradients changes were related to seasonal streamflow variation, and irrigation related activities from both surface and groundwater. During the summer the upper most monitoring site changed from a static to a gaining reach due to nearby surface water irrigation which caused groundwater elevations to rise above the nearby permeable stream channel. The middle site changed from a static to a slightly losing reach likely caused by a broad decline in groundwater levels from nearby pumping. The effects on streamflow appear to be attenuated by the presence of silts and clays in the channel substrate. The head gradient at the lower site reversed during the summer due to a diversion dam that caused backwater conditions to extend approximately 13 miles upstream.

**Spatial Patterns of Dissolved Organic Matter Characteristics in the Upper Willamette River Basin, Oregon - Baek Soo 'Peggy' Lee**, Oregon State University, Corvallis, OR (co-authors: K. Lajtha, J. Jones)

The objective of this study is to explore the use of a novel approach, 3-D excitation-emission matrices (EEMs), to distinguish and characterize varying sources of dissolved organic matter (DOM), such as terrestrial and in-stream sources, in the upper Willamette River Basin, Oregon. In the Willamette River Basin, forested headwaters transition to urban and agricultural lands in the valley. It is crucial to improve the understanding of sources and fates of DOM transport for water quality and land management within this study site. The study fingerprints fluorescent portions of DOM in stream water from 50 locations in contrasting land uses, to test the idea that EEMs can distinguish hydrologic and biotic processing of differing DOM sources to streams. Previous research has shown that chemical quality of dissolved organic carbon (DOC), which is assumed to be about 50% of DOM by mass, varies predictably with degree of biotic processing (decomposition) and flow passage through the soil profile. However, standard chemical techniques for characterizing DOC sources are time-consuming, expensive, and have many methodological issues that have made them not widely adopted. This study tests the feasibility of EEMs to offer a simpler and less expensive way to characterize sources and fates of DOM. EEMs could possibly distinguish between DOM originating from undisturbed forests and DOM that comes from an erosion or agricultural landscape. EEMs of DOM measured using a spectrofluorometer is processed with multivariate statistical parallel factor analysis (PARAFAC) modeling to distinguish differing DOM sources. This presentation shows the preliminary results of varying DOM sources with different land use types in the upper Willamette River Basin and discusses the implications of the observations.

**Modeling for Influence of the Bio-retention size on Performance - Jeonghoon Lee**, Pukyong National University, Busan, Korea (co-authors: M. J. Park, H. Sim, S. Kim)

This study is aimed to analyze the change of runoff hydrograph by changing bio-retention size. The range of bio-retention size is between 6.0x12.0m(72m²) and 12.0x36.0m(432m²), and applying it, the runoff hydrograph of each size(total 22) were simulated. Total four inflow hydrograph was designed and using rational formula, peak discharge was estimated for simulation. Drainage area was determined assumed 1000m² interval between 1,000m² and 4,000m², and we assumed these areas are impervious, hence the runoff coefficient was applied to a 0.9. Inflow hydrograph was designed by SCS unit hydrograph, and the duration of the inflow hydrograph was about 240minutes. Additionally, we used the 10-year period designed rainfall intensity, and Infiltration and evaportranspiration of bio-retention was assessed by Green-Ampt and Hamon method. Through this process, we analyzed the reduction efficiency both of peak discharge and total outflow. The results of this analysis are expected to be the base data for LID facilities modeling with a mechanism like a bio-retention.

Wapato Lake near Gaston, in the Tualatin River basin of northwestern Oregon, has been a productive resource for hundreds of years, providing food and habitat for fish, wildlife, and human populations. Historically, seasonal high flows in the upper Tualatin River filled the lowland area comprising Wapato Lake. In the 1930s, a network of levees and canals was created to minimize seasonal flooding, facilitate the drainage of the lake in springtime for summer farming, and convey water during summer to farmland in and around the lake. Construction of the levees eliminated tributary flow into the lake, leaving rainfall, groundwater seepage, and leakage through the levees as the only hydrologic inputs. To optimize the future management of the lake for water quality and its use as a resource, data have been collected that will provide a better understanding of the hydrology of the area and the quality of the water moving through the system. Since September of 2011, in partnership with the U.S. Fish and Wildlife Service (USFWS), the U.S. Geological Survey has been monitoring streamflow, water levels, and water quality in the Wapato Lake area. One water-level gage, one water quality station, and two streamflow gages were installed to continuously collect data at key sites upstream, within, and downstream of the lake. At one site an Acoustic Doppler Current Profiler was used to collect valuable velocity data during flow reversal events. The multiple parameters measured at the water quality station provide important information on the quality of the lake and canal water as well as the water exported to the Tualatin River. Data from these stations will be used to better understand the hydrology and quantify a water budget of the system. In combination with high-resolution topographic data collected by USFWS, the streamflow and stage data can be used to project flows and water levels under future management alternatives.