46th Annual
Stormwater and Urban Water Systems Modeling Conference
formerly the
SWMM Users Group Meeting

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Thursday, February 21 - Windsor Room C Morning Program

7:45 AM Registration formalities. Continental breakfast in Main Conference Area.

8:15 AM Opening remarks and introduction of exhibits. William James, University of Guelph

Session 1 - Windsor Room C

8:30 AM 1.1 - Field Investigation of Surcharging in Combined Sewer System. Steven J. Wright, University of Michigan, Ann Arbor, Michigan and Murat Ulasir and Robert Czachorski, Orchard, Hiltz and McCliment, Inc., Livonia, Michigan.

8:50 AM 1.2 - Achieving an Enhanced Understanding of Stormwater Pipe Condition through Data Mining of CCTV Inspection Records. Richard Harvey and Edward McBean, The University of Guelph, School of Engineering, Guelph, Ontario.

9:10 AM 1.3 - Simulation of Air Pockets Motion Using GC Integral Model Framework. T.M. Hatcher, C.D. Chosie and J.G. Vasconcelos, Auburn University, Department of Civil Engineering, Auburn, Alabama.

9:30 AM 1.4 - Field Monitoring and SWMM Modeling Applied to a Rural Intermittent Watershed. Kyle Moynihan and Jose Vasconcelos, Auburn University, Department of Civil Engineering, Auburn, Alabama.


10:00 AM Lunch break - Please join us in the main conference area for a complimentary conference lunch buffet.

10:10 AM Exhibits in Windsor Room B and Lobby Area; Coffee also in Lobby Area

Session 2 - Windsor Room C


11:00 AM 2.2 - Prioritizing System-Wide CSO Capture among Sewersheds with Green Infrastructures (GIs). Dingfang Liu and Nicholas Warrens, CH2M Hill, Boston, Massachusetts.


11:40 AM 2.4 - An Approach to Forecasting Typical-Year Wastewater Flow Rates under Future Conditions. Li Zhang and Fang Cheng, CDM Smith, Columbus, Ohio, and Robert Herr, Gregory Barden and Hunter Kelly, City of Columbus, Columbus, Ohio.

12:00 PM 2.5 - Investigation of Appropriate Model Structure for Modelling Small Urban Catchments. Naglaa Ahmed, Darko Joksimovic and James Li, Ryerson University, Department of Civil Engineering, Toronto, Ontario.

12:20 PM 2.6 - Water Quality Changes in Streams Located Near Urban Areas of the Northern Gulf Coast during Extreme Precipitation Events. Alexander Maestre, Derek Williamson and Amelia Ward, University of Alabama, Tuscaloosa, Alabama.

12:40 PM Lunch break - Please join us in the main conference area for a complimentary conference lunch buffet.
Thursday, February 21 - Windsor Room C Afternoon Program

1:00 PM Exhibits in Windsor Room B and Lobby Area; Coffee also in Lobby Area

Session 3 - Windsor Room C


1:40 PM 3.2 - 1D-2D Model Validation for the Assessment of Urban Flooding: A PCSWMM 2D Application. Rosa Sulzbacher, Robert Scheucher, Valentín Gamenit and Dirk Muschalla, Graz University of Technology, Graz, Austria.


2:20 PM 3.4 - On Modeling and Implications of Frequency Dependent Phenomena in Drainage System Design. William James, Computational Hydraulics Int. (CHI), Guelph, Ontario.

2:40 PM 3.5 - Comparison of Floodline Delineation Methods and Results: HEC-2, SWMM5 and PCSWMM 2D. Robert W. C. James and Karen Finney, Computational Hydraulics Int., Guelph, Ontario.

3:00 PM Exhibits in Windsor Room B and Lobby Area; Coffee also in Lobby Area

Session 4 - Windsor Room C


4:20 PM 4.4 - Disinfection By-Product Modeling Using Bayesian Networks. Zoe J.Y. Zhu, Edward A. McBean and Brett Harper, University of Guelph, Guelph, Ontario.

4:40 PM 4.5 - Impacts of Climate Change - Evidence and Prediction. Edward A. McBean, University of Guelph, Guelph, Ontario.

5:00 PM 4.6 - Heavy Metal Contamination in the Laurel Creek Watershed, Waterloo (Ontario), Canada. Gordon S. Gefer, Ana T. Lima, Hans H.Durr, Jon Jones and Philippe Van Cappellen, Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Ontario.


5:40 PM Closing remarks. End of Sessions.

6:30 PM CHI Dinner in Windsor Room A. All are welcome.

Friday, February 22 - Windsor Room C Morning Program

7:45 AM Continental breakfast in Main Conference Foyer.

Session 5 - Windsor Room C

8:30 AM 5.1 – Verification of Urban Drainage System Designs by Means of SWMM5 and Climate Change Scenarios. Dirk Muschalla, Valentín Gamenit, Jonas Olsson and Günter Gruber, Graz University of Technology, Graz, Austria.

8:50 AM 5.2 - Application of PCSWMM to Explore Possible Climate Change Impacts on Surface Flooding and CSOs in a Peri-Urban Area of Pathumthani, Thailand. Ashish Shrestha, Thirarat Chaosakul, Dedduwa PMP, Priyanka, Ly Hong Chuyen, Su Su Myat, T. Koottatep, M.S. Babel and Nan Kham Sone, Asian Institute of Technology, Pathumthani, Thailand and K.N. Irvine, Nanyang Technological University, Singapore.


9:30 AM 5.4 - High-Resolution Parameterization of a Hydrological Model in Areas with Varying Urban Density. Gerald Krebs, Teemu Kokkonen and Harri Kivioja, Department of Civil and Environmental Engineering, Aalto University, Espoo, Finland and Marjo Valtanen and Heikki Setälä, Department of Environmental Sciences, University of Helsinki, Lahti, Finland.

9:50 AM 5.5 - Energy Metrics for Water Distribution System Assessment. Rebecca Dziedzic and Bryan Karney, University of Toronto, Toronto, Ontario.

10:10 AM Exhibits in Windsor Room B and Lobby Area; Coffee also in Lobby Area

Session 6 - Windsor Room C


11:00 AM 6.2 - Developing an Online Tool for Facilitating Local Involvement in Watershed Implementation Plans. Olivia H. Devereux, Devereux Environmental Consulting, Washington, DC and Jessica R. Rigelman, J7 LLC, Annapolis, Maryland.


11:40 AM 6.4 - SUSTAIN Application for Modeling Green Infrastructure. Uzair (Sam) Shamsi and John Schombert, Michael Baker Corporation, Moon Township, Pennsylvania.

12:00 PM 6.5 - Evaluation and Demonstration of Stormwater Dry Wells and Cisterns in Millburn Township, New Jersey. Leila Talebi, Department of Civil, Construction and Environmental Engineering, The University of Alabama, Tuscaloosa, Alabama and Robert Pitt, Director of the Environmental Institute, Department of Civil, Construction and Environmental Engineering, The University of Alabama, Tuscaloosa, Alabama.

12:20 PM Lunch break - Please join us in the main conference area for a complimentary conference lunch buffet.
Friday, February 22 - Windsor Room C Afternoon Program

1:00 PM Exhibits in Windsor Room B and Lobby Area

Session 7 - Windsor Room C


1:40 PM 7.2 - Modeling Green Infrastructure with Large-Scale Monitoring at Kansas City, Missouri. Robert Pitt, Director of the Environmental Institute, Department of Civil, Construction and Environmental Engineering, The University of Alabama, Tuscaloosa, Alabama and Leila Talebi, Department of Civil, Construction and Environmental Engineering, The University of Alabama, Tuscaloosa, Alabama.


2:20 PM 7.4 - Application of the Green-Ampt Equation to a Watershed Runoff Simulation Using SWMMs. Taehun Jung, Dongguen Ko and Sangho Lee, Pukyung National University, Busan, Korea.

2:40 PM 7.5 - Prioritizing the Best Urban Watershed Management Alternatives Using a Continuous Simulation Model and TOPSIS. Eun-Sung Chung, Sang-Mook Jun, Boram Lee and Won-Pyo Hong, College of Civil Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea.

3:00 PM Exhibits in Windsor Room B and Lobby Area; Coffee also in Lobby Area

Session 8 - Windsor Room C

3:20 PM 8.1 - Advanced Bioretention Systems: Results from Four Years of Mesocosm Studies and Two Years of Field Studies. William Lucas and Margaret Greenway, Griffith University, Brisbane, Australia.


4:00 PM 8.3 - Laboratory Column Test for Predicting Changes in Flow with Changes in Various Biofilter Mixture. Redahegn Sileshi and Robert Pitt, Department of Civil, Construction and Environmental Engineering, University of Alabama, Tuscaloosa, Alabama and Shirley Clark, School of Science, Engineering and Technology, Penn State, Harrisburg, Pennsylvania.


4:40 PM 8.5 - Stormwater Pond Sediment Loading and Accumulation Analysis Using Continuous Simulation. Mike Gregory, AECOM, Kitchener, Ontario.

5:00 PM Awards and Conference Closure.
Investigation of Appropriate Model Structure for Modelling Small Urban Catchments
Naglaa Ahmed, Darko Joksimovic and James Li
(Session 2.5)

Lumped or partially distributed urban drainage models have been used over the past three decades by drainage engineers for evaluation of control options. During that period, many modelling tools have been developed, however, it is generally recognized that considerable experience is required to properly apply models in the analyses. With the more recent shift in control options towards source control and increasing availability of geospatial data at small scales, existing tools such as USEPA SWMM are being applied to study smaller areas in more detail, and are frequently used as uncalibrated models to evaluate source control options. Therefore, guidance for development of such models is still being developed and this study hopes to contribute to this goal.

This research evaluates and compares modelling single lot with and without low impact development (LID) implementation using USEPA SWMM to build distributed models and lumped models. A hypothetical data was examined by developing several grid based models with different grid sizes. The models were examined under two soil types and different time steps. The results from the hypothetical data were tested using runoff data from a 1.65 hectare developed urban area. The case study examined three different models configurations: 1) one catchment, 2) grid model of hundred metre square area and 3) homogenous areas model where every building, backyard, front lawn and streets were presented separately as single catchments. SWMM was run using local rainfall data for six months and for two short events. The results of the models were compared and evaluated based on the total runoff volume, peak flow rate and infiltration volume. Conclusions are drawn regarding appropriate model structure for small catchments, with and without application of LID practices.

Full-Scale Up-Flo® Filter Field Verification Tests
Yezhao Cai, Robert Pitt, Noboru Togawa, Kevin McGee, Kwabena Osei, and Robert Andoh
(Session 7.1)

The Up-Flo® filter was developed by University of Alabama researchers during EPA supported SBIR research and is commercialized by Hydro International. For typical stormwater conditions, the Up-Flo® Filter has been found to remove at least 80% of the suspended solids concentrations (SSC) during field tests, with variable amounts of treatment for other stormwater pollutants including metals, nutrients, and bacteria. The main advantages of the Up-Flo® Filter includes its high treatment flow rate in a small area, significantly decreased clogging problems compared to downflow filtration, and reduced maintenance requirements.

Full-scale field tests have been conducted at the Bama Belle Riverwalk parking lot test site in Tuscaloosa, Alabama for the past several years. Forty actual storm events have been monitored and sampled, and these field performance results indicate that the Up-Flo® Filter has excellent removals for particulates during a wide-range of hydraulic/rainfall conditions. During these monitored events, the flow-weighted average Total Suspended Solids (TSS) removal was about 82% for influent concentrations ranging from 11 to 571 mg/L (average 101 mg/L), while the SSC flow-weighted removal was about 90%. The flow-weighted turbidity removal was also good at about 61%. The Particle Size Distribution (psd) analysis determined that the influent median particle size ($D_{50}$) of the 40 sampled storms was about 345 µm and about 33 µm for the effluent. Nutrient reductions were less, being about 37 and 17% for total nitrogen and total phosphorus, respectively. Metal reductions are very good, with flow-weighted removals ranging from about 54 to 76% for total copper, 67 to 98% for total lead, and 79 to 83% for total zinc (removal ranges are due to some of the effluent concentrations being below the detection limits and the two values were calculated substituting 0 and the detection limit for these conditions). Bacteria reductions were also good, at 53% for E. coli and 57% for Enterococci. Additional event data are being collected and will be further analyzed to examine performance behavior as a function of a wide range of rainfall and runoff conditions.
Investigation of Appropriate Model Structure for Modelling Small Urban Catchments

Gordon S. Geller, Ana T. Lima, Hans H. Dürr, Jon Jones, Philippe Van Cappellen

(Session 4.6)

Metal pollution in our watersheds can have numerous and sometimes severe impacts on the health of organisms which interact with the affected water sources. Some metals are required for cellular growth and maintenance as micronutrients, but are toxic at larger doses, while others are not required and are toxic at even low concentrations. Anthropogenic activities provide pathways for these metals to enter waterways, including industrial activities, mining, and transportation. There is currently a limited amount of literature addressing metal budgets and pathways within individual drainage basins, leading to some limitations in the understanding of heavy metal sources and interactions within these basins. Here, we study Waterloo region, and specifically the Laurel Creek watershed. This tributary to the Grand River is divided in agricultural land (37% basin area), commercial (4.5% of basin), and industrial land (7% of basin), with some brownfields constituted of previously active tanneries. Extensive datasets, mostly at very high resolution, are available, both historical and current, including GIS data on land use, drinking water, storm water management and sewage system, particulate levels, and measurements of various other factors influencing contaminant pathways, with ongoing sampling for many of these. Using the data available, along with an available water model and GIS processing, the aim is to create a water and metal budget, following the methodology first presented by Meybeck et al. 2007 (Science of the Total Environment, 375, 204-231). The budget will focus on specific target heavy metals, such as copper, nickel, and cadmium. We anticipate that this work will introduce a more detailed conceptual model for heavy metals in urban settings, with a better description of some overlooked sources. This study will serve as a stepping stone for larger watershed studies.
Stormwater Pond Sediment Loading and Accumulation Analysis Using Continuous Simulation Mike Gregory (Session 8.5)

The permanent pool in stormwater detention facilities is designed for water quality treatment by providing an appropriate storage volume for the settling of suspended solids and particulate matter that is carried in stormwater runoff. The facility may include additional storage components designed to provide erosion and flood control, but it is the layout and configuration of the permanent pool volume that typically dictates the overall pond footprint size. Sizing of the permanent pool volume if often based on local regulatory requirements that dictate a prescribed total suspended solids (TSS) removal rate, expressed as a percentage removal on an average annual basis. The volume requirement is typically given as a function of the imperviousness and area of the tributary catchment. It is presumed that a pond that meets or exceeds the required volume will achieve its TSS removal target.

The actual treatment efficiency of the pond is a function of catchment hydrology (of which, imperviousness is just one of many variables), control structure hydraulics, and the particle size distribution of TSS in stormwater runoff. After the pond has been constructed, it is also important for the owner/operator of the pond to understand the sediment loading and accumulation characteristics, given the high cost of sediment removal. Presumptive design criteria used to size the permanent pool of stormwater ponds do not account for these site-specific characteristics.

To overcome the limitations inherent in presumptive design criteria, a modeling methodology was developed that improves the current state-of-the-practice design methods. It begins by representing the catchment hydrology based on source area delineations, to better characterize the generation of TSS loads across a range of urban land uses and using continuous simulation to better represent low-cost, average annual rainfall conditions. The unique capabilities of the EPA SWMM5 model were used to represent the dynamic control structure hydraulics as well as the settling characteristics of TSS and particulate pollutants in stormwater runoff. It is intended that the methodology could apply to similar models with the same capabilities.

In this paper, a modeling and design methodology using SWMM5 will be presented for estimating the sediment loading and accumulation in stormwater detention facilities, including lesson learned from two recently permitted and constructed ponds in Ontario, Canada. For both ponds, the water quality module of SWMM5 was used to simulate the generation of TSS loadings from all source areas within each subcatchment tributary to the pond, including pollutant buildup during dry weather periods and washoff during rainfall events. The pollutographs were subsequently quantified through the collection system and the deposition of particulate solids in the pond was simulated.

In SWMM5, particulate settling is represented by a characteristic settling velocity distribution. No local stormwater settling velocity measurements were available and so empirical data from other regions were used (Final Report of the Nationwide Urban Runoff Program, U.S. EPA, 1983). Six mass fractions were used to characterize the particle size distribution of the stormwater washoff load.

The pond removal efficiency and accumulation rates for the non-winter period of April through October were then estimated using local rainfall data. Snowmelt and hydrologic conditions during winter months were not included in this analysis. For comparative purposes, sediment accumulation rates within the pond were normalized by total tributary area and by impervious area.

Achieving an Enhanced Understanding of Stormwater Pipe Condition Through Data Mining of CCTV Inspection Records Richard Harvey and Ed McBean (Session 1.2)

Stormwater pipe condition is commonly assessed using closed-circuit television (CCTV) inspection. These inspections tend to be expensive and most municipalities have been limited to inspecting small portions of their aging stormwater systems. Data mining is proposed as a means of extracting valuable information related to stormwater pipe deterioration from existing CCTV inspection records. Classification tree algorithms are used to identify the influence of pipe-specific attributes (i.e. year of construction, material, diameter, length, and slope) on stormwater pipe condition in Guelph, Ontario. The municipality has inspected 25% of their system and the developed trees can be used to predict the condition of individual pipes that have not yet been inspected. The data mining approach presented in this research allows greater value to be extracted from inspection efforts and enhances stormwater pipe operation and management practice.

Simulation of Air Pockets Motion Using GC Integral Model Framworks T.M. Hatcher, C.D. Chosie and J.G. Vasconcelos (Session 1.3)

There are important adverse effects linked to the presence of entrapped air pockets in stormwater systems. These effects include loss of conveyance, surging caused by air compression, loss of storage and geysering. The ability of monitoring the formation and motion of entrapped air pockets is thus highly desirable when modeling extreme rain events in stormwater systems. Experimental investigation conducted at Auburn University has addressed the kinematics of air pocket motion in a scale model apparatus that allowed systematic variation of ambient flow velocity, pipeline slopes and initial entrapped air pocket volume. Experimental results indicate that for a first approximation the motion of the leading edge of air pockets is controlled by the initial air pocket volume and the ambient flow velocity. Also, an innovative approach to perform simulations of the air pocket has been proposed based on gravity current flows. This approach uses an expression that relates the thickness of the front and its celerity presented in Wright and Vasconcelos (2008). The integral approach also assumes that the air pocket thickness is uniform over its length. A comparison between measured experimental velocities and modeling predictions indicate that the latter is fairly accurate, and may constitute an innovative way to approach the description of entrapped air pocket kinematics in closed conduit flows.

SUSTAIN Application for the Optimization of Stormwater BMPs to Improve Biological Conditions in an Urban Stream in Southern British Columbia. Mauricio Herrera (Session 6.3)

Optimization of stormwater BMP siting and dimensions was achieved through the application of SUSTAIN, a decision support system available from the US EPA (Environmental Protection Agency). Interpretation of the B-IBI scores (Benthic Index of Biological Integrity) assessed the creek benthic invertebrates to be in “poor” biological condition. Management objectives included control of stormwater runoff discharges to reduce the flashiness of the hydrological response and to control pollutant emissions. BMPs were optimized through a multi-objective optimization geared towards obtaining a cost-effective suite of alternatives in order to achieve the best level of control for improving biological in-stream conditions.

The Four National Taps of Singapore: A Holistic Approach to Water Resources Management from Drainage to Drinking Water K.N. Irvine, L.H.C. Chua and Hans S. Elkaas (Session 6.1)

Singapore is a highly urbanized island country and as such faces significant water resources management challenges. Water resources in Singapore are managed following the principles of a closed-loop, hydrologic cycle by one agency, the Public Utility Board ( PUB), which promotes its management philosophy through the “Four National Taps of Singapore” program. The Four National Taps are: i) water from local catchment areas; ii) imported water (from Malaysia); iii) reused water (known as NEWater); and iv) desalinated water. Given the uncertainty of water contracting and imports in the future, the remaining three national taps have become increasingly important and this presentation begins with a general overview of the innovative programs that have been implemented by the PUB in support of these three taps. Stormwater runoff is now captured from two-thirds of
areas and manage flood damage by preserving natural storage volumes. Modeling suites for flood-line delineation include HEC-RAS, HEC-2 (the predecessor of HEC-RAS), and SWMM all of which are approved by the Federal Emergency Management Agency (FEMA). More recently high-resolution hydraulic models have leveraged GIS utilities within flood analysis models; improved computation power has allowed advanced flood line analysis in an open GIS environment, like PCSWMM, whereby transects are directly derived from digital elevation models (DEM) and water surface elevations computed against design storm inputs based on observed, long, continuous time series.

In this study, statutory flood lines were compared to two SWMM5-based floodline delineation methods: Method 1 uses 1-D SWMM5 and DEM-sampled transects to linearly interpolate flood inundation polygons that mark the extent of the flooding. Method 2 is a SWMM5-based integrated 1D-2D approach that estimates the extent and duration of overland flooding. PCSWMM generates a 2D overland flow mesh over the existing 1D major system model, and animates the flooding illustrating the duration and extent. Additionally these analyses allow for incorporation of a flood vulnerable assets layer providing additional information about buildings constructed within the floodplain. Both methods permit the hydrology and hydraulics to be modeled, however in the present study the hydrology component was ignored and design event inflows were entered directly into the hydraulic system to replicate official HEC-2 floodlines. Both new methods are inherently more complex than the original, and locally both match and significantly depart from approved floodlines.

On Modeling and Implications of Frequency-Dependent Phenomena in Drainage

William James

This study is a simplistic numerical exploration of the frequency response of simple drainage elements, and likely falls outside existing professional desiderata. Modern engineering analyses of drainage systems are performed exclusively in the time domain (TD, input and response functions are conceptualised as time series) – prognostic TD models are widely used for planning, design and operation, while diagnostic TD models are used for maintenance and litigation. These situations cover approximately 100% of our applications.

However, multicellular storm systems that track with sensitive speed and direction across complex drainage systems do occur routinely, particularly in summer convective storms in continental climates; common frequencies for such hydrologic input functions include thunderstorm cells of about two per hour or about 0.0005Hz; at significant storm speeds the resolved frequency might be finer, e.g. 0.002Hz (6/h); in slow-moving storms, perhaps 0.001Hz (1 in 3h, 0.3/h). Effective speeds may be even slower in maritime climates.

Drainage system response to such input has the well-known character of engineering systems: in particular, frequency-dependent amplification (resonance) or cancellation (detuning), depending on the geometrical layout of the physical drainage system and its components. In other words, at the extremes hydrologic response may be either damped or amplified by both (a) attenuation devices (such as ponds and LIDs) and (b) tuning devices (such as pavement, diversion structures and interceptors).

Basically, the problem boils down to this: common design storm methods simplify complex storms in the original record into simplistic, single, causative input functions, and therefore cannot replicate frequency-dependent flood responses (which are watershed specific, obviously). Engineers thereby, typically, opt to ignore such effects in their designs (perhaps reasonably).

But such engineering system responses are readily demonstrated by realistic and simplistic PCSWMM models, and the results can be presented in both the time and frequency domains. In this study, storm hyetographs are generated as a sinusoidal waveform covering a spectrum of discrete, representative frequencies, and applied to an elementary SWMM drainage model. Computed responses are presented in both the frequency and time domains. Standard design storms are also applied and discussed.

Several implications arise which may be potentially serious: for complex weather systems, standard engineering design of drainage may inadvertently underestimate floods and expose designers and modellers to legal risks. Suggestions are made and a fast routine demonstrated in PCSWMM for modeling some frequency-domain effects and for evaluating such risks. Whether this is a real problem is still too early to say.

Application of the Green-Ampt Equation to a Watershed Runoff Simulation Using SWMM5

Taehun Jung, Dongguen Ko and Sangho Lee

Infiltration methods affect the results of watershed runoff simulation. There are three major infiltration methods frequently used: the Green-Ampt method, the U.S. NRCS (Natural Resource Conservation Service) method, and the Horton method. The NRCS method and the Horton method were derived from experience or experiment, and the Green-Ampt method was derived from a physical mechanism of groundwater flow. Most Korean engineers prefer to use the NRCS method rather than the Green-Ampt method, as the parameters of the NRCS method are easily determined from land use and soil maps. The NRCS method, however, was derived from the soil types and the land use classifications of U.S.A., and it does not conform to the land use classifications of Korea. The purpose of the study is to find more suitable method between the Green-Ampt method and the NRCS method in watershed runoff simulation. We also describe estimation procedures of the Green-Ampt parameters.

Using the SCE-UA method, we automatically calibrated the SWMM for watershed runoff continuous simulation with the NRCS method and the Green-Ampt method for the Milyang Dam Basin, Korea. The curve number of the NRCS method and the three parameters of the Green-Ampt method were estimated from the automatic calibrations including nineteen hydrological parameters, respectively. The Green-Ampt parameters are the saturated hydraulic conductivity, the average capillary suction head at the wetting...
The City of Torrance Madrona Marsh Preserve is an Environmentally Sensitive Area and valuable habitat for a variety of birds, insects, mammals and plant species. Once sought out to be a condominium development, the City along with the Friends of Madrona Marsh saved the delicate habitat by forming an agreement with the developer to donate 54 acres surrounding the marsh. Upon acquiring the land, the City hired a professional naturalist to institute programs for restoring the preserve. With funding and support from the California Coastal Conservancy and Santa Monica Restoration Commission, the City began researching methods to reduce nutrients in the water before entering the marsh. The main concern was phosphates causing rapid algal growth in the marsh leading to oxygen depletion, otherwise known as hypoxia.

After reviewing several ineffective plans, the City looked to Wetland Systems, Inc. (MWS) for a solution. The company’s WetlandMod is a self-contained treatment train system that incorporates media filtration for pre-treatment and a subsurface flow wetland (wetland). MWS tweaked its traditional system incorporating a much larger scale wetland to treat various flow volumes. The City incorporated this design into a project that prevents trash from entering the Marsh and aerates the treated water.

The Marsh receives water via two large storm outfalls collecting in a large detention basin. The treated water is diverted back into the detention basin using a rip rap waterfall. Within 24 hours following filtration, samples were pulled resulting in a 37% nitrate reduction, over 50% phosphate reduction and 87% reduction in turbidity. Results will continue to improve as plant root systems establish growth within the wetland. Madrona Marsh staff will continue to monitor water quality.

The project included replacing pumps, installing retrainable curb gates on catch basins to prevent trash from entering the detention basin, installing Bio Clean filters at the storm drain outfalls to remove oil and grease, removing trees around the outfalls providing UV exposure and constructing a rip rap waterfall to aerate treated water flowing back into the basin. Project benefits include keeping the City of Torrance in compliance and extending water quality regulations to restore a preserve that continues to be a valuable habitat for the plants and animals as well as a sanctuary for bird watchers, college professors and children.

High-Resolution Parameterization of a Hydrological Model in Areas with Varying Urban Density

After reviewing several ineffective plans, the City looked to Wetland Systems, Inc. (MWS) for a solution. The company’s WetlandMod is a self-contained treatment train system that incorporates media filtration for pre-treatment and a subsurface flow wetland (wetland). MWS tweaked its traditional system incorporating a much larger scale wetland to treat various flow volumes. The City incorporated this design into a project that prevents trash from entering the Marsh and aerates the treated water.

The Marshall receives water via two large storm outfalls collecting in a large detention basin. The basin contains three pumps, two pumps deliver water into marsh and the third into the WetlandMod where water flows through a proprietary media removing high levels of TSS, hydrocarbons, particulate heavy metals and nutrients. Reducing particulates before entering the wetland media minimizes loading and prevents it from clogging. Water is then distributed through a manifold creating an even flow of water across the wetland. Treated water is diverted back into the detention basin using a rip rap waterfall. Within 24 hours following filtration, samples were pulled resulting in a 37% nitrate reduction, over 50% phosphate reduction and 87% reduction in turbidity. Results will continue to improve as plant root systems establish growth within the wetland. Madrona Marsh staff will continue to monitor water quality.


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not correlate well with ADP or with rainfall depth of the prior storm event. The results from this study show that the common modeling practice where the initial mass available for washoff $D_m$ is simulated using antecedence period and previous rainfall should be reassessed, at least when applied to tropical catchments. The study also shows that washoff parameters depend on catchment size. The slopes of regression between $C_o$ and $D_m$ with $D$ increase with catchment area, implying that washoff behavior in smaller catchments is less sensitive to changes in rainfall depth than larger catchments.

Prioritizing System-Wide CSO Capture Among Sewersheds with Green Infrastructures (GIs)

Dingfang Liu and Nicholas Warrens

( Session 2.2)

Onondaga County, NY, is one of the first Regional Authorities in the U.S. to include the use of green infrastructures (GIs) in a consent judgment for combined sewer overflow (CSO) abatement. The County initiated the Save the Rain program to implement GIs to prevent stormwater runoff from entering the combined sewer system. The GIs are an alternative to building expensive stormwater treatment facilities, for CSO abatement mitigation. One of the planning challenges is to figure out how to strategically place the GIs among the sewersheds while maximizing its effectiveness for CSO capture in conjunction with planned gray infrastructures. For example, an off-line storage facility in the Clinton Street (CSS080) sewershed could provide more than 6.0 million gallons of storage volume, and GIs projects constructed within the tributary area of the storage facility may not be as effective as the same project located outside its tributary area for reducing CSO volumes. Using an automated optimization procedure, this study will evaluate the optimal placement of GIs among the combined sewersheds to achieve the highest cost-effectiveness for the County's CSO abatement program. A ten (10) day period of precipitation data extracted from the existing long-term rainfall data was used for optimization runs in order to closely match the typical year condition without compromise computation time.

Advanced Bioretention Systems: Results from Four Years of Mesocosm Studies and Two Years of Field Studies

William C. Lucas and Margaret Greenway

( Session 8.1)

This presentation is a follow up to our mesocosm studies on advanced bioretention systems (ABS) designs that substantially improve removal of nitrogen ($N$) and phosphorus ($P$) from runoff. These findings are now being confirmed in field and pilot scale studies in WA, VA, DE, NJ, and MD, as well as Singapore and Shenzhen, PRC. Another year of mesocosm research will also be presented, with novel findings about processes involved in P retention.

The WA studies comprise the most rigorous and extensive experimental bioretention studies ever conducted. Completed in November 2010, initial results showed that the high compost media had considerable losses of N and P, even when inflow runoff concentrations were negligible. While this may highlight potential drawbacks from the compost used in current media recipes, results will be presented on how these systems responded when runoff was applied at higher concentrations after the systems had become well established. The DE facility treats 20 acres of agricultural and urban runoff in a full scale facility. It will have been established for over two years, with most of the first year's data obtained. The WA facilities comprise a bioretention cell treating half an acre of parking, plus a planter trench system for ultra-urban retrofits. These systems will have been established for over a year as well. The NJ system will have been established for almost three years, thus representing a fully mature facility. Currently in the design phase, the MD system is designed to remove nutrients found at much higher concentrations in agricultural runoff.

Prioritizing System-Wide CSO Capture Among Sewersheds with Green Infrastructures (GIs)
the grey alternative in the typical year. In the extreme year, the controlled LID systems outperformed the grey alternative, indicating the LID SCMs are more resilient in terms of meeting the challenges of future global climate change.

Water Quality Changes in Streams Located Near Urban Areas of the Northern Gulf Coast during Extreme Precipitation Events

Alexandra Maestrae

(Session 2.6)

The Northern Gulf Coastal Hazards Collaboratory (NGCHC) is interested in advancing the science and engineering of coastal hazards across southern states of the U.S., including Louisiana, Mississippi, and Alabama. One of the strategies of the collaboratory is to share and distribute reference implementation models that enable multi-disciplinary collaborations that motivate the research and development in Coastal Hazards.

One of the strategies developed by the collaboratory involves the generation of a hydraulic and hydrological model that evaluates inland flooding conditions, and ecosystem impact under extreme precipitation events (including tropical storms and hurricanes.) The University of Alabama is interested on the effects that these extreme events might cause to streams and rivers located near urban centers located along coastal areas of Mississippi, Louisiana, and Alabama. According to the Environmental Protection Agency (EPA), it is expected that the coastal population located in the five states of the Gulf of Mexico will increase from 44.2 million (1995 Census) to 61.4 million in 2025. To understand the changes in water quality and water quantity of streams located near urban areas of the Gulf Coast, we have conducted statistical analyses of the samples collected by local and state agencies using the STOrE and RETrieveal (STORET) Data Warehouse. In addition, we have analyzed daily water discharges from nearby stream gaging stations, and daily precipitation from major airports located along the Gulf Coast. The statistical analyses were completed using parametric survival regressions as those implemented in the tool Weighted Regressions in Time, Discharge, and Season (WRTDS) developed by the United States Geological Survey (USGS).

Impacts of Climate Change: Evidence and Prediction

Edward A. McBean

(Session 4.5)

Lumped or partially distributed urban drainage models have been used over the past three decades by drainage engineers for evaluation of control options. During that period, many modelling tools have been developed, however, it is generally recognized that considerable experience is required to properly apply models in the analyses. With the more recent shift in control options towards source control options, increasing availability of geospatial data at small scales, existing tools such as USEPA SWMM are being applied to study smaller areas in more detail, and are frequently used as uncalibrated models to evaluate source control options. Therefore, guidance for development of such models is still being developed and this study hopes to contribute to this goal.

This research evaluates and compares modelling single lot with and without low impact development (LID) implementation using USEPA SWMM to build distributed models and lumped models. A hypothetical data was examined by developing several grid based models with different grid sizes. The models were examined under two soil types and different time steps. The results from the hypothetical data were tested using runoff data from a 1.65 hectare developed urban area. The case study examined three different models configurations: 1) one catchment, 2) grid model of hundred metre square area and 3) homogenous areas model where every building, backyard, front lawn and streets were presented separately as single catchments. SWMM was run using local rainfall data for six months and for two short events. The results of the models were compared and evaluated based on the total runoff volume, peak flow rate and infiltration volume. Conclusions are drawn regarding appropriate model structure for small catchments, with and without application of LID practices.

Field Monitoring and SWMM Modeling

Applied to a Rural Intermittent Watershed

Kyle Moyhinan and Jose Vasconcelos

(Session 1.4)

The Storm Water Management Model (SWMM) has proven very effective in modeling urban/suburban watersheds since its conception in 1969. While heavily implemented in the simulation of urban watersheds, its performance in strictly rural watersheds has been less frequently evaluated. This paper presents an ongoing research effort in a rural, 600-acre site, located in Pittsview, AL and owned by the Alabama Associated General Contractors (AGC). The site is positioned at the headwaters of a watershed that contributes to the Hatchechubbee Creek, which then discharges into the Chattahoochee River north of Eufala, AL. The streams running in the watershed are intermittent, but areas of large streambed erosion indicate large rainfall-runoff events. A network of rain gauges, associated with a portable weather station, two monitoring wells and two stream weirs have been deployed and are continuously recording information that will offer insights of the local water budget. This information in turn will help in the design of a proposed recreational pond system. The collected field data has also been used in a SWMM model that provides a representation of the rainfall-runoff processes in the watershed, as well as the observed flows in the streams. As more insight is obtained with regards to the local water cycle, it is anticipated that the SWMM model calibration will improve, which in turn will facilitate and provide greater confidence on the design tasks related to the proposed pond system.

Verification of Urban Drainage System Designs by Means of SWMM5 and Climate Change Scenarios

Dirk Muschallia, Valentin Gamenith, Jonas Olsson and Gunter Gruber

(Session 5.1)

The Linzcatchment is situated in Linz, Austria at the Danube River and covers approximately 900 km² in total. The area of downtown Linz with mainly combined sewers and 39 neighbor communes with combined and separate systems are drained to one central waste water treatment plant (WWTP). Several CSOs and CSO tanks are installed in the combined sewer system. The primary clarifiers at the WWTP are also used as CSO tanks during rainfall.

Historical rainfall data from downtown Linz was available for the period from 1993 to 2006. For the scenario analysis four predicted future rainfall time series were available. They were obtained by downscaling a future global climate model projection representing an intermediate level of future greenhouse gas and covering the period 1961-2100. In a first step, the global projection was dynamically downscaled to a 50x50 km grid over Europe. In a second step, the regional results were further downscaled to local scale. Future local changes in the frequency distribution of precipitation intensities between periods 1993-2006 and 2079-2092 were estimated on a seasonal basis. The final predicted time series was obtained by applying the estimated changes to the historical time series.

Two versions of the downscaling approach were applied. In the first the future frequency is identical to the historical, which is common Delta Change practice. In the second also estimated frequency changes were transferred to the historical time series.

An aggregated model of the Linz catchment and sewer system was available in SWMM5. In total 43 CSOs were included in the model. State-of-the-art global sensitivity analysis and multi-objective optimisation methods were applied for model testing and calibration. The calibrated model was then used as basis for the following evaluations.

The predicted rainfall series generally show a decrease of rainfall intensities in the summer period and an increase in winter. High precipitation intensities and total precipitation generally increase.

The requirements as defined in the Austrian Regelblatt 19 guideline are met for both dissolved and particulate pollutants for the historical and for all so far available predicted time series. The total overflow volume is increased by approximately 21 – 22%. For the most important
CSO structures overflow volume increase in a range between 10 to 60%. The significant increases of the overflow volumes for single structures could locally seriously affect the water quality of the receiving waters.

Knowledge of the CSOs that are sensitive to climate change can help to find proper mitigation strategies and measures in time for these areas to prevent critical water quality conditions.

Adding to EPA SWMM5’s Capability to Model Long Term Continuous Rainfall Dependent Inflow & Infiltration

Joseph Pang (Session 5.3)

This paper describes a proposed addition to the existing SWMM5 Groundwater Module for use in calibrating long term continuous rainfall dependent inflow & infiltration (RD I/I) simulation. This addition is intended for use in cases where monthly infiltration patterns are not repetitive and the existing RTK method might not be applicable, and where the existing groundwater power function algorithm may not be applicable for modeling infiltration through defects in conduits. This proposed addition contains 2 parts. The first part includes adding an additional outlet to the existing Groundwater Aquifer to enhance the simulation of interflow infiltration into a conveyance system. The second part includes adding a second groundwater discharge algorithm to the SWMM5 Groundwater Module. Similar to the existing groundwater discharge algorithm, this new algorithm also utilizes the same 5 parameters but each having different functions than in the existing algorithm. With the same number of parameters as the existing algorithm, the new algorithm can be added into the existing SWMM5 code with minimal code revision. The aforementioned addition has been coded into an alpha-version of a SWMM5 engine and preliminary testing has been conducted. Testing results confirm that new algorithm works for calibrating long term continuous RD I/I simulations in cases where the RTK method and the existing groundwater power function algorithm might not be applicable.

Complete Dynamic 2D Modeling for Cost Benefit Analysis of Flood Mitigation: Case of a Densely-Populated Coastal City in France

Nelly Peyron (Session 3.1)

Located on the north coast of France, the city of Morlaix is subject to frequent floods, particularly in the dense downtown area at the confluence of two rivers, where flood levels are aggravated by sea tides. Following many recent floods, the municipality sought global and sustainable solutions, and a study was conducted 10 years ago to propose appropriate hydraulic works for both watersheds that would reduce peak flows upstream. Reduced peak flows would have reduced damages; however, no specific study quantified the impact and financial benefits of the proposed works, and so the process stopped.

Appropriate cost benefit analysis is the main objective of the present study. Detailed PCSWMM 2D modeling covers the entire hydraulic system, which comprises: two converging rivers, underground sewer networks and flood flows through the downtown area. To better understand the dynamic behavior of the flows, scenarios based on various flood and tide conditions were analyzed. Derived maximum flow depths and velocities helped quantify existing flood cost damages and costs (i.e. without the proposed hydraulic works).

Investments in the hydraulic works were found to pay off in a 12 year period, and the economic analysis reinforced public interest in targeting the proposed works within 50 years. Sensitivity analyses on all parameters validated the strength of the approach. PCSWMM 2D was found to be an effective and user-friendly method for cost analysis for flood mitigation in Morlaix.

Modeling Green Infrastructure with Large-Scale Monitoring at Kansas City, MO

Robert Pitt and Leila Talebi (Session 7.2)

The results presented in this paper summarize a small portion of the full project activities associated with the National Demonstration of Advanced Drainage Concepts Using Green Solutions for CSO Control Project in Kansas City, funded by the USEPA Office of Research and Development, Urban Watershed Management Branch. Runoff monitoring was conducted in the combined sewer system at several locations in the test and control watersheds. Event-based monitoring after the sewer was re-lined, and these data were used as a new baseline condition. WinSLAMM evaluated the test (pilot) and control watersheds during the two monitoring periods (post re-lining, as the new baseline versus after construction of controls) to verify the rainfall-runoff calibration based on site development characteristics and the actual rains monitored.

The Kansas City Gill demonstration project site is unique because a very large portion of the test (pilot) area receives direct treatment from many separate stormwater control devices, and the large area was monitored to demonstrate the actual flow reductions. However, as in all retrofit installations, stormwater controls could not be placed to treat all the flows from the entire watershed area because of limitations from existing infrastructure, large trees, and surface drainage paths. More than 135 bioretention controls (large curb cut bioretention, bioswale, porous sidewalks, and rain gardens) were installed in the 100 acre test watershed. The after-construction flow ratios (comparing the test to the control area flows) were significantly smaller (p = 0.004) compared to the before construction baseline flow ratios. The overall flow reductions were found to be about 70% less in the test area compared to the control watershed area for the runoff events monitored after the construction of the stormwater controls. The calibrated WinSLAMM analyses resulted in close agreements for both the baseline and the after installation events.

Urban Drainage: Monitoring, Modeling and Maintenance

J. Sansalone, G. Ying H. Zhang, S. Raje, G. Garofalo, G. Becciu, V. Ranieri (Session 4.1)

The urban environs are a complex constructed infrastructure that significantly alters rainfall-runoff relationships and through the generation of anthropogenic and biogenic constituents results in significant transport of chemical, thermal, microbiological and particulate matter (PM) loads. These loads are largely coupled with the altered rainfall-runoff or snow-snowmelt relationships. In North American cities with municipal separate storm sewer systems (MS4s) the load of volumetric runoff, chemicals and PM are equal to or greater than the untreated influent loads to municipal wastewater treatment plants (WWTP) yet the management of urban documents (runoff) loads is at least a half century behind municipal wastewater management and is greater in scale and cost. Urban runoff management is very challenging; in part due to PM hetero-dispersivity, interactions between aqueous and PM phases, stochastic hydrology and highly unsteady hydrodynamics. Such challenges and associated costs with resolving such challenges have led to the relatively common historical examination of a spectrum of urban constituent control systems as black-box systems and rainfall-runoff chemistry utilizing lumped measurements; and many indices and measurement methods adopted from wastewater treatment.

Urban drainage systems that do not provide some level of hydrologic restoration are not sustainable. Additionally given the PM, gross solids and constituent load inventories that build up in urban areas, source control practices and load credits must be an integral part of any management plan that includes restoration, treatment and reuse. Urban drainage treatment, urban maintenance and green infrastructure will play an increasingly critical role in the entire urban water cycle and therefore we must develop maintenance practices such as pavement cleaning, source control and near-source control. Advances with respect to sustainability of urban water require tools such as continuous simulation models (SWMM), smart sensors and computational fluid dynamics (CFD) and a focus on fundamental UO concepts.

The role of our constructed environs and activities therein on the urban water cycle and coupled delivery of constituent loads is examined. Results indicate the need for continuous simulation models such as SWMM to quantify hydrologic restoration. State of the art tools, specifically computational fluid dynamics (CFD) are introduced to illustrate the role of CFD in examining treatment of urban water.
When developing sites in Southern Ontario, to mitigate the potential impact of impervious surface creation on downstream flood risk it is typically required to provide “post-development to pre-development” water quantity control through the implementation of stormwater management infrastructure. Under conventional practice, the stormwater infrastructure designs are typically designed based upon analyses which apply rainfall data generated by synthetic design storm events that correspond to particular statistical return periods. Issues and limitations surrounding the application of synthetic design storm events for sizing stormwater management infrastructure have been recognized in previous studies and research literature. While continuous hydrological simulation using long-term, locally recorded meteorological data is generally considered to be a more rigorous technique for completing hydrologic design analyses, this approach is often precluded from application due to limitations in the available data.

This paper presents a case study for the Humber River Watershed, for which radar-generated rainfall was used to support evaluation of stormwater management practices for quantity (flood) control. The PCSWMM modelling software, developed by demonstrate SUSTAIN applications using examples from engineering projects in and around Pittsburgh, Pennsylvania. The main focus of the paper will be on SUSTAIN’s BMP siting tool which supports selection and placement of suitable BMP locations that meet user defined site suitability criteria such as size of drainage area, slope, hydrological soil group, groundwater table depth, property type, and buffer distance from buildings, roads, and streams.


Uzair (Sam) Shamsi (Session 6.4)

Stormwater Low Impact Development / Green Infrastructure

Stormwater Low Impact Development / Green Infrastructure

Chi has been utilized for the study, which enables users to directly use radar generated rainfall data. The analyses applied radar-generated rainfall for historic local storm events, as well as the transposition of radar-generated data for formative storms from other areas of Southern Ontario. The results of this study have demonstrated that the application of radar rainfall data can improve calibration of a hydrologic model and can provide important insight into the performance of stormwater management infrastructure.

SUSTAIN Applications for Modeling and Mapping Green Infrastructure

SUSTAIN Applications for Modeling and Mapping Green Infrastructure

The Innovative Wastewater Treatment Technologies alternative was confirmed as the Preferred Alternative for accommodating the growth forecasted to occur in the Upper York Sewage Solutions (UYSS) Service Area to 2031 in the Regional Municipality of York (York Region). The UYSS Individual Environmental Assessment (EA) Report is expected to be submitted to the Ontario Minister of the Environment for review and approval by late 2013. A key element was the influence of the treated clean water discharge from the proposed Water Reclamation Centre (WRC) on the East Holland River and its thermal régime. The purpose of the subject study, conducted as part of the EA, was to study potential thermal benefits and impacts of several locations for the WRC discharge location on the East Holland River.

Two hydrodynamic models, Environmental Fluid Dynamics Code (EFDC) and CEQUAL-W2 (W2 in short) were applied to evaluate the potential thermal benefits and impacts of the proposed alternative WRC discharge locations. River boundary conditions compiled in ArcGIS from various survey datasets. For the areas with no survey data, an interpolation algorithm was developed using VBA/ArcObject.

The EFDC grid was constructed by RGFGRID, a utility released with Del3d Suite, which can generate a quadrilateral grid confined with splines. The generated grid was then imported into EFDC_Explorer (EE, a GUI for EFDC) for model setup. A python script was written to convert the EE exported plot file to polygon shapefile for GIS display. W2 model divides the study domain along lateral direction into segments, and in vertical direction into layers requiring the widths of each layer at every segment. A width interpolation algorithm was formulated in VBA/ArcoObject from river shoreline boundary and a DEM covering the East Holland River to generate the widths for each layer. Typically W2 model segments have overlapping areas, causing difficulties in interpreting ice thickness in these areas. A GIS post-processor was therefore developed to convert segment polygons to vertices interpolated to raster for better ice thickness distribution display.

EFDC and W2 were built with the same external forcing variables except for using relative humidity for EFDC and dew point temperature for W2. The forcing variables were flow rates, water levels, water temperature, wind...
starting point to identify and evaluate adaptation options. This study focused on the peri-urban area of Rattanakosin Village, Pathumthani, a region that can be considered the suburban fringe of Bangkok. PCSWMM previously has been applied to assess CSO quality and surface flooding in the village, so it was possible to build on the past studies. Analysis of daily rainfall data from the nearby Don Mueang International Airport showed the year 2000 as similar to the 30 year norm, 1980-2011, and therefore was used as the baseline against which climate change scenarios were compared. PCSWMM, run at hourly increments with the rainfall from 2000, suggested 11 of 218 nodes in the village would be flooded for more than 24 hours, with a total annual flood volume of 367,201m³ and total annual CSO volume of 1,522,200m³. Two approaches to assess possible impacts associated with climate change were followed. The first approach looked at a synthetic rainfall time series downscaled through the ECHAM regional climate model for IPCC emission scenario B2 and available from the Climate Data Distribution System, Thailand. The synthetic rainfall record was divided into three periods and hourly rainfall data were run through PCSWMM for the years 2021, 2061 and 2091. The second modeling approach simply increased the 2000 precipitation by 10% intervals between 10% and 40%. PCSWMM results using the ECHAM4 rainfall showed the number of nodes flooded for more than 100 hours increased by a total of 3, total annual flood volume progressively increased from 370,543 m³ to 483,059 m³ and total annual CSO volume increased from 1,883,118 m³ to 2,071,355 m³ between 2021 and 2091. Under the second (proportional rainfall increase) approach, flood volumes increased by 19, 39, 60 and 82 percentages from the baseline scenario with 10% rainfall increments between 10% and 40%. The increased annual flood volume in 2091 under the ECHAM4 approach was similar to that generated by the 30% increase in rainfall scenario. PCSWMM results show that great increases in surface flooding and CSO discharges to a local drainage/irrigation canal (with attendant impacts to water quality) can be expected under the various climate change scenarios. Adaptation measures could include LiDAR technologies as well as hard engineering options such as increased pumping capacity to clear flooded streets (although under extreme events such as observed in 2011 the pumps likely would have limited impact). Adaptation measures should be evaluated in detail using a dynamic modeling approach.

Estimating Combined Sewer System Percent Capture

Sangameswaran Shyamprasad, Khalid N. Khan and Gary Mercer

One of the criteria within the “Presumption Approach” in EPA’s CSO policy is to provide “…the capture for treatment of no less than 85 percent by volume of the combined sewage collected in the combined sewer system during precipitation events on a system-wide annual average basis.” The percent capture criterion is applicable only to a system generating and conveying combined sewage (i.e., sanitary sewage and storm water). Estimating this important system performance evaluation measure can be a relatively straight forward process for a simple combined system with limited number of combined sewer overflows (CSOs). However, as the size and complexity of a collection system increases, computing percent capture process can quickly become a more involved task. Further, when multiple municipalities and/or basins contribute wastewater to a single wastewater treatment plant, percent capture may need to be estimated at both system-wide and basin levels.

This paper presents a tiered approach, whereby the percent capture is estimated for each combined point of connection, for each planning basin (which comprises of multiples of points of connections), and finally for the whole system (which includes the various planning basins). While the policy only requires for a certain percent capture criterion to be met on a system-wide level, the availability of percent capture results at the planning basin and point of connection can also be useful for planning appropriate level of control and determining the most benefit for dollar spent.

The CSO policy description of percent capture allows credit for the dry weather flow during a wet weather period as part of the captured flow. Thus, identifying the wet weather periods is a very important step when estimating percent capture. For the analysis discussed in this paper, a wet weather period is defined as ‘a reported period of time during which the system experienced wet weather flow conditions and the system inflow exceeds the system dry weather inflow by a threshold of five percent or a reported period of time when the system is experiencing an overflow event resulting from wet weather conditions.” Examples of these concepts are presented for a representative calibrated SWMM model.

Laboratory Column Test for Predicting Changes in Flow with Changes in Various Biofilter Mixture

Umer (Sam) Shamsi

Appropriate hydraulic characteristics of biofilter media, including flow rate and water contact time, along with pollutant removal, are important characteristics when designing a biofilter. Appropriate hydraulic characteristics of biofilter media are important for the effective removal of pollutants. The results of these tests will enable the biofilter designer to better estimate the flow rates and filter residence times for various mixtures of common biofilter media components. Future tests will examine the particulate trapping capabilities of these mixtures as a function of stormwater particle size.

As noted above, the laboratory columns used in the tests have various mixtures of sand and peat. The results of the predicted performance of these mixtures were also verified using column tests (for different compaction conditions) of surface and subsurface soil samples obtained from Tuscaloosa, AL, infiltration test areas, along with bioretention media obtained from actual Kansas City biofilters and standard samples of North Carolina biofilter media.

Three levels of compaction were used to modify the density of the media layer during the tests: hand compaction, standard proctor compaction, and modified proctor compaction. The infiltration rates through the media were measured in each column using municipal tap water. Particle trapping tests will be performed in order to confirm the compacted media columns using a mixture of fine ground silica particulates (Sil-Co-SiL250), medium sand, and coarse sand mixed with Black Warrior River water.

The preliminary laboratory compaction test results indicated that compaction and media particle uniformity have the most significant effects on the infiltration rates; however changes in bulk density resulting from amending the sand mixture with peat were observed.

1D-2D Model Validation for the Assessment of Urban Flooding:

A PCSWMM 2D Application

R. Sulzbacher, R. Scheucher, V. Gamerith and D. Muschalla

The investigated catchment is a small structured urban basin, with many narrow streets and small lots and buildings in the city of Graz (Austria). This led several difficulties in data collection. Hence a step-wise approach for the 1D-2D model-set up was chosen, providing the possibility to obtain intermediate results for evaluation.

The first step was to set up a 1D model in PCSWMM and calibrate it with observed rainfall and sewer flow data in the investigated area. Next, node flooding was evaluated with Euler II type design storms. Based on the node flooding results, several regions within the investigation area were identified for implementing a dual drainage approach.

The dual drainage model was then implemented in the 1D model using a bidirectional flow approach with two weirs for every manhole (Concha Jopia and Gomez Valerien 2010). As the dual drainage model served only to gather rough information about the flow paths along the streets, no street inlets were implemented in the 1D-1D model. The results from the 1D-1D model were then used for assigning hot-spots. Around these hot spots a detailed 1D-2D approach was implemented. The main goal of this detailed 1D-2D model is...
Evaluation and Demonstration of Stormwater Dry Wells and Cisterns in Millburn Township, New Jersey
Leila Talebi and Robert Pitt (Session 6.5)

The primary objective of this project was to investigate the effectiveness of the Township of Millburn’s use of on-site dry wells to limit stormwater flows into the local drainage system. The objective was to examine this stormwater management alternative applicable for mature urban and suburban communities to reduce stormwater discharges associated with new development and redevelopment. This objective was achieved by collecting and monitoring the performance of dry wells during both short and long-periods. The water quality beneath dry wells and in a storage cistern was also monitored during ten rain events.

There were varying levels of dry well performance in the area, but most were able to completely drain within a few days. However, several had extended periods of standing water that may have been associated with high water tables, poorly draining soils (or partially clogged soils), or detrimental effects from snowmelt on the clays in the soils. The infiltration rates all met the infiltration rate criterion of the state guidelines for stormwater discharges to dry wells (but not the state regulations that only allow roof runoff to be discharged to dry wells and that prohibit dry well use in areas of shallow water tables). Overall, most of the Millburn dry wells worked well in infiltrating runoff. The dry well findings reported in this paper indicate that the dry wells did not significantly change any of the water quality concentrations for the observed stormwater constituents. The cistern system did result in significant reductions in bacteria levels. Although the dry wells provided no significant improvements in water quality for constituents of interest for the infiltrating water, they resulted in reduced mass discharges of flows and pollutants to surface waters and reduced runoff energy, major causes of local erosion problems.

Combining Modeling Expertise and Optimization Algorithms in Water Distribution Network Design
Bryan A. Tolson, Ayman Khedr, Masoud Asadzadeh (Session 4.2)

Water distribution network (WDN) design problems are typically solved using only modeller expertise/engineering judgment or some type of global optimization algorithm. While there are many example problems available where both of these approaches work well, there are other more complicated and high-dimensional problems where both of these approaches may fail. This work highlights one such complicated example where modeller expertise and global optimization are combined to solve a multi-objective WDN expansion problem (http://www.wds2012.com/trn.html) involving more than 500 potential decision variables. EPANET2 is used to model the WDN and the efficient Pareto-Archived Dimensionally Diminished Search (PA-DDS) is used for optimization during the multi-stage solution approach. Our first solution to this problem was generated by evaluating a total of 20,000 different designs. In comparison with solution approaches relying mainly global optimization and super computing networks, our solution was non-dominated (of equivalent quality) and utilized orders of magnitude less computation time. This talk will highlight the importance of injecting modeller expertise into the design process and describe ongoing experiments designed to demonstrate that only novice modelling expertise is required to greatly enhance PA-DDS performance. Overall, results demonstrate the enormous difficulty associated with accurately approximating the set of non-dominated solutions in multi-objective WDN design optimization.

Low-impact Development Measures Implemented as Part of Stormwater Management at the Conestoga College South Campus
Brian Verspagen, Ann Sychterz and Tim Schill (Session 8.4)

Mitigating the quantity, quality, flow, and temperature of stormwater has presented a need for innovative, environmentally sensitive engineering solutions. Through a system of bioswales, infiltration galleries, detention ponds, oil and grit separators, and cooling rock cribs, the design factors can be modified in order for a new development to meet or exceed existing conditions. These design measures were implemented and monitored as part of the stormwater management system at Conestoga College’s new Cambridge Campus. The location of the new campus is south of the existing Doon Campus adjacent to Highway 401. The site was equipped with bioswale infiltration gallery inspection ports, seepage collection system monitoring locations, groundwater monitoring locations, temperature monitors, and water level monitors to assist in assessing the performance of the design to mitigate for development and measure the success of the design in maintaining and enhancing the local environment. Monitoring was also conducted for a 6-month period for the purposes of comparison to existing conditions and the proposed design objectives. In conjunction with rainfall and ambient temperature data, the effectiveness of the stormwater system to reduce the volume of runoff/ enhance groundwater recharge, mitigate peak flows, and maintain discharge temperature to a receiving coldwater fishery was assessed via statistical analysis. Runoff volume reduction and peak flow mitigation results were readily achieved. The temperature differential across the monitoring stations demonstrated that there was an average cooling of the runoff, thus validating the stormwater management system. Temperature differential was compared to initial conditions such as ambient temperature, initial run-off temperature, or water level. Each of these relationships fit a linear regression, which indicates a good method for predicting future performance.

Uncertainty Characterization of Design Rainfall Rates for Stormwater Infrastructure Design
Yi Wang and Edward McBean (Session 4.3)

Intensity-Duration-Frequency (IDF) curves from which the design rainfall magnitudes are developed, are constructed using rainfall predictions associated with different return periods and durations. However, the degrees of confidence of estimates of rainfall rates as input to stormwater infrastructure design are influenced by the length and character of historical records. The paper develops relations between the period of historical record of rainfalls and uncertainties of predictions for rainfall magnitudes.
Hydrants into the sewer system. It was possible to achieve maximum flow rates on the order of those experienced during the previous flooding events. A total of 8 flow meters were installed over approximately a two mile length of the sewer and several additional depth gauges were also installed. Because the hydrant inflows were much greater than the existing dry weather flow, it was possible to independently validate the flow meters in the sewer system. Two separate flow events were monitored. Several interesting observations were made from the monitoring data. The results of this monitoring will be presented and the results discussed in order to develop an understanding of the key issues that created the surcharging in this system. SWMM modeling is utilized in an attempt to further this understanding.

An Approach to Forecasting Typical-Year Wastewater Flow Rates Under Future Conditions
Li Zhang, Feng Cheng, Robert Herr, Gregory Barden, Hunter Kelly and Edward Burgess (Session 2.4)

It is often necessary to forecast flow with model simulations of future conditions to meet regulatory requirements for system improvement plans. It is very challenging to estimate flow in future conditions, especially for extremely long-term planning horizons. Overestimating of future flow will result in unnecessary cost to the system owner, while underestimating of future flow will result in inadequate performance of the sewer collection system. This paper presents a systematic approach to estimate both dry-weather flow (DWF) and wet-weather flow (WWF) in future conditions to avoid over-estimating or under-estimating future flow rates. The performance of sewer systems is often assessed on the basis of a typical year approach to represent the long term average. The paper also developed a unique approach to estimate typical year groundwater infiltration (GWI) for characterizing system performance with typical year simulations of future conditions.

The City of Columbus 2005 Wet Weather Management Plan (WWMP) provided projections for the planning horizons through 2025 for the combined sewer system and through 2050 for the sanitary sewer system. These projections re-visited with development of new and improved model and updated population data. As part of the City’s Sewer System Capacity Model Update (SSCM) 2006 project, DWF, composed of base wastewater flow (BWF) and GWI, and WWF (rainfall-derived inflow and infiltration, or RDII) were projected to year 2050 from 2010 rates. To re-evaluate the WWMP proposed system solutions, the SSCM 2006 model was modified to produce a Reduced Pipe Model (RPM) 2010, and further updated to represent both system and flow conditions for years 2012 and 2050.

This paper begins by documenting the approaches and results of the flow projections, including BWF, GWI and RDII, and follows with the associated analyses used in the flow projection calculations, including population projection, future flow characteristics and typical year GWI analysis. To develop a future condition model, the SSCM 2006 estimated future flow rates for the year 2050. Population projection to year 2050 was achieved by utilizing population growth trends, their geographical locations and population data for years 2010 and 2035 provided by Mid Ohio Regional Planning Commission (MORPC). To represent the DWF and WWF characteristics in future conditions, nine of the most recently developed flow monitor basin areas in the system were selected based on the analysis of pipe age, and flow characteristics for GWI, BWF and RDII were developed using these nine basins.

To characterize seasonally-variable GWI for typical year simulations, GWI rates were determined on a long-term monthly average basis by analyzing relationship of GWI and precipitation using long term wastewater treatment plant (WWTP) effluent data and long term precipitation data. The RPM 2010 model network was modified to generate estimated flow rates in 2050. The end product of the RPM 2050 model will be applied in evaluation of sewer collection system performance with future improvements for the City’s system.

Issues of Disinfection by-products (DBPs) formation in response to chlorination in drinking water treatment systems is a common issue encountered by water treatment plant (WTPs) operators. This is complicated by the presence of zebra mussels, which may inhabit the raw water intake of WTPs. While chlorination at the intake to control zebra mussel population is effective, the formation of DBPs is exacerbated. To evaluate alternative approaches of chlorination, a Bayesian network is developed using the Web weave-IV Toolkit, utilizing causal relationships between DBP-related parameters in the form of conditional probabilities. Four alternative chlorination scenarios are analyzed, one of which demonstrates the probability of high TTHM concentrations (>80µg/L) can be reduced from 25.2% to 24.5%; and the probability of high cancer risk from TTHM (<10-4) can be reduced from 96.6% to 96.2%.

Quantifying Components of RDII as a Foundation for Integration Solution
Hazem Gheith and Robert Herr (Session 4.7)

GIS data, flow monitoring, field measurements and a SWMM model were combined to quantify contribution from the different RDII sources. GIS layers and aerial maps were used to calculate runoff from the expected RDII source points in sanitary systems. RDII contribution from each source was calibrated using SWMM R-values which were calculated from historical storm events at which the surface and sub-surface were at saturation condition. Field data on individual RDII source types collected from two City of Columbus Study Areas were used in this analysis to improve the prediction of RDII contribution from each source. Splitting and quantifying RDII into its specific sources allowed for prioritizing an educated source control program in these basins. In addition, quantifying the surface runoff portion of the mitigated RDII sources will also be key to a successful integrated plan.