

The Leigh Flood Storage Area

The Environment Agency operates the Leigh Flood Storage Area (FSA) as a key flood risk management asset in the South East of England. The FSA was constructed following the 1976 River Medway (Flood Relief) Act to reduce flood risks in the Medway catchment; it protects 965 homes and 300 businesses downstream in Tonbridge and Hildenborough.

The main structure is an embankment across the River Medway flood plain at Leigh, 2 km upstream of Tonbridge; it is a Category A reservoir regulated under the Reservoirs Act 1975. A set of three in-line sluices control the flow down the River Medway; should the electric motors powering the gates fail to operate on demand, there are back-up arrangements to ensure resilience during an emergency.

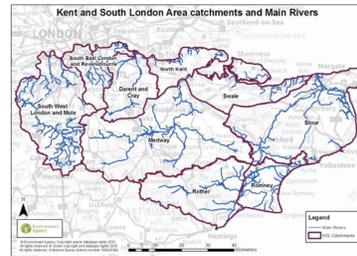
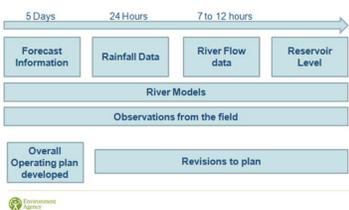
Key parameters for the Leigh FSA

Embankment length	1.3 km
Crest level	29.15 m ODN
Maximum height	5.7 m
Statutory maximum operational water level	28.05 m ODN
Storage at maximum permitted water level	5.56 Mm ³
Design discharge	300 m ³ /s
Sluice gate capacity	3 gates at 150 m ³ /s each

Operational procedures for the FSA

The operational procedures cover all flow conditions and they are reviewed regularly to incorporate learning from previous floods. When river flows are expected to exceed a specified threshold, Environment Agency staff take over direct control of the sluices. The key to successful operation is to time the filling of the storage area to use its full capacity around the peak of the flood, minimising the peak flow downstream. The operators use real time catchment data and bespoke operational tools to optimise the outflow.

How do we operate the Leigh FSA? Strategic Plan



There are three main modes of operation of the Leigh FSA.

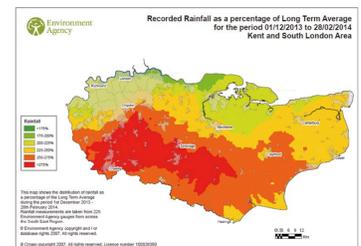
- 1 Automatic mode in quiescent periods
- 2 Default mode with a fixed outflow, known to not result in any property flooding downstream
- 3 Deviation mode when the operator varies the outflow using all the storage, to minimise the property flooding downstream.

Default mode is effective for most floods, but in the largest floods, such as December 2013, the operator uses the alternative deviation mode to actively manage downstream risks.

The floods of December 2013

The December 2013 flood on the Medway was large and unusual in its formation as the jet stream pushed several low pressure weather systems across the UK. The worst storm occurred on 23 to 24 December when up to 76 mm of rain fell in 24 hours, on already saturated catchments. There was wide-scale flooding in the Medway catchment on Christmas Eve and Christmas Day of comparable severity to the 1968 and 2000 floods but with a different distribution of flows from these earlier events. It is understandable that after the event there was public concern and criticism from those whose lives had been turned upside down during the Christmas holidays.

Kent and South London Rainfall December 2013 to February 2014



Operation of the Leigh Flood Storage Area

Five experienced operators staffed the control room continuously for about three days, together with support staff, working in shifts. The operators liaised frequently with other emergency management functions and had regular advice from the reservoir supervising engineer.



Operation moved to "deviation" mode on the morning of 24 December, with finally automatic operation mode returning late on 26 December.

Key statistics for the event

Peak inflow (estimated from tools during event)	340 m ³ /s (but varied erratically)
Peak inflow (reconstructed)	261 m ³ /s
Peak outflow passed downstream	160 m ³ /s
48-hour volume into FSA (multiple of storage)	22 Million m ³ (4 x storage available)
Return period of 48 hour volume	150 years approx.
Maximum level	28.045 m ODN (5mm below statutory maximum)
Properties protected	701 homes and 250 businesses

There was a more rapid rise of discharge into the FSA than had been experienced previously and decisions on the operation of the structure needed to respond to fast changing conditions which evolved differently from the forecasts.

Selected conclusions from the Audit

Did the Environment Agency follow the procedures?

- > The FSA procedures are well documented with clear lines of authority for effective decision making and consider the basis and consequences of decisions on operating the sluices.
- > The lead operator doubled-up on operators in the control room as the flood was clearly unusual; although non-standard, this decision ensured effective operation of the structure.
- > The operators' log books demonstrated that they followed the procedures at all key points of the event, with appropriate consultation with other relevant functions.

Did the operations worsen or cause flooding elsewhere in the catchment?

- > The rainfall meant it was inevitable that Tonbridge, Yalding, Maidstone and other communities would have flooded on 24 and 25 December 2013; the capacity of the FSA was insufficient to prevent all flooding.
- > Without the FSA there can be no doubt that the flooding in communities from Tonbridge to Maidstone would have been significantly greater. Its operation did not cause or worsen flooding downstream.
- > The operation of the FSA reduced peak flood levels in Tonbridge by approximately 0.6 m, in line with the rationale for its construction.
- > The benefits of the operation of the Leigh FSA for communities further downstream to Yalding and beyond probably were similar, but without detailed modelling it is not possible to quantify these precisely.

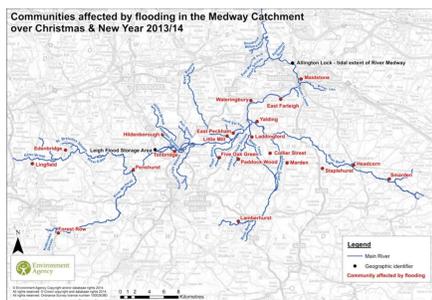
Could the Environment Agency have done better?

- > The description of the modes of operation, although clear for trained staff might cause unnecessary public concern; in particular the word "deviation" is open to misinterpretation.
- > Despite uncertain forecasts, the operators used local observations to plan outflows that achieved a substantial reduction of the discharge passed downstream. This use of local information ensures robustness of the operation of the FSA.
- > Although a better operational scenario was found, without perfect and certain flow forecasts the operators could not have identified or implemented this in practice.

Post flood reviews

Flood severity

The Environment Agency commissioned a report from JBA Consulting to assess the flood severity throughout the Medway catchment. The report concluded that in December 2013 flows in the Medway rivers were amongst the highest ever recorded, in several places exceeding those of the September 1968 flood. The rainfall was particularly severe on the Upper Medway catchment that drains into the Leigh FSA, both for the month of December as a whole and for the storm on 23 December.



Factual report

In line with good professional practice, the Environment Agency prepared a post-event report on the flood. This documents the extent of the event and the effects on the communities that experienced inundation during the event, as well as the Environment Agency's operational response. The Environment Agency made available a draft copy of this report for an independent audit of the operation of the FSA.

Operational debrief at Leigh FSA

During January 2014 the FSA operators attended a debrief to identify the most significant learning points from the flood. In all, 59 actions were captured and categorised onto an action tracker; these were prioritised and programmed to enhance future operations.

Independent audit of Leigh FSA operation

The Environment Agency commissioned HR Wallingford to audit of the FSA operation during the event. Paul Samuels visited the control room to hear first-hand from operators on duty throughout the event and to meet two representative members of the public by invitation of the Environment Agency.

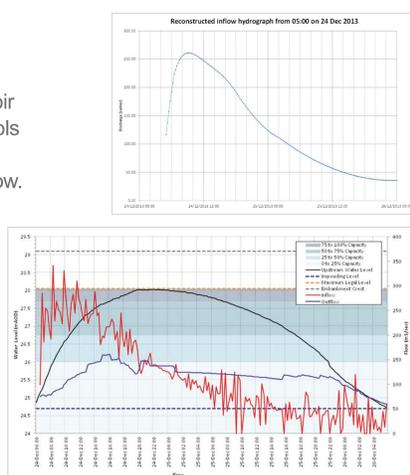
The log books and the forecast model results showed that the forecast inflow to the Leigh FSA was initially over-estimated and then substantially underestimated.

The jagged nature of the raw data for the inflow is clearly erroneous; this was recognised by the operators when making

decisions. Causes for the errors were identified as uncertainties in the reservoir volume represented in the modelling tools and coarse recording of timing of water level observations used to estimate inflow.

The audit examined whether an alternative operation of the FSA could have had benefits to downstream communities, using a reconstruction of the probable inflow into the FSA from the upstream catchment.

Inflow, outflow and water level from the Leigh FSA Operational tools for the event



Actions taken

The Environment Agency has incorporated the lessons identified in the audit into their action tracker. All actions have been prioritised and are either now completed or programmed for completion.

The operational procedures have been updated incorporating items from the action tracker, including renaming the modes of operation as "fixed" and "variable" rather than "default" and "deviation".

A training package has been developed for selecting new operators which uses the 2013 flood as a case study.

New cameras have been installed linked to a website that the public can access to show the flood storage area. This will eventually link to real time operational information.

The name of the structure was changed from Leigh Barrier to Leigh Flood Storage Area, to reflect the nature of the scheme as the term "barrier" could lead to misconceptions about how the FSA is operated.