SOURCE APPORTIONMENT OF URBAN POLLUTION

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Stormwater: What About Quality?
12th May 2011, Arup Campus, Solihull
“Sewage, why with rain dilute?
Your rain with sewage why pollute?
Each will the other spoil
To mix them is a great mistake”
(PUNCH 1858)
Outline of Presentation

• Urban wet weather discharges - we thought that we’d ‘almost’ sorted the problem and then along came the WFD!
• Pollutants in urban runoff – is urban runoff a new problem or is the WFD a new problem for urban runoff management?
• A pilot study of point source and diffuse pollution control at a river catchment scale
• A source apportionment tool for WFD catchment planning
• Looking to the future – understanding urban runoff as a resource?
Overview – what’s the issue?

• Complying with the WFD will drive improvements in water bodies over the next 20 years (and beyond?)
• WFD - water quality ‘good ecological status required’ - but ‘one out, all out’ – for potentially 40+ individual criteria excluding hydrology and morphology
• RBMPs requires an assessment of risk from urban runoff – as well as everything else!
• Can controlling urban runoff contribute to cost-effective WFD compliance?

• We need the tools to do this at a river catchment scale
Pollutants in Urban Runoff

- Environment Agency evidence suggests that at least 300 water bodies fail WFD due to urban runoff
- Wash-off from impermeable catchment surfaces – plus accidental spillages – soluble and insoluble pollutants to rivers
- Wide range of pollutants present – metals, nutrients, hydrocarbons, BOD, sediments, bacteria, ……. 
- Rainfall driven – first flush (or not) and potential acute and/or chronic impact on water quality and ecology
CSO Control in the UK: the dawn of UPM - FIS and 99%iles

• 1990s - need to comply with UWWTD
• 8000 unsatisfactory CSOs identified by 1990
• UPM Manual Procedure - Environmental Regulator policy for CSOs
• Over £3.5b spent on CSOs by 2005.. and still going - is this the end of the CSO problem?
• Surface water drains seen as a local issue, eg misconnections, spillages?

• Then WFD came, along with a lot more ‘stuff’ to be controlled!
UPM and WFD STANDARDS

- **UPM Standards – acute impact**
  - FIS for DO and NH3N – protect ecosystems
  - 99%iles for BOD and NH4N – protect river class

- **WFD Standards – chronic impact**
  - Mean, MAC, 95%ile – for a wide range of nutrients and chemicals –
  - WFD compliance to protect ecosystems

- **Do we need to achieve both? Yes, we do!**
  - To provide protection from continuous and intermittent discharges from point and diffuse sources to achieve ‘good ecological status’
WFD Catchment Demonstration - Ribble Pilot Study

• Objective: to demonstrate apportionment of urban and non-urban point and diffuse inputs to freshwaters

• SIMCAT model for the freshwater Ribble

• Catchment Scenarios – water quality benefits of PoMs
  • Phosphate, BOD, Ammonia and Nitrate

• Support catchment planning involving all sources and stakeholders
Environment Agency SIMCAT Model

- Allows **SIMulation of CATchments**
- Point source inputs – STWs and industry
- Based on data from routine monitoring programmes for rivers and effluents plus estimates of diffuse inputs
- Assess impact of point source and diffuse pollution
- Easy to use by non experts
- “It works with the data we have and the way we manage pollution control at a catchment scale” – Environment Agency
Quantifying Sources of Pollution

• First attempt in UK to apportion pollution sources at a detailed catchment scale using a model based approach
• River flow and quality - EA
• Point source inputs – STWs and industry
• Agriculture inputs of phosphate and nitrate – national databases – non urban diffuse inputs
• Urban wet weather discharges – urban diffuse inputs from CSOs, storm tanks and SWOs
  • Quantify pollution loads in urban runoff
Estimating Urban Wet Weather Inputs

- Over 360 CSOs and storm tanks in catchment
  - 49 network flow and quality models covering all urban areas – storm tanks included
  - Estimated 57/43 split for combined and separate systems
- Estimates for urban runoff pollutants based on land use (Mitchel, 2005; plus local data)
- Sewer models run for ‘typical year’ rainfall series to generate runoff flows and pollutant loads
- Waterbody loads for CSO, storm tank and SWO discharges added to river reaches
Estimating Urban Runoff to Water Courses

Map 1: Ribble Catchment
NH4_N kg/yr Spread across Urban Areas

Map 2: Urban Runoff Diffuse Loads (kg/yr)
Source apportionment for point source and diffuse pollution – pre 2005

BOD Input to Ribble Catchment

Total Input: 10414 kg/d

- Agricultural Diffuse: 51%
- Urban Diffuse: 17%
- Effluent Discharge: 32%

PO4-P Input to Ribble Catchment

Total Input: 1505 kg/d

- Effluent Discharge: 88%
- Agricultural Diffuse: 8%
- Urban Diffuse: 3%

Ammonia Input to Ribble Catchment

Total Input: 1188 kg/d

- Agricultural Diffuse: 24%
- Urban Diffuse: 5%
- Effluent Discharge: 71%
## Scenario Summary for P Removal

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Load Removal (kg/d)*</th>
<th>Pass Length (km)</th>
<th>Fail Length (km)</th>
<th>Additional Reach Length Passing (km) (Compared to Current Consented)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP3 Consents</td>
<td>-</td>
<td>499.8</td>
<td>159.6</td>
<td>-</td>
</tr>
<tr>
<td>WwTW @ Post 2010 Consents (UWWTD)</td>
<td>181</td>
<td>499.8</td>
<td>159.6</td>
<td>0.0</td>
</tr>
<tr>
<td>WwTW @ BAT Consents</td>
<td>263</td>
<td>502.2</td>
<td>157.1</td>
<td>2.4</td>
</tr>
<tr>
<td>100% Urban Diffuse Reduction</td>
<td>27</td>
<td>503.3</td>
<td>156.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Current Consents with P Removal in Detergents</td>
<td>89</td>
<td>499.9</td>
<td>159.5</td>
<td>0.1</td>
</tr>
<tr>
<td>UWWTD Consents with P Removal in Detergents, 54% Reduction in Agriculture and 100% Reduction in Urban Diffuse</td>
<td>282</td>
<td>509.2</td>
<td>150.1</td>
<td>9.4</td>
</tr>
<tr>
<td>Notional Consents Required to Achieve Full Compliance (Minimum Consent set to WQ Target)</td>
<td>609</td>
<td>583.0</td>
<td>76.3</td>
<td>83.2</td>
</tr>
<tr>
<td>Load Reduction Required to Achieve Full Compliance</td>
<td>663</td>
<td>659.4</td>
<td>0.0</td>
<td>159.6</td>
</tr>
</tbody>
</table>
UKWIR/EA Project WW02: Source Apportionment of Chemicals Under the WFD

• Provide the Water Industry, the Environment Agency and SEPA with SAGIS based SIMCAT models to apportion loads of priority chemicals to water bodies

• Use national datasets to identify effective programmes of measures for the 2nd cycle of WFD

• Work carried out by Atkins, AMEC Earth and Environment UK (formerly Entec) and WRc
  • completion by September 2011
  • SAGIS Databases and upgraded SIMCAT software
  • Updated National SIMCAT models for EA
UKWIR/EA/SEPA WW02 - Chemical source apportionment under the WFD

• Catchment planning for point sources has been based on national and regional SIMCAT models
• Need to quantify diffuse inputs at water body level
• WFD PoMs need to consider ALL significant inputs

Sources to WwTW

- WwTW discharges
- Other point sources

Monitoring data

Agricultural
Minewater
Intermittent urban
Highway runoff
Atmospheric
Natural
Septic tanks

Difference = ‘Diffuse’
Intermittent Discharges

- Includes:
  - Direct surface water run-off
  - Combined sewer overflows
  - WwTW storm tank overflows
  - Highway runoff – trunk roads

- Function of rainfall volume, intensity, land use category and substance concentration
Urban Runoff Load Estimation

- Regional Rainfall datasets – typical year
- Literature based event mean concentrations from land use
- Estimate annual runoff loads to each waterbody
- Assign non-parametric distribution correlated to river flow for input to SAGIS
- Example concentrations in urban runoff and domestic sewage

<table>
<thead>
<tr>
<th>Concentrations</th>
<th>Urban Runoff (µg/l)</th>
<th>Domestic (µg/l)</th>
<th>WFD Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>34.7</td>
<td>186.083</td>
<td>1-28 µg/l AA @hardness</td>
</tr>
<tr>
<td>Zinc</td>
<td>82.5</td>
<td>62.6</td>
<td>58-125 µg/l @hardness</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>0.06</td>
<td>0.093</td>
<td>0.1 µg/l AA &amp; 1µg/l MAC</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>0.08</td>
<td>0.077</td>
<td>2.4 µg/l AA</td>
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<tr>
<td>DEHP</td>
<td>20</td>
<td>33.109</td>
<td>1.3 µg/l</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.27</td>
<td>13.9</td>
<td>50-120 µg/l SRP AA</td>
</tr>
</tbody>
</table>
Estimated Urban Run-off Annual Waterbody Input Loads for DEHP
SAGIS/SIMCAT Outputs

- % contribution from multiple sector inputs at waterbody level
- Monthly summary inputs for each input summarised at each point /waterbody
- SIMCAT/GIS output to provide % contribution of each input for comparison against observed data
- Min, Max and Mean % contributions / inputs indication of uncertainty
Conclusions

• Pollutants in urban runoff need to be controlled in relation to both short term and long term environmental impacts – UWWTD and WFD driven

• UPM and SIMCAT based planning approaches to wet and dry weather pollution impacts – urban catchment to river basin district scales

• Increasing list of substances to be controlled – and possible ways of controlling them – source control to SUDS – what are viable sustainable options?

• What are the options for source control of chemicals?
Next Steps
– Making a Difference?

• Application of UPM and SAGIS/SIMCAT for WFD catchment planning - focused local PoMS for urban runoff - where cost-effective compared to controlling other sources to meet UPM and WFD standards

• Coastal impact of urban runoff and the RBWD

• Misconnections – forthcoming UKWIR Report

• Keep pollutants off the streets and out of sewers and drains – SUDS and ‘at source’

• Make use of urban runoff as an urban water and amenity resource
We’ve still got a lot to learn about urban runoff........