SESSION 2A – RECHARGE  II
The Orange County Water District Cloth Filter Demonstration Project: Increasing Recharge by Removing Suspended Sediment in Santa Ana River Water

Adam Hutchinson¹, Greg Woodside¹, Don Phipps¹, and Grisel Rodriquez²

As Herman Bouwer once said “Clogging of the infiltration surface and resulting reductions in infiltration rates are the bane of all artificial recharge systems.” The large artificial recharge system that the Orange County Water District (District) has developed over the last 80 years is no exception. Clogging caused by the accumulation of suspended sediment in Santa Ana River water on the bottoms of recharge facilities is a key constraint limiting the District’s recharge capacity. In an effort to reduce clogging and increase recharge rates, the District embarked on a multi-phase Sediment Removal Study. Out of this study, two mechanical treatment methods, Cloth and Riverbed Filtration were confirmed to be able to reduce suspended sediment concentrations and increase recharge rates at the pilot scale. Using a cloth filter to pre-treat water prior to recharge in a percolation basin is a novel application and has not been tested before. As a result, this effort is a field experiment that researches how effective the system will perform.

An AquaDisk cloth filter system, manufactured by Aqua-Aerobic Systems, Inc. (http://www.aqua-aerobic.com), with a capacity of 5 – 8 cubic feet per second (cfs) was installed to treat all the water supplied to the District’s Riverview Recharge Basin. Riverview Basin is a small, shallow basin with a wetted area of 3.6 acres and a maximum storage capacity of 11 acre-feet. During its first season, the cloth filter operated from September 18, 2012 to April 2, 2013. The average weekly concentration of total suspended solids (TSS) of the influent water ranged from 1 to 29 mg/L while the average weekly TSS concentration of the effluent (filtered water) ranged from 2 to 12 mg/L. Removal efficiencies ranged from 11 to 78 percent and were highest when the influent TSS concentrations were highest. Data from pilot and demonstration testing indicates that the cloth filter is most efficient in removing TSS when TSS concentrations range from 10 to 30 mg/L.

In addition to reducing elevated TSS concentrations, the cloth filter was able to increase recharge. It is estimated that the cloth filter increased recharge in Riverview Basin by 200 acre-feet during the winter 2012-13 season, which is a 35 percent increase. Winter 2012-13 rainfall totals were very low and thus test conditions were not representative of average conditions. Continued testing is planned for the next few years to obtain data for the full range of storm flow conditions. Because the cloth filter is most effective when TSS concentrations are higher than 10 mg/L, the cloth filter unit will only be operated in the future during the storm season when TSS concentrations in the Santa Ana River are elevated.

¹ Orange County Water District, 18700 Ward Street, Fountain Valley, CA, 92708
² Orange County Water District, 4060 E. La Palma Ave, Anaheim, CA 92807
In April 2008, Tucson Water began delivery of Colorado River water from CAP to constructed recharge sites at Southern Avra Valley Storage and Recovery Project (SAVSARP). Water quality data has been collected from groundwater monitoring and production wells, located both proximally and distally to the recharge basins. Data suggests that over time, natural groundwater is mixing with the recharged CAP water and will eventually have water quality characteristic of recharged CAP water.

After five years of operations, water quality sampled from wells adjacent to constructed recharge basins has changed significantly in response to CAP recharge. Average concentrations have increased up to; approximately 337mg/L for TDS, 230mg/L for Sulfate, 30.25mg/L for Calcium, 180mg/L for Total Hardness, and 8.12mg/L for Chloride. Bromide concentrations have decreased by 0.17mg/L as well as Arsenic by 0.01mg/L. Cl/Br ratios have increased up to approximately 900 matching that of the CAP. Water quality data that mirrors CAP water quality in conjunction with stable isotope monitoring used to track movement of recharged CAP water, suggest that the most proximal wells are now 100% CAP water.

Farther away from the basins, similar water quality trends are observed. The time it takes for CAP water to begin to mix with the natural groundwater varies spatially depending on where the well site is located in relation to the recharge basins. Generally, the farther away the well site is from the recharge basin the longer the time lag to begin mixing of CAP water, and the slower the rate in becoming 100% CAP water.

After recharge began, well sites observed a spike in concentrations of nitrate as nitrogen and bromide that exceed both natural groundwater and CAP recharge water. This is attributed to constituents in the vadose zone that, for nitrate and bromide were flushed out in the initial surge of CAP recharge water into the aquifer. Calcium and total hardness concentrations also exceed CAP concentrations, likely due geochemical reactions. Calcium and total hardness are also expected to eventually subside to match the composition of CAP recharge.
Measuring gravity over time to identify changes in aquifer storage has a long history in Arizona – one that continued with a recent project at Tucson Water’s Southern Avra Valley Storage and Recovery Project (SAVSARP) artificial recharge facility. For the first time in the United States, multiple gravity meters of all types were used for a single study, leading to new interpretation methods that allow estimates of hydrologic properties and subsurface water movement that were previously difficult or impossible. First, the timing of the advance of the wetting-front through the vadose zone below a recharge basin was monitored and the total volume of recharge estimated using continuous gravity data from five meters, including two high-precision superconducting gravity meters. As infiltration progressed, gravity change occurred sooner than water-level changes in nearby wells, which were influenced by nearby pumping in addition to recharge. A second new interpretation method was the integration of absolute and relative gravity measurements to rapidly cover a large area in a short amount of time. At SAVSARP, three synoptic surveys were conducted in spring 2013, each comprising 75 stations with an average spacing of 100 m between stations. Simultaneous least squares network adjustment of both the relative and absolute gravity measurements was used to estimate gravity change and uncertainty. Difference-maps of the change in gravity over a one-month period show spatial variations that reveal differences in subsurface properties and the spatial correlation structure of the measurements.
SESSION 2B – WATER MANAGEMENT AND ECOSYSTEMS
Water Footprint as a tool for freshwater ecosystem services assessment and water scarcity management

Dulce B. B. Rodrigues1,2; Eduardo Mario Mendiondo1; Hoshin V. Gupta2

1University of São Paulo, São Carlos School of Engineering, São Carlos, Brazil. 2Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona, USA

Freshwater ecosystem service provisioning refers to the amount of water appropriated by humans for the purpose of developing goods and services; it can be divided into Green and Blue Water Footprints (Green and Blue-WF), in accordance with the hydrological processes involved. The Blue provision depends on limits imposed by Environmental flow requirements (EFR) for the minimum maintenance of aquatic ecosystems, while the Green provision is related to soil moisture availability for agriculture development. Here, we develop a quantitative analysis of the provision and demand for blue and green freshwater ecosystem services, so as to provide water scarcity indicators at the sub-basin level. We used the Soil and Water Assessment Tool (SWAT) to model the hydrology of an agricultural basin within the Cantareira water supply system in southeast of Brazil. The blue freshwater provision was computed using three different hydrological-based methods for specifying monthly EFR (based on fraction of long term mean flow, flow duration curves, and minimum flow of 7 days and 10 years) for the period 1987-2009. The current Blue-WF was defined using permissions for water withdrawal and waste water discharge for reference year 2012. Both Blue and Green-WF were analyzed against mean monthly values of freshwater availability. Our findings reveal the spatial and temporal pattern of water scarcity within the study basin. The results provide a joint analysis of provisioning (in accordance with EFR goals) and water footprint thereby helping us to distinguish between human and natural reasons (drought) for reduced water availability in present and future situations.
Meeting Multiple Demands:  
Water Transaction Opportunities for Environmental Benefits

Amy McCoy, Ecosystem Economics Inc.

In Arizona, the puzzle of balancing water use among a diversity of sectors expands in lock step with conditions of water stress that are exacerbated by climate variability, prolonged drought, and growing demands. The challenge of striking a sustainable balance is evidenced by reductions in both overall water availability and freshwater ecosystem health, as well as by recent projections of shortages on the Colorado River within the next five years. Arizona’s water sustainability challenge can therefore be viewed through the lens of water stress, a condition wherein demands on water—including the needs of freshwater ecosystems—exceed reliable supplies, and the full range of water needs cannot be met without tradeoffs across multiple uses. Water stress influences not just ecosystems, but Arizona’s economy, quality of life, and cultural heritage—each of which requires water to thrive. Achieving full water sustainability in Arizona would allow for water to be successfully divided among the water needs throughout the state—including maintaining the health of freshwater ecosystems—at a level that meets the goals of water users and the state. Over the last ten to fifteen years, the use of transactional approaches has appeared on the water management scene as a viable method of achieving stream flow and shallow aquifer restoration under the prior appropriation doctrine in the western U.S. By broad definition, environmental water transactions focus on the use of tradable water rights by institutions to facilitate voluntary reallocation of water to meet ecological needs. This talk will present a basic framework of necessary hydrologic conditions, enabling laws and policies, pertinent tools and techniques, and potential ecological outcomes that are essential components of environmental water transactions. The overarching goal of the presentation seeks to explore ways in which environmental transactions can contribute to the protection and restoration of streams and shallow aquifers in Arizona.
Stakeholder Incentives for Effluent Utilization in the Tucson Metropolitan Region and Recharge in the Santa Cruz River

Jacob Prietto, Water Resources Research Center
CAP Award Winner

The Tucson region has historically relied on groundwater to meet its water demand. To reach the Tucson Active Management Area’s goal of safe-yield by the year 2025, water providers are utilizing effluent as a renewable supply. Wastewater treatment facilities adjacent to the Santa Cruz River treat a portion of the effluent to reclaimed water standards and convey it back to the city for reuse.

Constructed Underground Storage Facilities are utilized to recharge effluent, where 100% recharge credits are accrued by stakeholders. Effluent discharged to the Santa Cruz River is conveyed through Managed Underground Storage Facilities where infiltration occurs in the natural streambed, accruing only a 50% recharge credit. High in nutrient concentration, the effluent creates a clogging layer in the streambed, significantly decreasing infiltration rates. The effluent conveyed downstream beyond the facilities is considered “lost opportunities”, as it is not utilized in any way or receiving any recharge credit.

Initiatives by stakeholders have been conducted to increase recharges rates of effluent in the Santa Cruz River. Excavations and diversions, which require a substantial amount of labor and maintenance, have demonstrated increased recharges rates over small spatial and temporal scales.

With the monetary value of reclaimed water increasing and a 100% recharge credit off of the river, there is no incentive for stakeholders to discharge effluent into the river, which provides an environmentally and culturally important riparian corridor. Stakeholders need to derive sustainable initiatives to improve the recharge rates of the effluent dependant Santa Cruz River, address the legislative constraints hindering the motivation to recharge in the river, and prioritize the health of the effluent dependent riparian corridor in their long term planning efforts.
A point-scale model of soil moisture dynamics is applied to two different urban landscape designs in the Phoenix, AZ metropolitan area: a xeriscaped site (gravel base and low water-use plants), and a mesiscaped site (turf grass and shade trees). The model is calibrated to observed soil moisture data from a sensor at the xeric site with no anthropogenic water input, as well as irrigated sensors at both sites, using local meteorological records as model forcing. Experiments are then run using the calibrated model at both irrigated sites to investigate the effects of irrigation scheduling, plant stress characteristics, and inter and intra-annual variability of precipitation on soil moisture dynamics, water partitioning, and plant water stress.

Calibration results include a substantial difference in storage capacity at the two sites primarily due to differences in the depth of the rooting zone; this affects the applicability of different irrigation schedules at the two sites. At the xeric site, seasonal variation of irrigation input is shown to be highly important to avoid losses to deep infiltration beyond the rooting zone while simultaneously maintaining plant health. At the mesic site, seasonal variation is less important, though water savings may be achieved under certain circumstances using large infrequent irrigation pulses, as opposed to daily applications of smaller volumes. A final analysis determines the monthly minimum water input required to achieve specified levels of stress tolerance at both sites, using several decades of precipitation and potential evapotranspiration data.

These types of analyses are intended to assist water and landscape managers in developed desert and semiarid areas, by identifying opportunities for water savings and assessing the benefits and drawbacks of xeriscaped landscaping and flood-style irrigation, based on a quantitative model that incorporates local soil, vegetation, and climatic parameters.
SESSION 2C – COLORADO RIVER ISSUES
Lake Powell is a large reservoir on the Colorado River in Utah and Arizona, impounded by Glen Canyon Dam, which was completed in 1963. In cooperation with the Bureau of Reclamation, the USGS Grand Canyon Monitoring and Research Center conducts long-term water-quality monitoring in Lake Powell, consisting on monthly surveys of the reservoir forebay and quarterly surveys of the entire reservoir, including the major tributary arms of the Colorado, San Juan, and Escalante rivers. Since 1998, longitudinal sediment delta profiles of Lake Powell inflow tributaries have been collected on an opportunistic basis, in conjunction with quarterly reservoir water-quality surveys. These profiles have been recorded with a sonar depth finder on annotated thermal strip-chart paper. Digitization of these charts yields a record bottom depth vs. time. Concurrently, a GPS unit has recorded a track log that is associated with these profiles to give a record of location vs. time. Merging of these files over common values of time, combined with GIS processing, results in a profile of bottom elevation vs. river-channel distance, which can be used to compare profiles through time and against pre-dam bottom elevations and a complete sediment survey conducted by the Bureau of Reclamation in 1986.

This project provides a record of sediment deposition patterns in Lake Powell under different inflow scenarios and reservoir elevations. It demonstrates sediment transport and deposition patterns as affected by inflow currents, underwater landslides, and other channel obstructions and can help to explain unusual water-quality conditions observed in portions of the reservoir.
Soil and Groundwater Conditions at Lower Colorado River Riparian Restoration Sites

Matthew R. Grabau¹, Michael A. Milczarek¹, Monisha Banerjee¹ and Ashlee Rudolph²

¹GeoSystems Analysis, Inc., Tucson, AZ, USA
²US Department of Interior, Bureau of Reclamation, Boulder City, NV, USA

For the Lower Colorado River Multi-species Conservation Program, the Bureau of Reclamation will revegetate over 2,900 ha of historic floodplain with salt-intolerant native riparian vegetation. Due to river flow modification and levee systems, much of the riparian habitat creation must be implemented on disconnected floodplains. Salinity in these floodplains is often elevated due to a lack of seasonal overbank flooding, evapoconcentration of salts in reservoirs, and addition of fertilizer salts to the system. Additionally, irrigation over shallow groundwater can result upward salinity migration and further salinization. As a result, groundwater and soil salinity exceeds the tolerance of native vegetation in many areas, and additional irrigation might exacerbate conditions. Alternatively, irrigation and drainage might be managed to mitigate salinity.

A study was implemented to determine current soil and groundwater salinity conditions on the lower Colorado River at three riparian restoration sites between Needles, California, and Cibola, Arizona. Soil and groundwater salinity and groundwater elevation was monitored beginning in 2010. Higher soil salinity was correlated with shallower groundwater and finer-grained soils. At sandy sites, soil salinity was significantly reduced with higher irrigation rates. In finer-grained soils with intermediate depth to groundwater, soil salinity greatly exceeding published riparian trees salinity tolerances. Groundwater salinity ranged from that of river water (1 dS/m) to over 20 dS/m, more than double the published salinity tolerance of desired trees. Groundwater salinity was largely controlled by the incoming groundwater, but was sometimes mitigated by high irrigation rates. Adjacent salinity management (leaching) and flooding of adjacent salt-laden areas for waterfowl negatively impacted groundwater salinity at one site.

Study results confirm the presence of salinity accumulation in soils and groundwater where native riparian vegetation is desired. In many cases, irrigation alone can mitigate salinity to acceptable levels. Conversely, poor drainage or elevated incoming groundwater salinity, as observed at a subset of MSCP habitat creation sites, might necessitate more intensive management strategies.
Is it possible for a diverse assemblage of parties representing state and federal regulatory agencies, nine sovereign Native American nations, water authorities representing millions of consumers in two states, and a public energy utility to agree on anything? The Topock Compressor Station Site, situated along the Colorado River near Needles, California, is both a Superfund and RCRA Corrective Measures Site that involves participation of such diverse entities in a collaborative effort to achieve responsible and effective remediation of a hexavalent chromium plume in groundwater and prevent its seepage into the Colorado River. Adding to the complexity of this remedial effort is the matter of the Site’s location within an area held sacred by the Native Americans.

As a means of addressing this situation, the project leaders have established various vehicles directed towards the coordination among the involved parties and the resolution of their particular needs and issues. Specifically, the project leadership has created a Clearinghouse Task Force (CTF), comprising invited representatives of each distinct entity. This group works to advance identification and resolution of key issues and decisions necessary to keep the project moving forward. Progress achieved by the CTF is then reported to a larger group known as the Consultative Work Group (CWG) on approximately a quarterly basis. And whenever the issues necessitate consideration by technical experts, a select group known as the Technical Work Group (TWG) becomes involved.

This paper describes the overall process employed at the Site and reports on examples illustrating the types of issues and particular successes of the project to date.