South Platte River Urban Waters Partnership (SPRUWP)
QUARTERLY MEETING
February 19, 2019, 12:30 pm – 3:30 pm
Jefferson County Government Center, Golden, CO
Meeting Summary – FINAL

ATTENDANCE
Participants: Bill Battaglin, Randi Brazeau, Rachel Crouch, Stacey Eriksen, Kristin Garrison, Liia Koiv-Haus, Steve Materkowski, Madelene McDonald, Mike McHugh, John McCray, Sam McKinney, Jordan Parman, Donny Roush, Andrea Savage, Catherine Schloegel, Kim Slinski, Jason Stawski, Sam Stein, Weston Toll, Scott Williamson, Alison Witheridge, and Shane Wright

Facilitation: Sam Haas and Dan Myers

ACTION ITEMS

Randi Brazeau	• Send presentation to Sam Haas for distribution to the group.
Stacey Eriksen	• Send the factsheet on SPRUWP to Sam Haas for distribution to the group.
Group members	• Contact Randi Brazeau if interested in visiting Metro State as a guest speaker. • Send anything else of interest to Sam Haas for distribution to the group.
John McCray	• Send presentation to Sam Haas for distribution to the group. • Send information on the beneficial use of stormwater workshops to Sam Haas for distribution to the group.
Mike McHugh	• Send a factsheet on the London Mine to Sam Haas for distribution to the group.
Jordan Parman	• Send the Metro Wastewater Reclamation District's annual report to Sam Haas for distribution to the group. • Connect with Randi Brazeau about sharing South Platte Coalition for Urban River Evaluation data.
Donny Roush	• Keep group posted on the City of Denver's stormwater permit renewal process.
Jason Stawski	• Send Urban Drainage and Flood Control District's ReNUWIt data from non-rain garden sites to John McCray.
Scott Williamson	• Send an electronic version of Water Education Colorado's updates to Sam Haas for distribution to the group.
Alison Witheridge	• Send information about Denver Water's internship opportunities to Sam Haas for distribution to the group.

SPRUWP PARTNER UPDATES
SPRUWP partners provided updates on their roles and current work priorities. Their comments are summarized below.

Bill Battaglin-US Geological Survey (USGS)
• Battaglin is a hydrologist working on a variety of water quality issues, including nutrient dynamics and E. coli. Battaglin is interested in the potential advantages of monitoring in

urban areas. He is also working on the use of orthophosphates in the potential optimal corrosion control treatment (OCCT) being considered by Denver Water.
- USGS is also studying the effects of controlled burns.

Rachel Crouch- Bluff Lake Nature Center (BLNC)
- A few years ago, the BLNC reinforced the dam on the lake. This has been successful in that the lake has now had consistent water for two years, but it is still fed entirely by stormwater.
- BLNC has $300,000 in grant money that it is working to get a recycled water pipeline from Denver Water.

Stacey Eriksen-Environmental Protection Agency (EPA)
- Eriksen is working on the OCCT issue. Some of SPRUWP's tools are being considered in discussions of how best to monitor potential impacts from OCCT.
- Eriksen is going to have an intern do work on creating a teacher's guide for SPRUWP's Water Quality Assessment Tool.
- The Urban Waters Learning Network has created a factsheet highlighting SPRUWP, the Water Quality Assessment Tool, and its Natural Capital Resource Tool.

Kristin Garrison and Weston Toll- Colorado State Forest Service
- Toll is a watershed specialist who will represent the Colorado State Forest Service (CSFS) at SPRUWP meetings in the future. Much of his work involves working with municipalities on forest health issues in the upper portions of the South Platte watershed.
- Garrison is the CSFS' Fire, Fuels, and Watershed Management supervisor. She works on agency agreements and oversight and is helping Toll get up-to-speed on SPRUWP.

Liia Koiv-Haus- City of Aurora
- Koiv-Haus is a planner for the City of Aurora working on environmental reviews of new developments and is attending today's meeting on behalf of Karen Hancock.

Steve Materkowski and Jason Stawski-Urban Drainage and Flood Control District
- Stawski does water quality research, works with local partners (especially on stormwater quality), and develops specifications for the District.

John McCray and Kim Slinski-Colorado School of Mines
- McCray is the campus leader for a National Science Foundation-funded collaborative (between Mines, Stanford University, New Mexico State University, and the University of California-Berkeley) called Reinventing the Nation's Urban Water Infrastructure (ReNUWIt).
- Slinski is a post-doctoral research fellow at Mines who works closely with McCray. Her research focuses on how changing land use in metropolitan areas changes corrosion inputs (especially nitrogen and phosphorus) that end up in stormwater.

Mike McHugh-Aurora Water
- McHugh works in sourcewater protection for Aurora Water.
- Aurora Water recently purchased the rights to seven cubic feet of water flowing from the London Mine (located near Alma, Colorado). The water is treated in the mine itself using a biological treatment involving molasses and ethanol.
- Aurora Water is updating its sourcewater protection plan.

- Aurora Water is getting more involved in the South Platte Regional Water Development Concept.

Madelene McDonald and Alison Witheridge-Denver Water
- Witheridge works on sourcewater protection for Denver Water, with a geographic focus on the upper South Platte watershed. She is working to document and spatially inventory risk factors in the watershed like abandoned mines and land use changes. She is also working on a water quality database in collaboration with local partners. Denver Water is working with Leonard Rice to find connections between water quality data and spatial risk factors.
- High-intensity wildfires remain the biggest risk facing Denver's water quality, so Denver Water is continuing to work in the upper South Platte with the US Forest Service and other partners on mitigating the risk of such fires. Denver Water will also address quality concerns in key areas near Gross Reservoir and the urban South Platte.
- Denver Water is going to be posting opportunities for a large number of data-heavy internships this summer.
- McDonald is working as an intern with Denver Water, focusing on the Forests to Faucets program. She is also a graduate student at the Colorado School of Mines pursuing a master's degree in Natural Resources and Energy Policy.

Jordan Parman-Metro Wastewater Reclamation District (MWRD)
- Parman works to assess water quality from metro north Denver to Platteville. His team also studies fish, insects, and other biological factors. OCCT is also a major area of work for the MWRD.
- Parman is involved with the Colorado Data Sharing Network (CDSN) which provides the State, professionals, and the public with water quality data from around Colorado. CDSN recently completed its annual report.

Donny Roush-City and County of Denver
- Roush works on education and outreach for Denver Public Works' stormwater team.
- Discussions on the OCCT issue are ongoing. Three task forces are holding frequent meetings, examining the implications of orthophosphates for the watershed, their effects on wastewater treatment plants, and other ways to solve the problem of lead delivery pipes. OCCT is a major portion of the stormwater team's current workload.
- The City of Denver's stormwater permit is currently up for renewal. There was a public meeting on the permit last week, and many stormwater stakeholders suggested improvements for the permit and stormwater operations. A draft of the permit will be released in the coming months and then considered in a public comment period. The permit could serve as a template for other stormwater permits in Colorado.

Andrea Savage-Groundwork Denver
- Savage and her team continue to monitor lower Bear Creek for E. coli and are investigating its sources.

Catherine Schloegel-The Nature Conservancy (TNC)
- Schloegel works in the upper South Platte with representatives of many of the agencies present today to mitigate wildfire risks by thinning forests and using controlled burns. In the winter, The Nature Conservancy (TNC) and its partners work to burn slash piles in the upper portions of the watershed.
- Chris Hawkins is TNC's urban program director. Among other things, he has been working with the Globeville Elyria-Swansea Coalition to plant trees in Globeville.

- Schloegel hopes to foster connections between those working in the downstream portion of the watershed and those working upstream.
- Until recently, the US Forest Service (USFS) had a vacancy in its urban forestry program, so it has not been represented at SPRUWP meetings. A representative will attend SPRUWP meetings in the near future.

Sam Stein-Colorado State University (CSU)
- Stein is pursuing a master's degree in Water Economics at CSU. He is working on his thesis, which focuses on the value of flows in the South Platte river basin.

Scott Williamson-Water Education Colorado
- Williamson works on education and outreach for Water Education Colorado.
- On March 8, Water Education Colorado will be hosting two retrospective panel discussions on the Environmental Protection Agency's veto of the large Two Forks dam projects.
- Water Education Colorado is organizing its Colorado Water Leaders Program and will soon announce this year's participants.
- In April, registration will begin for the Water Fluency Bootcamp, to be held in the Denver metro area in July.
- The Water Festival Coordinators gathering will be held on March 4 and will focus on, among other things, improving best practices.

Shane Wright- Lincoln Hills Cares
- Lincoln Hills Cares is a fly fishing and environmental education space on South Boulder Creek right after the Moffat Tunnel. It has a deep history of connecting people, having served as a lodge for African Americans during the segregation era.
- Today, Lincoln Hills Cares connects over 1,500 youth from urban Denver to nature each year through fly fishing, horseback riding, etc.
- Lincoln Hills Cares is also working on a career pipeline program with CSU to provide youth from Denver's urban corridor with opportunities to work on restoring the South Platte.

PRESENTATION: JOHN MCCRAY, COLORADO SCHOOL OF MINES
John McCray, Professor of Civil and Environmental Engineering at the Colorado School of Mines, presented on some of his current research along with postdoctoral associate Kim Slinski. McCray's work focuses on chemical transport in hydrological systems, the use of green infrastructure for urban storm restoration, urban water quality enhancement, and the water quality repercussions of infill development. His comments are summarized below.

ReNUWIt
- SPRUWP members are invited to participate in Mines' upcoming ReNUWIt workshops on finding beneficial uses for stormwater. ReNUWIt is the first National Science Foundation-funded Engineering Research Center (ERC) focused on an environmental subject.
- The workshop's organizers hope to identify ways to overcome barriers to the beneficial use of stormwater along the Front Range and beyond. Encouragingly, the Colorado Water Conservation Board (CWCB) has warmed to the idea of doing so (which has been difficult historically because of stringent water rights laws).
- The workshops will be held in the late summer or fall this year and meeting locations are still being explored. SPRUWP partners interested in hosting one of the workshops should reach out to John McCray.

Automated Urban Stormwater Quality Sampling Program
- McCray's team has received funding from the City of Denver and ReNUWIt and is working with the Metro Wastewater Reclamation District to collect data on stormwater in the city.
- The City's 2020 Sustainability Goals aim to make all of Denver's creeks and rivers swimmable and fishable. The team's initial data indicates that fewer waterways are supporting those activities than in the past.
- The researchers are examining the effects of infill development on stormwater quality. Infill development is the increasingly common practice of building structures up to property lines and thus eliminating many existing permeable surfaces. In Denver, it characterizes much of the recent redevelopment in the Highlands and, increasingly, Berkeley neighborhoods. For lots smaller than an acre, stormwater quality control is not currently required; as such lots turn to infill development, the researchers expect more runoff and are examining its effects on stormwater quality. As Denver considers regulating infill development for lots smaller than half of an acre, the researchers hope to provide data to guide the City's decision-making. The researchers are also modeling the effects of potential green infrastructure improvements on stormwater quality.
- The researchers are using automated sampling to collect stormwater at three locations in west Denver: an area south of Berkeley Lake (where a lot of infill development is happening), the Tennyson district (which is highly infill-developed, but still developing), and an area near Federal Boulevard with less infill development. The team mapped infill-development in these areas between 2004 and 2018.
- The researchers have placed automated samplers with flow sensors in stormwater drains in city streets. When a sufficiently large storm event takes place, the sensors collect water, which the researchers quickly take back to the lab. There, they analyze the samples for total dissolved solids (TDS), acidity, phosphorus, nitrates, E. coli, etc. The levels of these factors were weighted by flow (rather than time) to provide a representative view of the flow regime. The team also collects samples of dry-weather flows from irrigation, car washes, basement parking lots, etc.
- There is not much dry-weather yet, but the initial results show surprisingly high nutrient levels in dry weather flows. Data from rain events (nine so far) have shown that event mean concentration (EMC) levels in the study area are generally worse than those in the city at large, with the exception of TDS levels. E. coli levels are very high in the study area. Median phosphorus levels are higher than the Colorado Department of Public Health and Environment's (CDPHE) standard, but media ammonia and nitrates levels are under those thresholds. Again, more data is needed before policy recommendations can be made.
- In urban water management, the idea of a "first flush" (wherein the first large rain after a long dry period will wash pollutants into a water system, making subsequent storm events cleaner) is generally accepted. The team's early results show evidence of a first flush for nutrients and total suspended solids (TSS), but not for many other pollutants.
- The preliminary results show significant correlations between rainfall intensity and levels of TDS, TSS, and nitrogen. Most of the other variables in the dataset are weakly correlated, probably because not enough data has been collected yet. The dataset needs to include multiple rounds of sampling across seasons before it can reasonably be used to inform decision-making.

Group Discussion
Group members discussed the researchers' automated stormwater sampling results. Their discussion is summarized below.
- Phosphorus seems to have followed a first flush pattern.

- While the team does not have the results from its analysis of the presence of metals in the samples yet, previous research has shown that green infrastructure designed to catch metals often releases those metals in the winter after reacting with de-icing salts.
- The researchers are not sure if they will monitor for organics (i.e., pesticides, pharmaceuticals, flame retardants, etc.), partially because they are expensive to monitor. They may consider adding pesticides to their sampling protocols. Other researchers at Mines are working with the Urban Drainage and Flood Control District to measure levels of contaminants of emerging concern (CECs), which are typically found elevated in stormwater.
- Chloride was an indirect parameter of initial sampling, because it was probably a factor in TDS levels.

Engineered Streambeds for Water Quality for Urban Streams
- McCray is working to engineer streambeds (mainly urban streams and stormwater channels) to treat pollutants. Urban stormwater channels are prevalent, so there are numerous opportunities to use their streambeds to treat pollutants. The engineered streambeds could have applications for stream restoration, acid mine drainage, agriculture, polluted ditches, and stormwater treatment.
- The streambed, also known as the hyporheic zone (HZ), serves as an interchange for surface and groundwater in streams. The HZ is a biogeochemical hotspot because of its heterogeneous nutrient and oxygen levels, temperature fluctuations, etc. These properties allow it to transform any chemical with enough water and a long enough HZ.
- The researchers briefly studied an HZ near Tucson below a wastewater treatment plant that lacked the necessary levels of water exchange and residence time to remove urban water pollutants. They found that heterogeneity (particularly the presence of ponding) helps to drive flows into the subsurface and back up into the stream.
- There has been a lot of research into the role of HZs in carbon and nutrient cycling, and some local and state governments have counted HZs as water infrastructure. However, most best management practices surrounding HZs have not been used in practice because there has not yet been a natural HZ with enough exchange and residence time to be effective at the reach level (in stream terms).
- Accordingly, the team designed a system with two subsurface permeability features (composed of a permeable natural material like wood or biochar) that can be expected to create the necessary levels of interchange to transform a chemical. They call the system "Biohydrochemical Enhancements for Streamwater Treatments," or BEST.
- Modeling suggested that BEST would work; contaminants can be removed by sorption, geochemistry, and microbes if there are porous media and the right oxygen levels for a given pollutant (probably not for nitrates, which would require longer residence times).
- The team also built a two-dimensional version of the systems, which revealed the flow paths that they expected. Next, they conducted a larger pilot test at Mines Park, which found that BEST is 150% more effective than a plain sand channel in terms of water exchange, 200% more effective at removing nitrogen, and 50% more effective in removing nitrates. Further modeling based on testing of HZs in other studies indicated that BEST could remove 99% of pollutants over 125 meters, compared to 190 meters for a sand channel (and over 20,000 meters for a concrete channel).
- Urban streams represent low-hanging fruit for applying BEST because flows are relatively low and uniform. Detention ponds (of which there are hundreds of thousands in the United States) are particularly promising candidates because they capture large amounts of

stormwater and release that water steadily over a few days. Detention ponds also settle out particulates, complementing BEST's ability to remove dissolved pollutants.
- The team modeled BEST in a detention pond on the Mines campus and found that BEST could reduce nitrate concentrations to a milligram per liter over 60 meters, for around $120 per kilogram of nitrogen removed. To reach similar concentrations would require spending $1500 per kilogram of nitrogen removed in restoring or constructing wetlands.
- The team partnered with the City of Golden and State of Colorado to test the system at a detention pond in Golden. It did not work as well as they hoped because the slope of a nearby parking lot funneled a lot of the available stormwater away from the pond. The team is seeking a site that would catch more water.
- The team is working with Seattle Public Utilities to include a modified BEST system in an upcoming stream restoration project and with a European Group studying HZs.
- The researchers plan to customize BEST to remove specific pollutants. BEST is not a silver bullet, but it could be part of a treatment train that improves urban water quality issues stemming from nonpoint source pollution.

Group Discussion
Group members discussed the BEST system. Their discussion is summarized below.
- The researchers plan to examine nitrogen loss more carefully this summer. Existing data suggests that it is likely for there to be sorption to organic matter, but it is unclear if this reversible.
- The researchers are working to determine how often the subsurface material (probably woodchips) would need to be removed, because it will become saturated with pollutants at some point. For the system to be cost-effective, the subsurface media would need to last for at least three years before being replaced.
- Once the woodchips (or other material) are removed, they may be hazardous waste. Regulations for what constitutes hazardous solid waste and how it needs to be disposed of vary by state, but this will not be an issue in most areas without unusual levels of heavy metals.
- The European group that the researchers collaborated with were analyzing HZ's ability to transform the diabetes drug Metformin. Metformin is showing up a lot in EPA testing.
- One of the possible applications for BEST is for stormwater water "polishing" (i.e., trying to remove things from the water that are not yet known or regulated but could cause harm).
- MWRD uses equipment that filters out many pharmaceuticals. It is also experimenting with biological phosphorus removal.
- Aurora Water has found that in-bank filtration with wells that travel through banks and into lined gravel pits removes a lot of additional contaminants before flowing into a water purification facility.
- BEST has interesting applications for treating E. coli, which is resilient in sediment and the source of which is difficult to locate. One original goal of the project was to build a centralized stormwater treatment facility at a golf course near Berkeley, which would be more effective at removing stormwater pollutants (like E. coli) than distributed point source mechanisms alone. That project fell through. Another option could be placing BEST in sewer systems.
- The researchers think that long-term grab samples would be the most effective way to monitor for orthophosphates (currently pertinent because of the OCCT question), given the variability of the data. Autosamplers would be less reliable.
- Group members are welcome to reach out to Professor McCray with questions at jmccray@mines.edu.

PRESENTATION: RANDI BRAZEAU, METRO STATE UNIVERSITY OF DENVER

Randi Brazeau, Associate Professor of Environmental Science at Metro State University (MSU) Denver, presented on her proposal and course leading undergraduate researchers in an investigation of water quality and restoration options along the South Platte in metro Denver. She was joined by one of her undergraduate researchers, Sam McKinney. Her comments are summarized below.

- This is a proposal for a Five Star and Urban Waters Restoration Grant with an education and outreach component. Funders and partners for the course to-date have included the One World One Water Center, Denver Botanic Gardens, Groundwork Denver, CDPHE, the National Fish and Wildlife Foundation, and South Suburban Parks and Recreation.
- Brazeau's course included high schoolers and community students who were awarded scholarships to take the course. The MSU Denver undergraduate students who participated were mostly non-science majors. A core goal of this project was to allow students to conduct research themselves and to create proposals for restoring two sections of the South Platte that water quality testing indicated were degraded. These student proposals were reviewed by guest judges during a Riparian Restoration Design Showcase.
- The goal of the project was to assess water quality in the South Platte River in metro Denver. Water was sampled every three miles between Chatfield Reservoir and Brighton. Water was also sampled at a mountain site as a control. The researchers tested for nutrients, acidity, dissolved oxygen, chlorine, lead, mercury, cadmium, etc. They also made notes about unique features of each sampling site, such as turbidity, the size of storm drains, the presence of impermeable surfaces, etc. The team identified two particularly degraded locations by running regression models on nutrients, temperature, and biochemical oxygen. Students identified several possible point and nonpoint sources of degradation. The team also used ion coupled plasma mass spectrometry (ICPMS) to identify elements of concern like lead and cadmium.
- The project included four parallel studies conducted by more than 25 students over the course of three years. The project will conclude this summer, then the researchers will sift through the data for further insights.
- Brazeau created the Global Water Concerns summer course to engage students on water quality issues beyond the school year. The course is a guaranteed as a transfer class in Colorado, which enabled non-majors to participate. During the most recent eight-week course, students conducted intensive sampling, learned about global water issues, went on four field trips, heard from two guest speakers, and participated in the Design Showcase.
- The Design Showcase featured nine student poster presentations offering a wide range of creative ideas for restoring the damaged portions of the river. The winning proposal called for a three-pronged approach consisting of check dams, pollution prevention, and the revegetation of banks.
- One of the most important results of the project has been a spike in the number of undergraduates who are interested in going to graduate school because of their positive research experiences.
- Group members are welcome to reach out to Professor Brazeau with questions at rbrazeau@msudenver.edu.

Group Discussion

Group members discussed the project and its results. Their comments are summarized below.

- The students who participated in this project could be good candidates for Denver Water internships.

- Brazeau is not sure if this course will continue in the summers to come, partially because of the challenges of securing funding. The team is considering teaching these concepts to secondary education majors so that they can teach their students in turn. This could maximize the project's impact.
- The researchers chose to sample every three miles (every two weeks) to build a baseline model of flows. However, they may redesign the sampling protocols to better reflect what they have learned. Lagrangian sampling, in which the same parcel of water is sampled as it proceeds down a river (based on timing assumptions informed by flow rates) could help the team get a better idea of what inputs and outputs are affecting water quality and where they are in the river.
- The South Platte Coalition for Urban River Evaluation (SPCURE) samples the river on the first and third Wednesday of each month. SPCURE and the research team could compare their data.
- The National Fish and Wildlife Foundation grant that partially funded the project was itself funded by several federal agencies. The Five Star and Urban Waters Grant application should be released soon.

NEXT STEPS
- The next SPRUWP quarterly meeting will be on May 21 from 12:30pm to 3:30pm. Peak Facilitation will send out a calendar invite closer to the meeting.
- SPRUWP's two sub-groups (Education and Outreach and Science and Data) meet bi-monthly. The groups work to achieve concrete results on topics of interest to the partnership. Those who are interested in participating should reach out to Sam Haas.
- Group members with ideas for speakers or meeting topics should contact Sam Haas. Group members should also send anything of interest to the broader group to Sam Haas for distribution in her monthly SPRUWP update email.
- Presentations from both of today's speakers will be available on the SPRUWP website (https://www.epa.gov/urbanwaterspartners/urban-waters-and-south-platte-watershed-headwaters-denver-metropolitan-area). Group members should feel free to reach out to Stacey Eriksen with questions.
- The Coalition for the Upper South Platte (CUSP) will be sponsoring a conference in Denver called "After the Flames," which will focus on the actions that stakeholders take after catastrophic wildfires.