Water Quality Session
Rudd Turner, Chair
Wednesday, May 25
8:00 AM – 4:15 PM

The Oregon Water Conference 2011: Evaluating and Managing Water Resources in a Climate of Uncertainty

Oregon State University – CH2M Hill Alumni Center – Corvallis, Oregon

OR Chapter, American Water Resources Association and OR Section, American Institute of Hydrology

Reconnaissance Investigation of Emerging Contaminants in Wastewater-Treatment-Plant Effluent and Stormwater Runoff in the Columbia River Basin

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ABSTRACT

In order to efficiently reduce toxic loading to the Columbia River basin, sources and pathways need to be identified. Little is known about the toxic loadings coming from wastewater-treatment facilities and stormwater runoff in the system. This study provides preliminary data on these sources and pathways throughout the basin. The cities sampled in Oregon and Washington were chosen for their diverse characteristics, including population density. Samples were collected from a wastewater-treatment facility in each of the cities and analyzed for wastewater-indicator compounds, pharmaceuticals, PCBs, PBDEs, organochlorine or legacy compounds, currently used pesticides, mercury, and estrogenicity. Currently, these treatment facilities are required to sample their effluent to meet their permit requirements, which are very limited. Little is known about the environmental implications of emerging contaminants in these effluents. Results indicate that a majority of these compounds are present in the effluent and some at environmentally relevant concentrations. Although the grab samples were not time-integrated and the effluent is expected to change in nature throughout time, the continuous input of this number of compounds and at these concentrations can have implications on the receiving waters, the foodweb reliant on these waters, and the ecosystem as a whole.

The second component of the sampling effort was directed at characterizing stormwater runoff for a slightly different set of emerging contaminants—PCBs, PBDEs, organochlorine compounds, PAHs, metals, currently used pesticides, and oil and grease. Studies have shown that stormwater, most often untreated before entering the receiving waters, can deliver significant loadings of these compounds. Unlike WWTP effluent, stormwater runoff is sporadic and unpredictable, and the sudden input of these contaminants has implications for the ecosystem. These two pathways are poorly understood in terms of their toxic contribution to the system, yet they act as integrators of human activities and offer an area where changes could be made to reduce harmful human impact on the environment.

Keywords: Emerging contaminants; Wastewater treatment plant; Stormwater; Effluent; Runoff; Columbia River basin

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A Greenhouse Gas Inventory of a Conventional Water Treatment Plant

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ABSTRACT

The Joint Water Commission (JWC) in Forest Grove, Oregon completed a greenhouse gas (GHG) inventory of all the direct and indirect emissions associated with the daily operations of its 75 MGD conventional water treatment plant. Currently, very few water and wastewater facilities have completed a greenhouse gas inventory to date.

This analysis uses a variety of data sources and public-domain tools for emissions factors and calculation methods. Embodied emissions in purchased goods and services were calculated using dollar values spent and emissions factors based on averages for the U.S. economy. Emissions related to electricity consumption include analysis of utility specific, regional, and national electricity emissions factors. Emissions from disposal of solid waste are based on the weight and general type of the waste, and the operations of the receiving facility.

In 2007, the JWC's total emissions were 21,440 metric tons of carbon dioxide equivalent (MT CO_2e), roughly equal to the annual emissions of 4,099 passenger vehicles. Yearly variations (2007-2009) in emissions were very low and were due to construction projects. The JWC's largest GHG emissions source was the consumption of electricity (81% on average) and the embodied emissions within purchased water treatment chemicals (13% on average).

One climate change risk facing utilities is financial. If a "cost of carbon" (at levels currently anticipated) were passed along to JWC through its purchases of energy, goods, and services, the organization could pay an additional $313,000 each year. Reducing this financial risk can be accomplished by reducing purchases of high emission intensity goods, namely electricity and treatment chemicals. Limiting emissions due to electricity consumption can be done by replacing older equipment with high-efficiency equipment or utilizing electricity from less carbon intensive sources, such as creating renewable solar and micro-hydro energy on site.

Keywords: Water treatment; Greenhouse gas

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The Orange County Water District Riverbed Filtration Pilot Project: Solids and Organic Carbon Removal Using Induced Riverbed Infiltration

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ABSTRACT

In an effort to reduce suspended solids and organic carbon loading and to increase long-term groundwater recharge rates at Orange County Water District's spreading basins, a pilot project was conducted to evaluate riverbed filtration as a technology to treat river water prior to groundwater recharge. A shallow under-channel lateral drain system was constructed within a channel adjacent to the Santa Ana River to induce and capture infiltration. Water pumped from the drain system was analyzed for a variety of water quality parameters and then recharged into test spreading basins to evaluate recharge rates compared to Santa Ana River water without treatment. Riverbed filtered water and untreated water was also tested in percolation columns. At the pilot project drain system, phreatic surface and temperature were continuously monitored at thirteen points. River water inflow and outflow and drain system pumping rates were also monitored.

The pilot test was divided into two periods: Period 1 had shallow overflow (1- to 3-inches) within the river channel; Period 2 achieved deeper surface water depths (3- to 12-inches). Lateral drain system pumping during both test periods were incrementally increased to establish the maximum pumping capacity of the drain system for each test period. Monitoring data indicate that riverbed filtration effectively removed essentially all suspended solids and reduced organic carbon contents with the bulk of water captured by the under-channel drain system from induced infiltration. The phreatic surface and subsurface water movement within the drain system area was shown to be very sensitive to changes in surface water flow rates and depth, and drain system pumping rates. In addition, surface clogging was observed. The pilot project results indicate that riverbed filtration is a viable technology for treating surface water prior to recharge operations, however, additional testing and optimization is needed.

Keywords: Treatment, Recharge; Recycling; Stormwater management; Harvesting

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Spatial and Temporal Patterns in the Influence of Land Use on Water Quality in Five Portland Area Creeks Representing Differing Levels of Urbanization

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ABSTRACT

While the negative effects of urban development on freshwater systems are well documented, impacts of human disturbance on water quality vary depending on land cover, local climate, and temporal and spatial scales of analysis. To better understand this variation, we analyzed water quality data for a total of 15 sites from six Portland, Oregon area creeks at multiple spatial and temporal scales. The creeks are characterized by differing levels of urban development, from relatively pristine to highly developed. More than ten years of monthly data gathered by the Portland Bureau of Environmental Services were used to analyze temporal trends, and five years of these data were used to analyze spatial patterns. Analytes of interest were specific conductivity, dissolved oxygen, nitrate, phosphorus, total suspended solids, and temperature. These variables were compared to contributing area land use metrics at three scales: full contributing sub-basin, 100-meter riparian corridor, and 50-meter riparian corridor. We calculated seven land use metrics: population density, street density, Green Streets density, percent low density development, percent high density development, percent forested area, and percent agriculture. We found Spearman's Rank Correlation Coefficient between the water quality parameters for annual, wet, and dry seasons and the land use metrics at each spatial scale for each parameter. The same water quality data were also analyzed for correlations to same day as well as 3-, 5-, and 7-day antecedent precipitation to examine relationships between water quality and environmental moisture conditions. Additionally, we used a Seasonal Kendall test to search for temporal trends. For each site included in the temporal analysis, changes in population density and street density metrics from 2000 to 2010 were compared to changes in water quality. Results vary across space, but generally confirm that urban development has negatively impacted the creeks. Specific conductivity, total suspended solids and nitrate are particularly sensitive to the level of urban development, especially following rain events. This work will help to better understand and mitigate urbanization impacts on freshwater systems.

Keywords: Water quality; Land use; Antecedent precipitation; Urban hydrology

Water Quality Data Synthesis in the Metolius River Basin, Oregon

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ABSTRACT

The Metolius River basin is a sub-basin of the Deschutes Basin within central Oregon. Considered one of the crown jewels of the state, this historically undisturbed basin drew attention in 2009 because the Oregon legislature designated the basin as the first Area of Critical State Concern (ACSC) under the state's land use laws. One of the factors in the historic land use designation was preserving the water quality of the Metolius River. This controversial action prevented both eco-resort and large scale destination resort development and generated much debate on state versus county roles in land use.

A leading non-profit conservation organization, the Friends of the Metolius, has been monitoring land use and water quality within the basin for over 20 years. Motivated by the ACSC and using the data collected throughout the basin, a comprehensive study on the water quality of the Metolius River basin was initiated for the first time.

This presentation will introduce the voluntary effort of a non-profit organization to synthesize and share its spatial data publicly through the Oregon Explorer portal, a large spatial data library. Also, a preliminary display of the water quality data and observations within the basin will be presented for the first time.

Keywords: Water quality; Data synthesis; Temperature; Nutrients

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Managing for Ecosystem Services through Governance Networks: An Analysis of Oregon Senate Bill 513

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ABSTRACT

Human adaptation to change is an essential determinant in the resilience of complex social-ecological systems. In the field of water policy and management it has become increasingly clear that traditional government actors cannot fully address emerging water problems at every scale given a demonstrated lack of resources, increasing variability in available water supplies, and dependence on the actions of individual users. Theories of democratic network governance recognize that traditional mechanisms of governmental control, generally represented through top-down policy and bureaucratic oversight, do not fully realize the interests, resources and expertise offered by individuals and evolving social networks. Adaptive water management necessitates strong networks within and between local, state and regional organizations that have the institutional capacity to measure and respond to changing ecological and social conditions.

There are myriad local, state and federal agencies, in addition to private organizations in the state of Oregon that are responsible for managing the services performed by ecosystems in urban and rural landscapes. In 2009 the Oregon State Legislature recognized, however, that "these efforts are generally fragmented, uncoordinated and often work at cross-purposes." In the Oregon Senate Bill (SB) 513 the legislature calls for "new or improved regulatory schemes" that will result in greater coordination between existing public and private natural resource management organizations, though SB 513 does not explicitly define a new institutional arrangement. SB 513 advocates for an ecosystem-based approach to natural resource management that includes diverse stakeholders in policy development and implementation. Consequently, SB 513 has the potential to foster a complex network of public and private natural resource managers and professionals who rely on public, private and civil resources to implement large-scale conservation and restoration efforts. Any governance networks that emerge from SB 513 will have a significant impact on the future of water resources management in Oregon.

Keywords: Adaptive management; Water management; Ecosystem management; Democratic; Network governance; Resilience

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Seasonal and Elevational Variation of Surface Water δ^{18}O and δ^{2}H in the Willamette River Basin

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ABSTRACT

Climate change is expected to dramatically alter the timing and quantity of water within the nation's river systems. These changes are driven by variation in the form, location and amount of precipitation that will affect the temporal and spatial distribution of river source water over time. To manage the impact of climate change, we will need to understand how water sources for rivers are shifting over time. Yet methods for knowing where river water comes from within the drainage basin at various times of the year are not well developed. Because stable isotopes of precipitation vary geographically, variation in the stable isotopes of river water can indicate source water dynamics. We monitored the stable isotopes (^{18}O and ^{2}H) of river and stream water within the southern Willamette River basin in Western Oregon over two years. We sampled sites along the Willamette River, and up six major river tributaries to the Willamette, and eight small catchments along each tributary that spanned the elevation range in the tributary. All sites were sampled four times a year, with a selected set of sites being sampled eight times a year. Seventy-five percent of the isotopic variation in stream water from the small catchments could be explained by the mean elevation of the catchment. A decrease in catchment water isotope values with increasing elevation is caused by Raleigh distillation of precipitation where heavy isotopes fall first, and rain is progressively lighter isotopically as storms move eastward from the Coast Range, across the Willamette Valley and up the Cascade Mountains. Coast Range catchments did not have a clear elevation pattern in the water isotopes.

Water within the lower Willamette River showed distinct isotopic seasonal patterns. Isotopic values were at their lowest during summer low flow and at their highest during Feb/March when snow was accumulating in the mountains. This seasonal variation likely comes from a change in source elevation for water in the river. During winter when rain occurs in the valley and snow is accumulating in the mountains, the river isotopic signal reflects the valley bottom rain sources. During the dry Mediterranean summer, valley soils are dry and the water comes from snow melt and high elevation spring water. Using our relationship between catchment elevation and water isotope values, we estimated that the mean elevation of the source water shifted upward approximately 350 m during the summer low flow period. Reliance on high-elevation snowmelt water during summer low flow highlight the vulnerability of this system to influences of climate change, where snowpacks in the Cascade Mountains are predicted to decrease in the coming years

Keywords: Willamette basin precipitation; Water stable isotopes; Climate change; Snowpack; Elevation

Toxic Pollutants Measured in Surface Water and Fish Collected from the Willamette River Basin by the Oregon Department of Environmental Quality (2008 – 2010)

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ABSTRACT

In 2008 the Oregon Department of Environmental Quality (ODEQ) initiated a program to monitor Oregon's surface waters and aquatic biota for the presence of pollutants that pose risks to human and/or environmental health. ODEQ's Toxics Monitoring Program was first implemented in the Willamette River Basin (WRB) between 2008 and 2010. Surface water samples were at collected 20 locations 6 times during that period and fish were collected at 12 sites in 2008. A variety of organic compounds and metals were detected in WRB surface water samples as well as in fish fillet samples. Concentrations of toxic organic compounds in water were generally low. Herbicides were the most frequently detected pollutant class; insecticides were rarely detected. Multiple, "emerging contaminants" were detected in surface water. Generally, water collected at sites located lower in basin contained a higher number of detected compounds. Composited fillet samples (northern pike minnow and smallmouth bass) contained concentrations of dioxins and furans (expressed as total toxic equivalents) that exceeded EPA screening levels for recreational and subsistence anglers. Other contaminants detected in fish fillet samples included DDT (legacy pesticide), polychlorinated biphenyls (widely used in electrical generation/transmission, banned in 1970's), polybrominated biphenylethers (flame retardants) and mercury. Findings will be presented relative to established criteria or screening values (where available).

Keywords: Water quality monitoring; Toxic pollutants; Surface water; Freshwater resident fish

Emerging and Legacy Contaminants in POCIS, SPMDs, and the Largescale Sucker (*Catostomus macrocheilus*) in the Lower Columbia River – USGS ConHab Project

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ABSTRACT

An interdisciplinary study, USGS Columbia River Contaminants and Habitat Characterization (ConHab) project, is underway to investigate transport pathways, chemical fate and effects of polybrominated diphenyl ethers (PBDEs) and endocrine disrupting chemicals (EDCs) in aquatic media and the foodweb in the lower Columbia River. Polar organic chemical integrative samplers (POCIS) and semipermeable membrane devices (SPMDs) were co-deployed at each of 10 sites to provide a measure of the dissolved concentrations of select PBDEs, chlorinated pesticides, and other EDCs. PBDE-47 was the most prevalent of the PBDEs detected. Numerous organochlorine pesticides, both banned and current-use, were measured at each site including hexachlorobenzene, pentachloroanisole, dichlorodiphenyltrichloroethane (DDT) and its degradates, chlorpyrifos, endosulfan, and the endosulfan degradation products. EDCs commonly detected included a series of polycyclic aromatic hydrocarbons (PAHs), fragrances (galaxolide), pesticides (chlorpyrifos and atrazine), plasticizers (phthalates), and flame retardants (phosphates). The site near Columbia City tended to have the highest concentrations of contaminants in the Lower Columbia River.

Resident largescale suckers (*Catostomus macrocheilus*) were collected at three of the ten sites. Brain, fillet, liver, stomach, and gonad tissues were analyzed. Concentrations of halogenated compounds in tissue samples ranged from <1 to 400 ng g^{-1} wet tissue. PBDEs, organochlorine pesticides, DDT and its degradates, and polychlorinated biphenyls (PCBs) were detected at all sites in nearly all organs tested. Concentrations increased moving downstream from Skamania to Columbia City to Longview. Chemical concentrations were highest in livers, followed by brain, stomach, gonad, and fillet. PBDE congeners most frequently detected and at the highest concentrations were BDE47 > BDE100 > BDE154 > BDE153. These congeners are some of the major constituents of the commercial penta-BDE formulation. Results support the hypothesis that contaminant concentrations in the environment correlate to bioaccumulation in the foodweb. The fish concentrations will be compared to concentrations in other levels of the foodweb and to biomarker results also determined as part of the ConHab project to improve understanding of bioaccumulation and effects of these contaminants in the lower Columbia River.

Keywords: Emerging contaminants; PBDEs; Endocrine disrupting chemicals; SPMDs; POCIS

Integrated Water-Quality Assessment using Conventional, Passive-Sampling, and Metabolic Assay Techniques: Approaching System-Level Understanding of Risk

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ABSTRACT

Conventional monitoring to assess water quality of drinking water sources in streams and rivers is typically focused on identifying primary sources and conditions that are associated with mobilization of contaminants. This approach is often organized as a series of discrete samples collected in such a way as to capture the influence of specific land use activities or climatic events. Often streamflow data are included to facilitate calculation of loads, which allows the relative contribution from different sources and events to be compared. This approach is limited by the episodic nature of contaminant transport, so that integrating the health risk presented by observed concentrations is challenging with the limited data that are usually available. This limitation is especially pronounced because it does not account for synergistic effects among individual compounds. Other critical limitations include cost, considering the large number of compounds that may be relevant, and the analytical challenge of quantifying the very low concentrations that are typically present.

An alternative approach is provided by the use of passive sampling techniques that specifically address the detection level challenge by concentrating contaminants into sorbent material over a long period of deployment, generally on the order of 30 days. These samplers provide an integrated view of contaminant exposure over time, and can better detect trace amounts of chemicals because of the increased mass of material. Additional information on the synergistic effects of chemicals on biota is provided by analysis of metabolic assays, such as the yeast estrogen screen bioassay.

A combination of these three approaches in monitoring for drinking water source protection provides a more system-level perspective on transport and behavior of contaminants. This combined approach facilitates more complex understanding of contaminant occurrence and behavior than the simple monitoring of individual chemicals during targeted conditions, without sacrificing that more specific and detailed view. These three alternative modes of sampling are being used to evaluate risks to drinking-water quality in the McKenzie River. Early results demonstrate that the data complement each other and provide different insights. This approach is proposed as a useful foundation for monitoring a range of systems in Oregon that could provide a valuable opportunity for cost-effective collaboration by a number of drinking water providers.

Keywords: Drinking water; Water-Quality monitoring; Passive samplers; Yeast estrogen bioassay; Synergistic effects; System perspective

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Influence of Hydraulics and Streamflow Regime on the Habitat of *Manayunkia speciosa*, the Definitive Host of the Salmonid Parasite *Ceratomyxa shasta*.

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ABSTRACT

Management strategies for parasites with complex lifecycles typically target not the parasite itself, but one of the alternate hosts. *Ceratomyxa shasta* is a myxozoan parasite of salmonids that requires a freshwater polychaete *Manayunkia speciosa* to complete its lifecycle. In the Klamath River, CA/OR, *C. shasta* causes significant mortality in juvenile salmon, imposing social and economic losses on sport and tribal fisheries. An interest in manipulating the polychaete host to decrease the abundance of *C. shasta* in this system has therefore developed. *Manayunkia speciosa* is a small (3mm) benthic filter-feeding worm that attaches itself perpendicularly to substrate through construction of a flexible tube. There are several hydropower dams on the Klamath River and pulsed flows as well as gravel augmentation have been proposed as methods to decrease *M. speciosa* populations through scouring action. The presence of the dams, and their projected deconstruction in 2020 have also raised questions of whether the dams are influencing disease dynamics and what changes might be anticipated with their removal. One hypothesis is that dam construction has increased polychaete habitat by modifying the natural flow regime, leading to amplification of *C. shasta*. Unfortunately, there are limited data on the life-cycle and habitat requirements of *M. speciosa* or the influence of streamflow regime and hydraulics on their population dynamics. This work aims to address the data need by characterizing the physical habitat utilized by *M. speciosa* and applying a hydraulic model at a study site to investigate how habitat changes under a range of flow conditions. Populations of *M. speciosa* are also being monitored year round for density and infection prevalence to better understand the influence of seasonal changes in temperature and flow.

Keywords: Salmonid parasite; Polychaete; Habitat characterization; Streamflow regime; Hydraulic modeling

Quantitative Relationship between Resazurin and Respiration in Stream Ecosystems

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ABSTRACT

After three decades of active research in hydrology and stream ecology, the connection between solute transport, stream metabolism and nutrient dynamics is still unresolved. This existing gap obscures the functionality of stream ecosystems and how they interact with other landscape processes. To date, determining rates of metabolism is accomplished with techniques that are not spatially representative, mainly because of the limited sample volume of the methods (e.g., benthic and hyporheic chambers) and the uncertainties associated with them (e.g., estimation of reaeration rates in the two-diel technique). On the other hand, correlations between solute transport and nutrient dynamics have shown weak or even contradictory results. Clearly, the finding of mechanistic relationships among solute transport, stream metabolism and nutrient retention is required to advance our understanding and predictive ability to assess the growing pressure that exists, worldwide, on stream ecosystems.

We hypothesize that most metabolism and nutrient retention is associated with key active areas within transient storage zones, where high hydraulic and biogeochemical gradients stimulate processing by microorganisms and macrophytes. These zones are located in the near-subsurface of hyporheic zones and in the benthos of pools and eddies in surface transient storage zones; they are referred to as metabolically active transient storage (MATS) zones. To quantify MATS, we characterized the use of the bio-reactive tracer resazurin (Raz). In the presence of respiration, Raz undergoes an irreversible reduction to strongly fluorescent resorufin (Rru). Laboratory and mesocosm experiments have shown that the transformation of Raz to Rru is negligible in the water column, but rapid in colonized sediments; this is consistent with previous independent findings about biogeochemical hot spots. Results from field experiments strongly suggest that the Raz to Rru transformation is correlated with whole-reach respiration and can differentiate metabolic activity in reaches with contrasting hydrological and biological characteristics.

Keywords: Resazurin; Transient storage; Nutrient retention; Stream ecosystems