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Summary of Publications

by The University of Birmingham SWITCH Hyporheic Zone Research Site Study
under SWITCH Work Package 5.3 Natural Systems and the Urban Water Cycle
under Task 4: Study of natural systems for water retention and self purification
as SWITCH Deliverable D5.3.9-10
as of March 2011



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Executive summary of research

The University of Birmingham (Water Sciences, School of Geography, Earth & Environmental Sciences) has undertaken research on the urban hyporheic zone since 1999. This document is a *Summary of Publications* arising from studies on the University of Birmingham SWITCH Hyporheic Zone Research Site Study, located on the River Tame, Birmingham, UK. This research was undertaken as part of the European Community (EC) Sixth Research Framework Programme (FP6) *SWITCH (Sustainable Urban Water Management Improves Tomorrow's City's Health) Project*. The SWITCH urban hyporheic zone work package was conducted over 2006-11 and was part-funded by the UK Environment Agency. The research contributed to *SWITCH Work Package 5.3 Natural Systems and the Urban Water Cycle* specifically contributing to *Task 4: Study of natural systems for water retention and self purification*. Specific aims were: to evaluate the potential of the urban hyporheic zone to naturally attenuate water contamination; and, to predict potential for engineered enhancement of hyporheic zone attenuation. The approach involved the development of a major field-research study site on the River Tame from which a significant dataset of field-scale urban hyporheic zone behaviour has been realised. The dataset has been interpreted quantitatively, including numerical modelling, to elucidate processes controlling contaminant natural attenuation. Data obtained, assessment methodologies developed and findings developed are of value to the science, practitioner and regulatory / planning communities. Key findings are that contaminant natural attenuation in the urban hyporheic zone, although occurring, may sometimes be quite limited, typically variable in space and time and challenging to quantitatively predict with high confidence although general predictions of attenuation may be reasonably made for reaches with modest data. The influence of a bank-side borehole extraction on contaminant residence times in

the hyporheic zone was insignificant, its impact largely being overwhelmed by natural river-stage variability. Engineered enhancement of hyporheic zone attenuation through hydraulic manipulation was hence not seen as being particularly fruitful. Rather, engineered enhancement may be better achieved as part of wider urban river restorations schemes via riverbed and whole river bank amendments to increase sorption and biodegradation or reaction as well as the homogenising and, or lowering of riverbed sediment permeability to increase residence times and hence attenuation potential.

Significant publications and presentations have arisen from the SWITCH Hyporheic Zone study and are listed under the categories below. Additionally, due to their relevance, we indicate in the last category several *non-SWITCH project journal publications* that have been published during the research project period from our wider urban hyporehic zone studies of the River Tame, Birmingham system in the vicinity of the SWITCH Hyporheic Zone study site. Categories listed (and numbers of publications) are:

- Academic journal articles (3)
- Published reports (2)
- Conference proceedings (book format) – Non-refereed papers (9)
- MSc theses (5)
- Abstracts (of conference presentations, posters) (10)
- Other academic journal articles – *derived from SWITCH related projects*, that are topic and location relevant (3)

Future research and applications are arising and anticipated to continue to arise from the SWITCH Hyporheic Zone study. The dataset is a large one and we continue to explore further nuances and applications of the dataset and anticipate continuing to publish from it. We are exploring the options for research grant proposals to further field research on the urban hyporehic zone on the SWITCH site and surrounding River Tame reaches. We have also developed over the past 2 years a further urban hyporheic zone research site on the Battlefield Brook site that is complimentary and contrasting to the effluent Tame, it being an influent system. We anticipate further working with the Environment Agency, and others, to continue to develop the regulatory / practitioner relevance of the urban hyporheic zone and its use as a natural system for water self purification.

Dr Michael O. Rivett, University of Birmingham

March, 2011.

PUBLICATIONS

Academic Journal Articles

Rivett, M.O., Ellis, P.A., Mackay, R., 2011. Urban groundwater baseflow influence upon inorganic river-water quality: the River Tame headwaters catchment in the City of Birmingham, UK. *Journal of Hydrology*, 400, 206-222.

[doi:10.1016/j.jhydrol.2011.01.036](https://doi.org/10.1016/j.jhydrol.2011.01.036)

<http://dx.doi.org/10.1016/j.jhydrol.2011.01.036> - Paper

<http://www.switch.watsan.net/page/4954/offset/10> - Abstract

Cuthbert, M.O., Mackay, R., Durand, V., Aller, M.-F., Greswell, R.B., Rivett, M.O., 2010. Impacts of river bed gas on the hydraulic and thermal dynamics of the hyporheic zone. *Advances in Water Resources*, 33, 1347–1358.

[doi:10.1016/j.advwatres.2010.09.014](https://doi.org/10.1016/j.advwatres.2010.09.014)

<http://dx.doi.org/10.1016/j.advwatres.2010.09.014> - Paper

<http://www.switch.watsan.net/page/4954/offset/10> - Abstract

Greswell, R.B., Ellis, P., Cuthbert, M. O., White, R., Durand, V., 2009. The design and application of an inexpensive pressure monitoring system for shallow water level measurement, tensiometry and piezometry. *Journal of Hydrology*, 373, 416–425.

[doi:10.1016/j.jhydrol.2009.05.001](https://doi.org/10.1016/j.jhydrol.2009.05.001)

<http://dx.doi.org/10.1016/j.jhydrol.2009.05.001> - Paper

<http://www.switch.watsan.net/page/4954/offset/10> - Abstract

Published reports

Cuthbert, M.O., Durand, V., Greswell, R.B., Aller, M.-F., Rivett, M.O., Mackay, R., 2011. River Tame hyporheic zone test site – data report. SWITCH and Environment Agency Science Report SC050070/SR, Web-only publication at: <http://www.switchurbanwater.eu> Publ. SWITCH CMU, Delft, The Netherlands. 36 pp.

<http://www.switch.watsan.net/page/4300> - Report (*SWITCH Deliverable D5.3.13*)

Durand, V., Rivett, M.O., Mackay, R., Aller, M.F., Greswell, R.B., 2008. Development of the Hyporheic Zone Test Site and Experimental Design. EC 6th Framework Programme, Sustainable Water Management in the City of the Future, SWITCH Project Report 018530, Web-only publication at: <http://www.switchurbanwater.eu> Publ. SWITCH CMU, Delft, The Netherlands. 42 pp.

<http://www.switch.watsan.net/page/4954/offset/10> - Report

Conference proceedings (book format) – Non-refereed papers

Rivett, M.O., Cuthbert, M.O., Mackay, R., Durand, V., Aller, M.-F., Greswell, R.B., 2011. Natural attenuation potential of the urban hyporheic zone. Long abstract in: Proceedings of SWITCH Fifth Scientific Meeting - The future of urban water: Solutions for livable and resilient cities. 24 - 26 January, UNESCO, Paris, 70 – 73.

<http://www.switch.watsan.net/page/4954/offset/10> - Long abstract

<http://www.switch.watsan.net/page/4954/offset/20> - Talk

Cuthbert, M.O., Durand, V., Aller, M.F., Greswell, R.B., Rivett, M.O., Mackay, R., 2010. Impacts of river-bed gas on the hydraulic and thermal dynamics of the hyporheic zone. Long abstract in: Proceedings of the XXXVIII IAH Congress on *Groundwater quality sustainability*, 12-17 September, Krakow, 315 – 316.

<http://www.switch.watsan.net/page/4954/offset/20> - Long abstract

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Durand, V., Cuthbert, M.O., Aller, M.F., Greswell, R.B., Rivett, M.O., Mackay, R., 2010. Three dimensional modelling of a long term bank-side borehole pumping experiment for better understanding of river-aquifer interactions. Long abstract in: Proceedings of the XXXVIII IAH Congress on *Groundwater quality sustainability*, 12-17 September, Krakow, 321 – 322.

<http://www.switch.watsan.net/page/4954/offset/20> - Long abstract

Cuthbert, M.O., Durand, V., Aller, M.F., Greswell, R.B., Rivett, M.O. & Mackay, R. 2009. Hyporheic Zone Testing on the River Tame, UK. Long abstract in: Proceedings of the 4th SWITCH Scientific Meeting, October 2009, Delft, The Netherlands.

<http://www.switch.watsan.net/page/4954/offset/20> - Long abstract

Rivett, M.O., Durand, V., Aller M.F., Cuthbert, M., Mackay, R., Greswell, R.B., Tellam, J.H., Kisz, D. 2008. The SWITCH Hyporheic Zone Test Site, Birmingham: Overview of Baseline and Extraction Test 1 data. Long abstract in: Proceedings of the 3rd SWITCH Scientific Meeting, 30 November – 4 December, 2008, Belo Horizonte, Brazil.

<http://www.switch.watsan.net/page/4954/offset/20> - Long abstract

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Rivett, M.O., 2008. VOC groundwater plume discharges to urban surface water. Invited keynote paper in Proceedings of the Australian Land & Groundwater Association (ALGA) 1st Annual Conference, EcoForum 2008; Conrad Jupiters, Gold Coast, Queensland, Australia, 27 – 29 February 2008. *Paper e8092*.

<http://www.switch.watsan.net/page/4954/offset/20> - Paper

Durand, V., Fernanda Aller M., Greswell, R.B., Rivett, M.O., Mackay, R., Tellam, J.H., Smith, J.W.N., 2007. Investigation of the urban groundwater – surface-water interface via bank-side extraction well field tests: Concept and natural site conditions. In: Groundwater Quality 2007 - Securing Groundwater Quality in Urban and Industrial Environments, Proc. of the 6th International IAHS Groundwater Quality Conference, Fremantle, Western Australia, 2-7 December 2007, 286P, 61.

<http://www.switch.watsan.net/page/4954/offset/20> - Paper

<http://www.switch.watsan.net/page/4954/offset/40> - Poster

Durand, V., Aller, M.F., Greswell, R.B., Rivett, M.O., Mackay, R., Tellam, J.H., Whelan, J., 2007. Natural attenuation potential of the urban hyporheic zone: preliminary results before the field experiment under controlled hydrodynamic conditions. Long abstract in: 2nd SWITCH Scientific Meeting, 25-29 November 2007, Tel-Aviv, Israel.

<http://www.switch.watsan.net/page/4954/offset/20> - Paper

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Rivett, M.O., Greswell, R.B., Mackay, R., Lydon, C., Conran, D.J., Ellis, P.A., 2007. Natural attenuation potential of the urban hyporheic zone: Foundational studies to the River Tame (Birmingham, UK) dipole field experiments. In: Proceedings of the First SWITCH Scientific Meeting, Birmingham, UK, 9-10 Jan 2007.

<http://www.switch.watsan.net/page/4954/offset/20> - Paper

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

MSc theses

Hendrie, M.B., 2009. Assessing vertical water flux between groundwater and surface water at the River Tame Hyporheic Zone SWITCH Test Site using temperature time series. MSc thesis (unpublished) School of Geography, Earth & Environmental Sciences, University of Birmingham, UK.

<http://www.switch.watsan.net/page/4950/offset/10> - Thesis

Shepherd, S., 2009. Hydraulic controls on water quality variations: The River Tame hyporheic zone SWITCH urban test site. MSc thesis (unpublished) School of Geography, Earth & Environmental Sciences, University of Birmingham, UK.

<http://www.switch.watsan.net/page/4950/offset/20> - Thesis

Whelan, J., 2007. Hyporheic zone hydraulic testing. MSc thesis (unpublished) School of Geography, Earth & Environmental Sciences, University of Birmingham, UK.

<http://www.switch.watsan.net/page/4950/offset/20> - Thesis

Conran, D.J., 2006. Assessment of groundwater-surface water mixing zone transients: Birmingham – River Tame study. MSc thesis (unpublished) School of Geography, Earth & Environmental Sciences, University of Birmingham, UK.

<http://www.switch.watsan.net/page/4950/offset/20> - Thesis

Lydon, C., 2006. Design for the Hyporheic Zone Dipole Setup. MSc thesis (unpublished) School of Geography, Earth & Environmental Sciences, University of Birmingham, UK.

<http://www.switch.watsan.net/page/4950/offset/20> - Thesis

Abstracts

<http://www.switch.watsan.net/page/4954/offset/20> - Listing of abstract titles (per below)

Rivett, M.O., Cuthbert, M.O., Mackay, R., Durand, V., Aller, M., -F., Tellam, J.H., Greswell, R.B., Roche, R., 2011. Natural attenuation potential of the urban hyporheic zone: observations from research sites on the River Tame, Birmingham, UK. European Geosciences Union (EGU) General Assembly 2011, 3 – 8 April, Vienna, Austria. Geophysical Research Abstracts Vol. 13, EGU2011-9838.

<http://www.switch.watsan.net/page/4954/offset/60> - Poster

Rivett, M.O., 2010. Groundwater influences on urban river water quality. Univesitas 21 Water futures for sustainable cities programme - Urban rivers workshop. 12 – 14 November, University of Delhi, Delhi, India.

Cuthbert, M.O., Durand, V., Aller, M.-F., Greswell, R. B., Rivett, M.O., Mackay, R., 2010. The dynamics of hyporheic exchange flows during storm events in a strongly gaining urban river. European Geosciences Union (EGU) General Assembly 2010, 2 – 7 May, Vienna, Austria.

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Durand, V., Cuthbert, M. O., Aller, M.-F., Greswell, R. B., Rivett, M. O., Mackay, R. 2009. River-aquifer interactions investigated by bank-side borehole pumping experiment. Auftaktworkshop von Hyporheisches Netzwerk, 14-15 December 2009, Berlin.

Rivett, M.O., 2009. Integrated assessment of chlorinated VOCs in the Birmingham aquifer – river Tame system, UK. Proceedings of RiskPoint Fall International Workshop *Assessing the risks posed by point source contamination to groundwater and surface water resources*, 5 -6 October 2009, Copenhagen, Denmark.

Durand, V., Cuthbert, M.O., Mackay, R., Aller, M.-F., Rivett, M.O., Greswell, R. B., Tellam, J.H., 2009. Is it possible to control the water exchanges in the hyporheic zone by long-term bank-side extraction field tests? European Geosciences Union (EGU) General Assembly 2009, 19-24 April, Vienna, Austria.

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Durand, V., Aller, M.F., Greswell, R.B., Rivett, M.O., Mackay, R., Tellam, J.H., 2008. Bank-side extraction well field tests to investigate water exchanges and physico-chemical conditions in the hyporheic zone. European Geosciences Union (EGU) General Assembly 2008, 13 – 18 April, Vienna.

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Durand, V., Aller, M.F., Greswell, R.B., Rivett, M.O., Mackay, R., Tellam, J.H., 2008. First experimental and simulation results of bank-side extraction well field tests to influence water exchanges in the hyporheic zone. British Hydrological Society (BHS) Meeting, Birmingham, UK.

<http://www.switch.watsan.net/page/4954/offset/30> - Poster

Durand, V., Aller, M.F., Greswell, R.B., Rivett, M.O., Mackay, R., Tellam, J.H., Smith, J.W.N., 2007. Use of bank-side extraction well field tests to investigate hyporheic zone natural attenuation: Concept and natural site conditions. Abstract in: *Proc. of the Geological Society Bicentenary Conference: Earth Sciences in the Service of Society*, QE II Centre, London, UK, 10-12th September, 2007, 104.

<http://www.switch.watsan.net/page/4954/offset/40> - Poster

Durand, V., Fernanda Aller M., Greswell, R.B., Rivett, M.O., Mackay, R., Tellam, J.H., 2007. Investigation of the Hyporheic Zone via bank-side extraction well field tests: Concept, design and site conditions. Hyporheic Network workshop, 11-12 June 2007, Sheffield, UK.

<http://www.switch.watsan.net/page/4954/offset/30> - Poster

Rivett, M.O., 2006. SWITCH - Natural Systems and the Urban Water Cycle. Hyporheic Zone Network Scientific Meeting, October 2006, University of Sheffield, Sheffield, UK.

<http://www.switch.watsan.net/page/4954/offset/30> - Talk

Other academic journal articles – derived from SWITCH related projects, that are topic and location relevant

Rivett, M.O., Ellis, P.A., Greswell, R.B., Ward, R.S., Roche, R.S., Cleverly, M., Walker, C., Conran, D., Fitzgerald, P.J., Willcox, T., Dowle, J., 2008. Cost-effective mini drive-point piezometers and multilevel samplers for monitoring the hyporheic zone. *Quarterly Journal of Engineering Geology & Hydrogeology*, 41(1) 49-60.

doi: [10.1144/1470-9236/07-012](https://doi.org/10.1144/1470-9236/07-012)

<http://dx.doi.org/10.1144/1470-9236/07-012> - Paper

<http://www.switch.watsan.net/page/4954/offset/40> - Abstract

Ellis, P.A., Mackay, R., Rivett, M.O., 2007. Quantifying urban river–aquifer fluid exchange processes: A multi-scale problem. *Journal of Contaminant Hydrology* 91, 51-80.

doi: [10.1016/j.jconhyd.2006.08.014](https://doi.org/10.1016/j.jconhyd.2006.08.014)

<http://dx.doi.org/10.1016/j.jconhyd.2006.08.014> - Paper

<http://www.switch.watsan.net/page/4954/offset/40> - Abstract

Ellis, P.A., Rivett, M.O., 2007. Assessing the impact of VOC-contaminated groundwater on surface-water at the city scale. *Journal of Contaminant Hydrology*, 91, 107-127.

doi: [10.1016/j.jconhyd.2006.08.015](https://doi.org/10.1016/j.jconhyd.2006.08.015)

<http://dx.doi.org/10.1016/j.jconhyd.2006.08.015> - Paper

<http://www.switch.watsan.net/page/4954/offset/40> - Abstract

Roche, R.S., Rivett, M.O., Tellam, J.H., Cleverly, M.G., Walker, M., 2008. Natural attenuation of a TCE plume at the groundwater – surface-water interface: spatial and temporal variability within a 50 m reach. In: GQ07: Securing Groundwater Quality in Urban and Industrial Environments, IAHS (International Association of Hydrological Sciences) Publ. 324, 475 – 482.

<http://iahs.info/redbooks/324.htm> - 'Red Book' Volume with paper

<http://www.switch.watsan.net/page/4954/offset/40> - Abstract