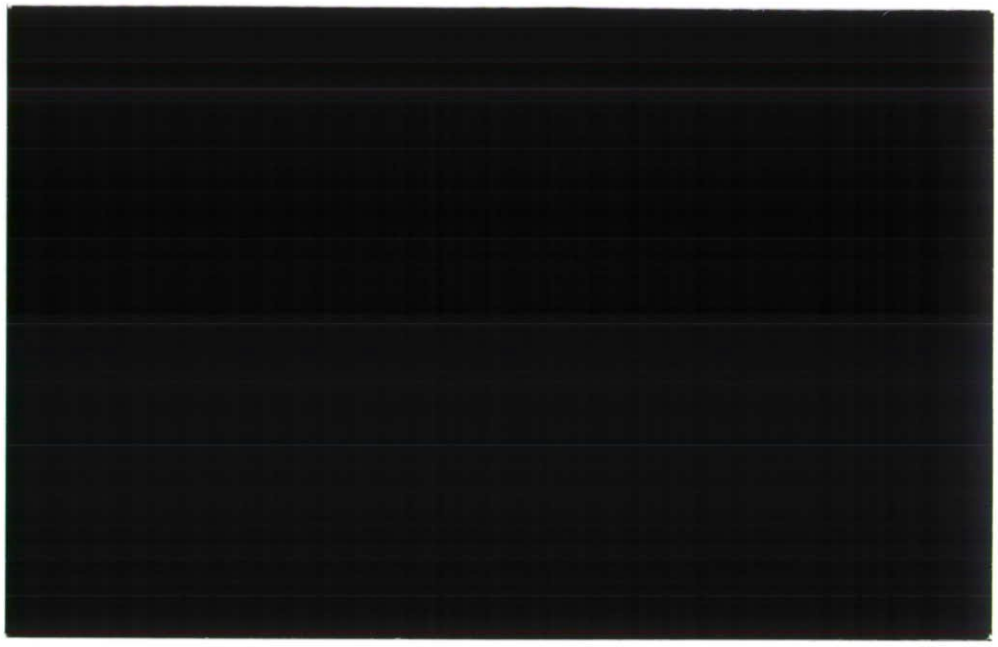
1995/024

Institute of Hydrology



Natural Environment Research Council

Wallingford Water

Floodplain Mapping - Model Study of the River Frome (Gloucestershire)

Ebley Mill Gauging Station Physical Model Study

Report EX 3170
August 1995

Wallingford Water

Contract

This report describes the physical modelling work carried out by Wallingford Water as part of the "Floodplain Mapping - Model Study of the River Frome" commissioned by the National Rivers Authority - Severn Trent Region. The NRA representative was Mr D Pettifer, and Wallingford Water was represented by Mr TE Parkinson and Mr RJ Millington. The HR job number was RQR 1568. The work was carried out by Mr PG Hollinrake.

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Approved by R Bettess Rivers Group

Date 7th August 1995

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Summary

Floodplain Mapping - Model Study of the River Frome (Gloucestershire)
Ebley Mill Gauging Station Physical Model Study

Report EX 3170
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In September 1993 the National Rivers Authority - Severn Trent Region commissioned Wallingford Water, the joint venture between the Institute of Hydrology and HR Wallingford Ltd, to carry out the "Floodplain Mapping, Model Study of the River Frome (Gloucestershire)" study.

As part of the hydrological component of this study a calibration of the Ebley Mill gauging station was undertaken to extend the rating at the site. This was required for the purpose of accurately assessing the magnitude of flows which were greater than bankfull, and therefore beyond the applicable range of the current rating curves. Under flood conditions the weir, and the cableway site 90 metres upstream which is used to calibrate the weir for in-bank flows, is bypassed by flow over the left bank flood plain. The work was carried out using a physical model and the results of the modelling and the revised rating curve are presented in this report.

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Contents

1 Introduction

1.1 Background

In September 1993 the National Rivers Authority - Severn Trent Region (NRA-ST) commissioned Wallingford Water (WW), the joint venture between the Institute of Hydrology and HR Wallingford Ltd, to carry out the "Floodplain Mapping, Model Study of the River Frome (Gloucestershire)" study. The overall objective of the study was to construct and prove a hydraulic model of the River Frome and a part of its tributary, the Nailsworth Stream, in order to determine the flood plain limits for six design events of specified return periods of between 5 and 150 years.

The study included an assessment of the hydrology of the Frome catchment, and as part of this it was thought desirable to ensure that the rating curve for the Ebley Mill gauging station on the River Frome was accurate for out-of-bank flows, since the station is bypassed at flows over bankfull. A physical model was therefore required to develop the rating curve beyond the range for which the station had been calibrated in the field.

1.2 Terms of reference

The terms of reference for the overall study are defined in the NRA-ST document "Brief for Report and Advisory Works. Floodplain Mapping - Model Study of the River Frome (Gloucestershire)" of July 1993, the WW proposal to undertake the study of August 1993 and the NRA-ST letter of appointment dated 24 September 1993. The terms of reference for the physical model study can be summarised as follows:

(a) Construction of a physical model of a 600m length of the River Frome from the confluence with the Nailsworth Stream at Dudbridge to downstream of the Ebley gauge site, and of the Dudbridge flood relief channel downstream of Dudbridge Lock weir to its confluence with the River Frome.

(b) Calibration of the model for recorded in-bank flows at Ebley gauging station, and identification of appropriate tailwater conditions for these events.

(c) Derivation of the out-of-bank stage-discharge relationship for flood flows at Ebley gauging station.

2 Physical model

2.1 General

The procedure for the physical model study was as follows :

(a) Construct the model to 1993 geometry.

(b) Calibrate the river channel using river flow data provided for the gauging station.

(c) Run the model with twelve flood events to obtain a stage-discharge relationship for out-of-bank flows at the gauging station for the 1993 geometry.

2.3 Tailwater conditions

The physical model required tailwater levels at the downstream limit of the model, which was approximately 150 metres downstream of the weir at Ebley Mill. In order to provide these tailwater levels the HR computational modelling package FLUCOMP was used to derive the stage-discharge relationship by interpolation of the section data analysis file from the formula

$$Q = K.s^{1/2}$$

where

K = conveyance
s = channel slope

In determining the conveyance a Manning's n of 0.03 was used to represent the channel roughness and 0.08 for the flood plains. Conveyance pointers were used to delimit the active flow from areas of storage on the flood plains.

2.4 Model calibration

The model is calibrated by using the flow data from observed events and adjusting the river and flood plain roughness until the model gives acceptable agreement between observed and predicted water levels at locations where water levels were recorded during the events in the modelled area. The physical model was a fixed bed model in which the roughness of the mortar surface is less than the roughness required to produce the equivalent prototype roughness on the model. It is therefore possible to calibrate the model using various techniques for increasing the roughness. It is normally desirable to calibrate a model of this type for one in-bank and one out-of-bank event. However, data was only available for in-bank flows at the gauging station. The model was therefore calibrated using this data.

The maximum gauged discharge recorded on the NRA-ST gauging summary report for the Ebley Mill Gauging Station is 18.93m^3/s, equivalent to a mean stage of 1.029m with the gauge datum being the lowest weir crest level at Ebley Mill of 30.88mODN. This event was considered to represent bankfull conditions and was used to calibrate the model as the discharge was closer to the flood events to be used in the model.

The model was calibrated to within 0.025m with a discharge of 18.93m^3/s.

2.5 Out-of-bank stage-discharge relationship

Twelve out-of-bank events were selected to allow derivation of the stage-discharge relationship for flood flows at the Ebley Mill Gauging Station. The discharges, tailwater levels and recorded water surface levels at the gauge used for the station calibration are given in Table 1.

The stage-discharge relationship for out-of-bank flows is shown in Figure 2. The curve fitted to the data is a third order polynomial with the relationship :

$$Q = -1257.7 + 2532.9y - 1654y^2 + 365.5y^3$$

where

y = stage relative to weir crest level (30.88mODN) in metres.

15.8m³/s, approximately 40% of the total flow, with average and maximum flow velocities of 0.41m/s and 0.73m/s respectively.

For the 50m³/s flood event only the bowling green and land contained by the river and canal confluence at the western end of the playing fields at Dudbridge was above the flood waters. The flood plain on the left bank of the River Frome upstream of Ebley Mill was inundated with the exception of the tongue of land extending west from the nursery on Meadow Lane. At the weir a narrow strip of land on the left bank remained above the flow for a distance from 30 metres upstream of the weir to the upstream face of the bridge at Meadow Lodge. A strong flow was passing between the council offices and Meadow Lodge. The council car park was totally immersed with ponded flood water extending north eastwards along the approach road.

The discharge on the left flood plain bypassing the cableway site was 20.0m³/s, ie 40% of the total flow, with average and maximum flow velocities of 0.41m/s and 0.88m/s respectively.

With a discharge of 60m³/s the flooded extent was similar to that observed for 50m³/s. The land on the left bank at the weir raised above the flood level was slightly reduced in extent. More notable was the fact that the bridge at Meadow Lodge was surcharged.

For discharges of 75m³/s and 90m³/s respectively inundation of the left flood plain at the weir and cableway was complete with just a residual strip of land emerging above the flood between the weir and bridge at Meadow Lodge. Flood waters were starting to encroach onto the road at Frome Gardens 120 metres upstream of the confluence of the River Frome with the Stroudwater Canal.

3 Conclusions

(1) A physical model has been constructed of the Ebley Mill Gauging Station and been calibrated for a bankfull flow.

(2) A series of steady flow events have been modelled to extend the rating curve for out-of-bank flows to 90m³/s.

(3) It is recommended the new rating curve is used for flows in excess of 20m³/s.

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Tables

Table 1 Modelled flows and results

Discharge (cumecs)	Tailwater (mODN)	Gauging Station (mODN)	Stage relative to weir crest (m)
20	31.08	32.012	1.132
25	31.20	32.033	1.153
30	31.29	32.074	1.194
35	31.37	32.099	1.219
40	31.44	32.146	1.266
45	31.50	32.200	1.320
50	31.56	32.294	1.414
55	31.61	32.416	1.536
60	31.66	32.519	1.639
67	31.72	32.606	1.726
75	31.79	32.683	1.803
90	31.89	32.799	1.899

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Figures

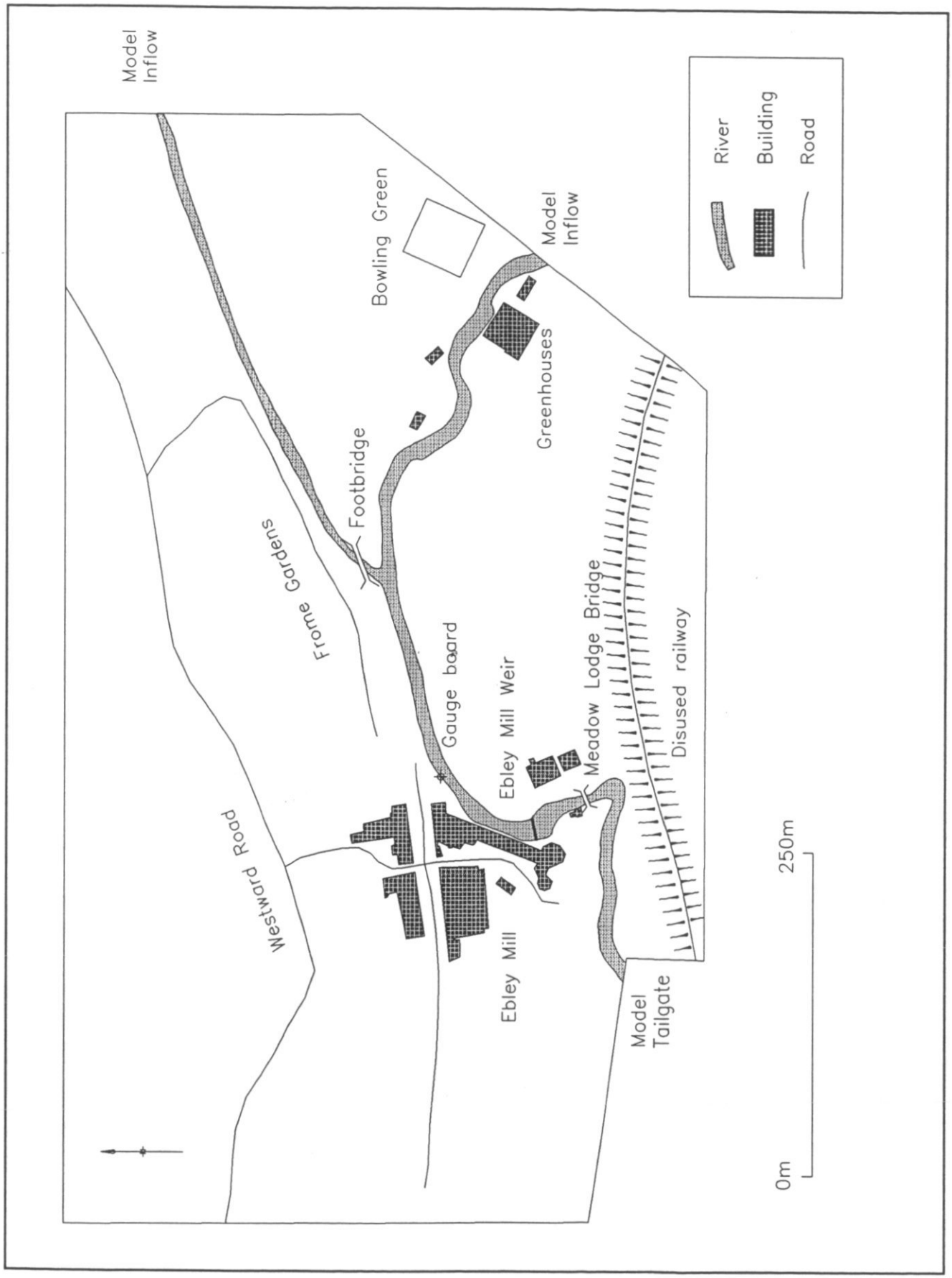

Figure 1 General layout of model

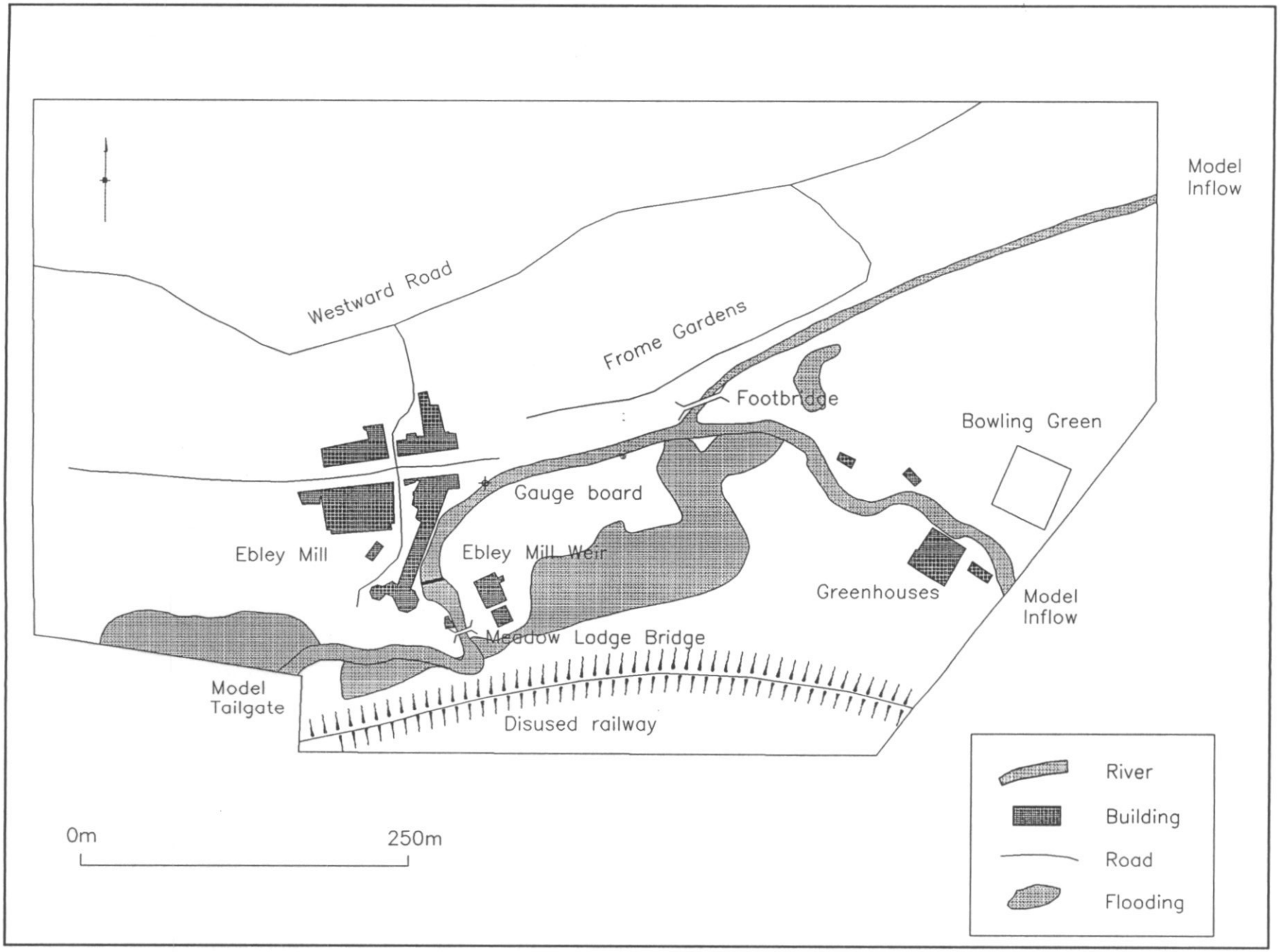

Figure 3 Predicted flood outline, 20 m^3/s flow

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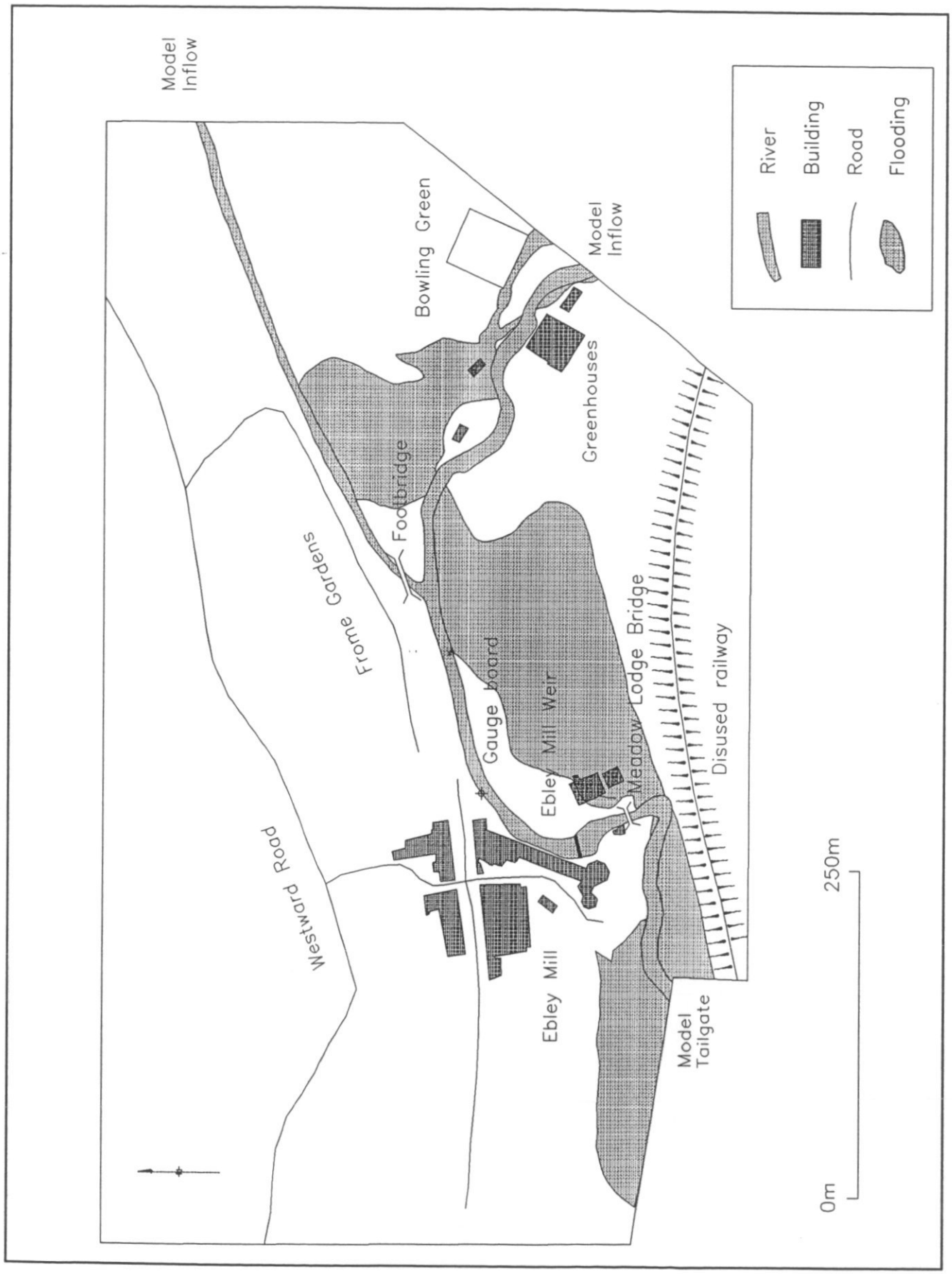

Figure 5 Predicted flood outline, 30 m^3/s flow

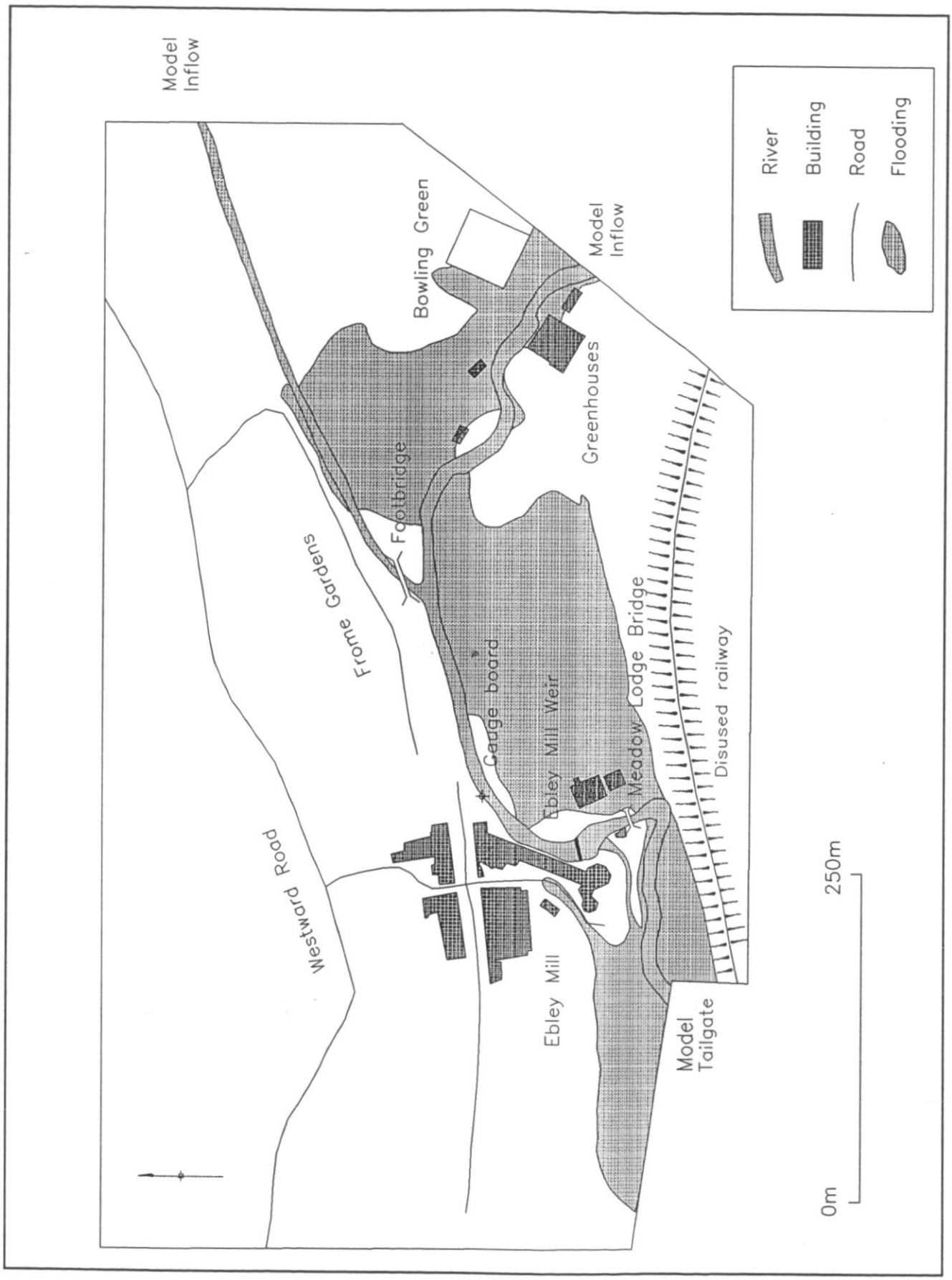

Figure 7 Predicted flood outline, 40 m^3/s flow

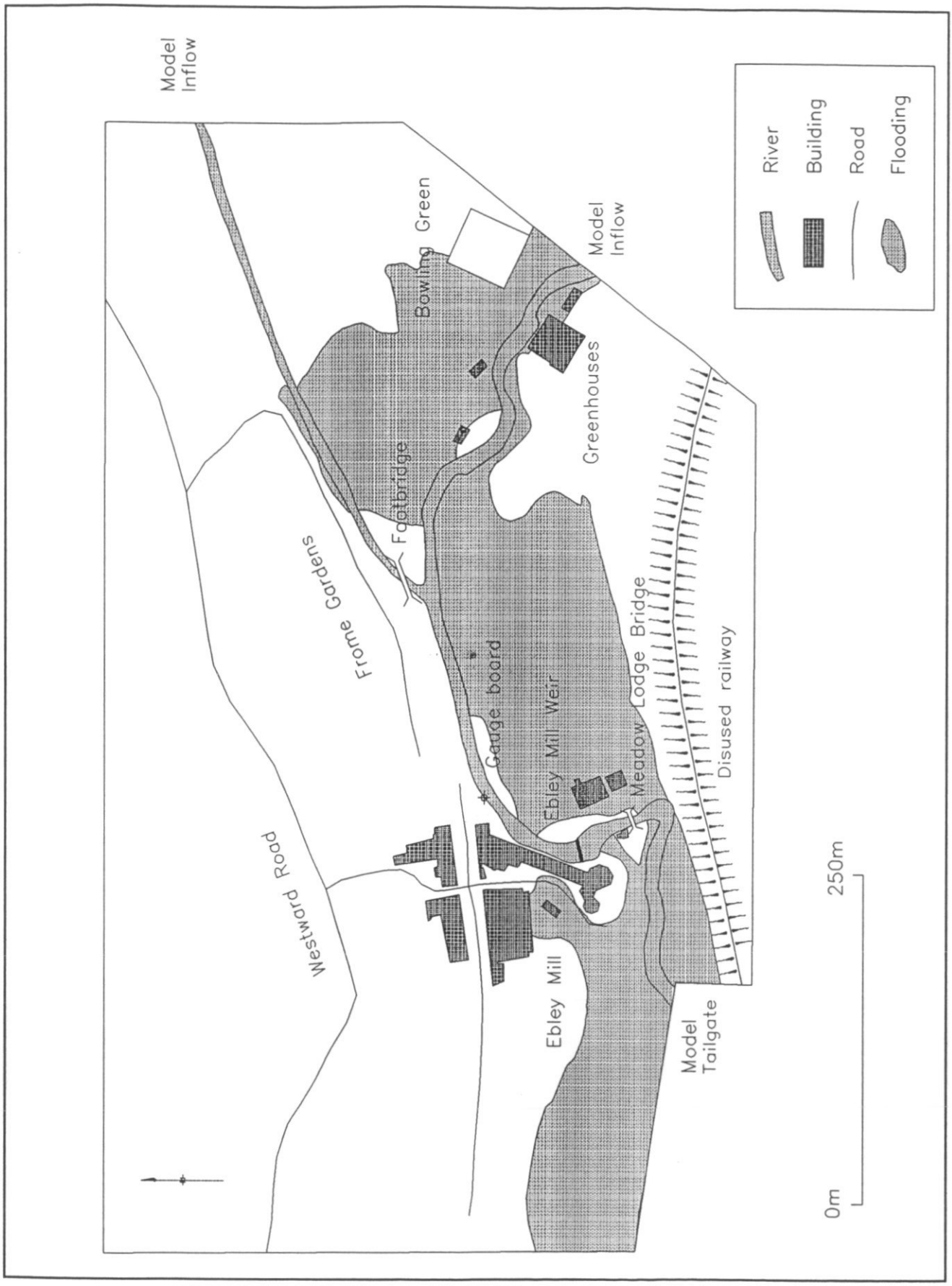

Figure 9 Predicted flood outline, 50 m^3/s flow


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