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SURREY COUNTY COUNCIL CASE STUDY

# How Atkins modelled rainfall runoff to investigate flood risk alleviation options in Reigate

## Background

Can rainfall runoff modelling decide the fate of a flood risk management scheme? That was the question facing Ruchi Sayal, a hydraulic modeller within Atkins' Engineering, Design and Project Management Team.

Using InfoWorks ICM from Innovyze, she was able to model a catchment in Reigate, Surrey to reflect the flooding experiences of its residents and businesses. In this case study, Ruchi shares the modelling approach and decisions she made to build a model that Surrey County Council could have confidence in, in order to understand the existing flood risk mechanisms and to investigate flood risk alleviation options for Reigate. The project was a lesson on the potential impacts that modelling decisions could have on scheme decision making.

## The short read

- The town centre of Reigate flooded frequently during heavy rainstorms, flooding roads, homes and shops.
- Surrey County Council commissioned Atkins to undertake a flood alleviation study for the town.
- InfoWorks ICM was used to build a catchment model of river, surface water and foul water components.
- Using the Green Ampt model to calculate infiltration of soil types, the catchment was modelled and remodelled to include three different soil types.
- The third model set up proved to be the 'Goldilocks' solution, not too 'clayey', not too sandy, but just right!


## The Challenge

The town centre of Reigate in the southern English county of Surrey had flooded regularly over the last 20 years. Historical flooding was put down to a number of sources, fluvial flooding from the Wallace Brook, a tributary of the River Mole, surface water and foul flooding and known siltation issues in the Wallace brook.

One particular rainfall event in August 2015 saw 36.6mm of rainfall in one day – around half of the expected monthly rainfall. This resulted in extensive flooding. Shops and roads in the town centre were flooded and access to homes and care homes was affected.

Surrey County Council (SCC) commissioned Atkins, one of the world's most respected design, engineering and project management consultancies, to undertake a flood alleviation study for Reigate.

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Ruchi Sayal, Hydraulic Modeller
Atkins

# The Solution

Atkins is a long-term user of Innovyze's integrated catchment modelling tool, InfoWorks ICM, which Ruchi used to build a catchment model of the river, surface water and foul water components. The model shows the Wallace Brook and its tributary, ponds and other watercourse structures. A 2D ground model (mesh) used LiDAR data to show surface features. The drainage systems (surface water and foul) complete the picture to give a better understanding of the areas at risk of flooding and flood mechanisms. The model has been used to understand the existing flood risk and test different flood alleviation options.

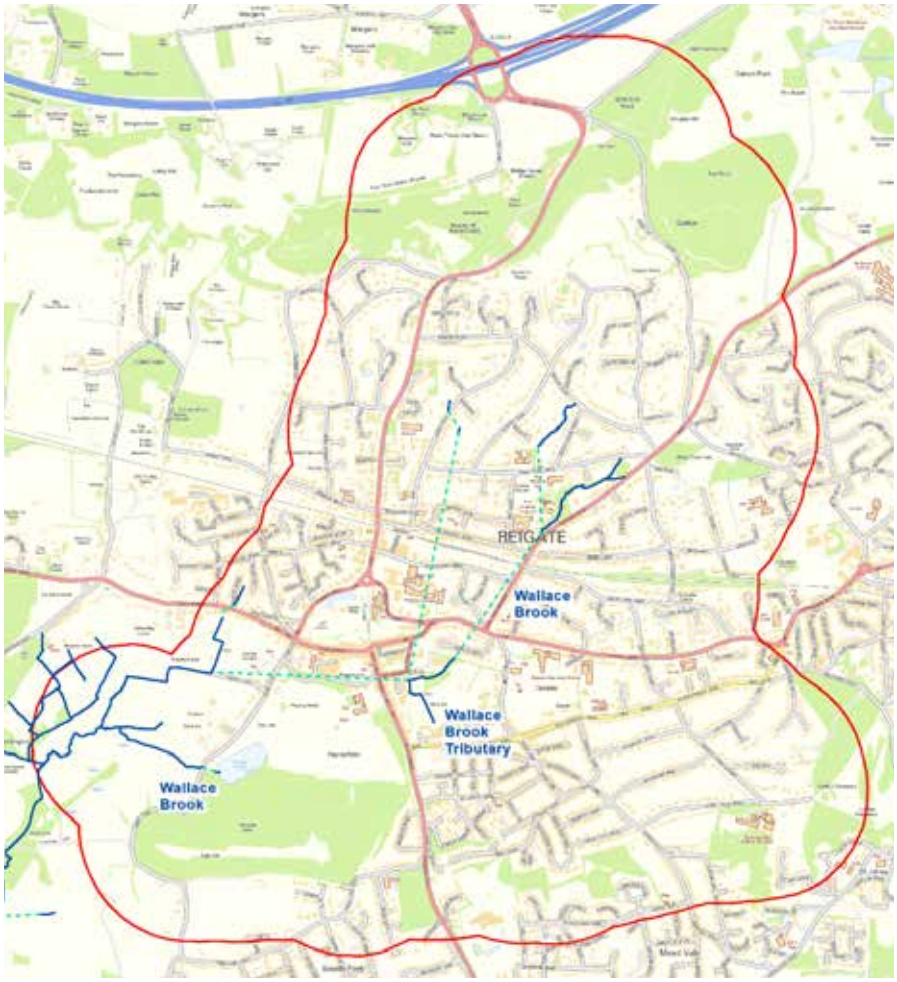


Figure 1: Reigate ICM 2D model extent (red boundary)

# Working with Infiltration Models

The infiltration of rainwater into the soil is an important consideration for modelling the effects of direct rainfall runoff, and the characteristics of the soil play a big part in understanding infiltration in the catchment.

There are multiple infiltration models available in ICM to calculate the infiltration in the catchment, including Horton, Green Ampt, Fixed Infiltration and Constant Infiltration. Ruchi opted for Green Ampt as "Green Ampt considers a wide range of soil characteristics," she explains. "This gives a more realistic representation over the catchment. Furthermore, Green Ampt was used for a catchment model of an adjacent area built for the Environment Agency, which was calibrated to actual conditions."

Data from the British Geological Survey (BGS) website (www.bgs.ac.uk) showed the broader soil distribution of the whole of the UK, so Ruchi could compare Reigate's soil composition with the geology of the adjacent catchment.

## The solution used by Atkins for Surrey County Council

InfoWorks ICM

# The Green Ampt model

The Green Ampt model is useful as it varies the rate of infiltration over time, based on factors such as:

- Average capillary suction
- Saturated hydraulic conductivity
- Initial moisture deficit

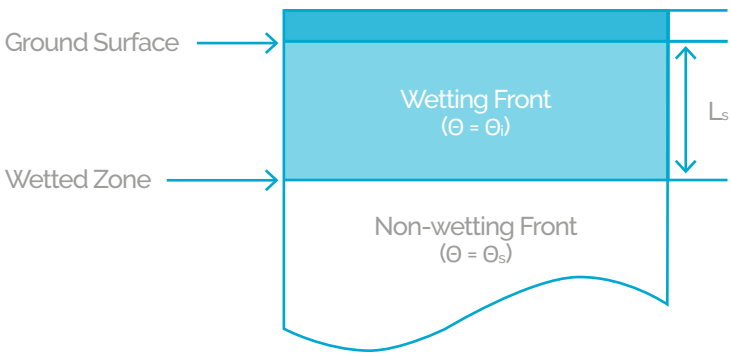


Figure 2: Two zone representation of the Green Ampt infiltration model (EPA website)

The Green Ampt parameters corresponded to a clay-loam for the Reigate catchment, and these parameters were adopted across the whole of the catchment. This used a low value of hydraulic conductivity of around 2mm per hour. Hydraulic conductivity is the rate at which water is likely to infiltrate the soil: an impermeable soil type like clay would have a low number, but a sandier soil would have a higher rate.

The Reigate catchment had limited gauge data available from historic flood events, and so the Reigate ICM could not be calibrated. Verification to historic flood events was important to establish model reliability. Comparing the initial draft model results to historical data verified the model reasonably well. The expected areas were modelled to flood. However, for the 20% (1 in 5annual probability) flood event, the model showed that over 30 properties would flood to over 1m depth internally. This extensive, regular and severe flooding was deemed unrealistic.

Further work was put into investigating the various soil types within the catchment in more detail. Local bore holes on the BGS website indicated that the southern part of the catchment had a sandier soil type than the clay-loam that formed the basis of the first modelling analysis. This altered the hydraulic conductivity value from as low as ~2mm/hr for clay-loam to as high as ~128mm/hr for sandy loam.

The updated model results verified well, and expected areas were modelled to flood. However, applying a 5% (1 in 20 annual probability) rainfall event didn't activate some significant flow routes which had been historically observed in the centre of Reigate.

## Refining the model

A third stage of model refinement was undertaken. This took into account the urban character of the catchment in the centre of Reigate. Here soil would be compacted, which would affect infiltration rates. The catchment was divided into three sectors. The top sector (northern) was clay-loam, the bottom sector (southern) the more sandy soil as identified by the BGS bore holes, and the large middle sector (central) showed the urban nature of the town centre.

In this final set up, parameters varied not only to match the different soils but the impact on hydraulic connectivity of soil compaction, construc-tion and urbanisation. Using research that suggested that these factors can reduce infiltration rates by 70-80%, Ruchi modelled the catchment based on the three different soil types likely to affect infiltration across the area.

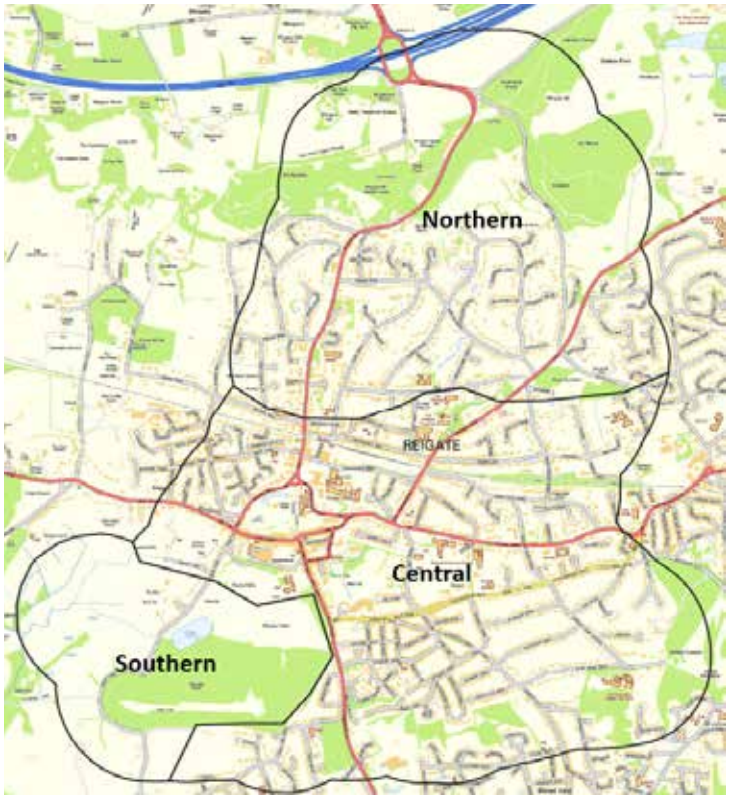


Figure 3: Green Ampt parameter sub catchments

Ruchi's decision to look in more detail at the effect of soil type on rainfall runoff infiltration paid off. The results from the revised model verified well. The expected areas were modelled to flood, and depths were verified by reported incidents of flooding.

In the first model set up, using a uniform soil type across the whole catchment, any flood alleviation solution would only have taken a low conductivity soil into account. The amount of runoff infiltrating into the soil would be too low, and so any solution would have been over engineered to handle more water than would actually be the case. Overestimating risk can lead to models being unbelievable, undermining the evidence base used to justify schemes and making it difficult when consulting with communities at risk.

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Atkins

Although the second model set up differentiated between soil types, the large central area would have returned a high level of infiltration that didn't reflect reality. Underestimating flood risk corresponds to underestimation of the damages / benefits and property counts to justify a scheme. A flood alleviation solution based on these parameters would be insufficient to prevent flooding and just wouldn't solve the problem.

The third model set up, the 'Goldilocks' solution, proved to be just right. It represented the reality of the situation across the catchment and provided a better understanding of the flood risk areas and mechanisms as well as providing a strong foundation upon which flood risk management option investigation could be undertaken. As Ruchi Sayal says: "modellers always have to make decisions about how to make best use of the data they have and the level of detail to go into. The Reigate ICM posed a key challenge to get the right balance between being proportionate and including sufficient detail to build a model giving results that we were confident in."

## Enabling technology from Innovyze

Even though Atkins is a long-standing user of InfoWorks ICM and Ruchi being an experienced hydraulic modeller on other software this project was the first time Ruchi had used it, and she was immediately impressed. "I was learning throughout the whole project," she explains. "These big catchment areas are complicated, and at first I was sceptical as to whether the model would run, but it did. I found ICM's stability really impressive." She particularly noted ICM's ability to bring everything together on one window. "InfoWorks ICM shows where everything is in the catch-ment. It can be difficult to visualise the full picture, but ICM was very useful for me to see the flood risk in the catchment." There were other features that Ruchi liked; "The tools in ICM to customise scripts made my work really fast and efficient."

The reaction from Surrey County Council was positive. "They were happy with the result from the model," says Ruchi. Confidence in the model was reflected in further usage to test flood alleviation options. As a final word, Ruchi says, "The work we undertook with InfoWorks ICM has shown that we were justified in using the best modelling tools to get the best result."

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# Get in touch

**Our offices in the US, Australia, and the UK, plus our global network of partners, are here to help you get the most from your water systems.**

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