Institute of Freshwater Ecology

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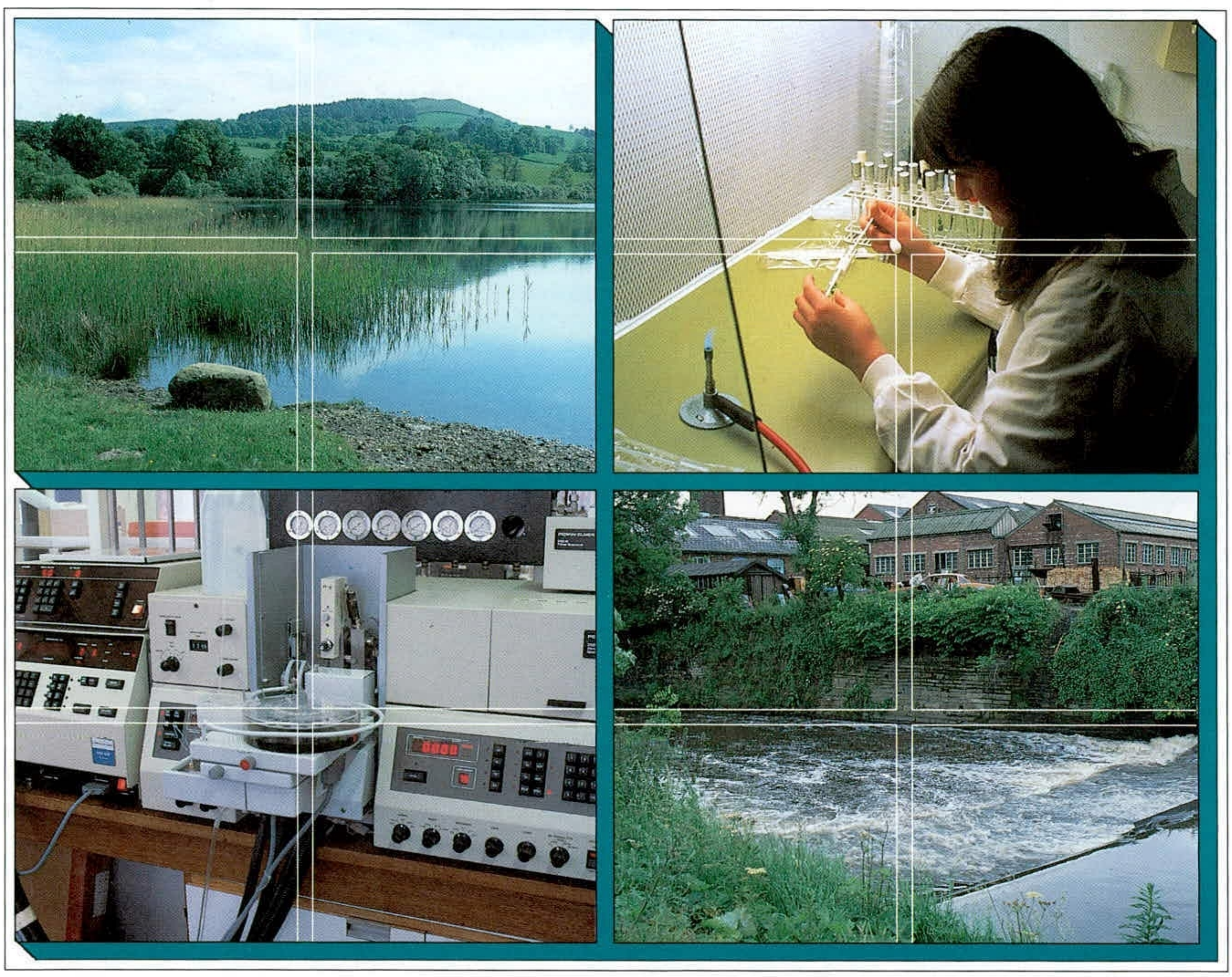

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An experimental treatment of *Simulium posticatum* with *Bti* at selected sites on the River Stour, Dorset, 1993

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Report date: September 1993
Report to: North Dorset District Council
IFE report ref: RL/T11053c5/5
TFS project no: T11053c5

CONCLUSIONS

1. In 1993, as in previous years, TEKNAR HP-D (*Bti*) was found to be an effective simuliicide when used against the larvae of *Simulium posticatum* under the conditions prevailing in the River Stour.

2. Surveys of the overwintering populations of simuliids showed that most had emerged as adults by the end of March.

3. *Bti* application was scheduled for the end of March when the overwintering populations had emerged and the first pupae of *S. posticatum* had been found.

4. The full river survey identified 19 sites with high densities of *S. posticatum* and of these 13 were treated on 31 March 1993.

5. Statistical analysis of samples of larvae taken before and after application showed that the mortality was 87% at Blandford and 93% at Longham.

6. Samples of pupae gave an indication of the timing of the emerging flies but not their abundance.

7. The pattern of pupation indicated a possible second hatching from eggs. The oviposition sites were wetted during a flood immediately after *Bti* application and more larvae may have had access to the river. In future it may be necessary to treat again if flooding causes rewetting of oviposition sites. It may also be necessary to decide whether it is acceptable to kill part of the next generation of other species of simuliids as it is likely that they will be present by the middle of April at the latest.

1. INTRODUCTION

In 1993, the Health and Safety Executive (HSE) gave permission to treat the river Stour with *Bti*, where necessary, along the whole length of the river. Previously, restrictions to the areas treated were imposed by the HSE but following the successful treatments in 1989, 1991 and 1992 these restrictions were lifted for an experimental period of 3 years. Previous trials had shown no adverse effects on any fauna in the river apart from the target species *Simulium posticatum* (The Blandford Fly). Treatment sites were no longer limited to a maximum of eight and the restriction of "no spraying within 7 km of the intake of Bournemouth Water Co. at Longham" was lifted. This meant that for the first time, large populations of larvae could be targeted in places close to residential areas of Poole and Bournemouth where complaints of bites has been increasing in recent years.

The conduct of the present treatment took into account the "Guidelines for Biological Monitoring" put forward by the Pesticides Registration Section, 28 February 1990.

2. RECONNAISSANCE SURVEYS

2.1 Introduction

These surveys were designed to monitor the over-wintering populations of simuliids and the increase in density of *S. posticatum* in order to determine the best time for treatment of the pest species. This was expected to be after the pupation and emergence of the overwintering larvae and after the hatching of all of the eggs of *S. posticatum* but before pupation of that species. In order to identify the stage in the life cycle of the Blandford Fly, it was necessary to recognise first and last instar larvae. The presence of first instar larvae would indicate that individuals were still hatching and that the population was still increasing. Treatment at this stage would not affect the entire population. The presence of last instar larvae would indicate that pupation and emergence was imminent.

2.2 Methods

Sites at Blandford (NGR ST886062) and Longham (NGR SZ065973) were chosen for the surveys as they were known to have had large numbers of larvae in previous years and were near two of the main residential areas affected by the fly. These two sites were well separated to provide suitable information on any differences in timing of the life cycle along the river.

At each site, 30 weed samples were taken in the standard manner every two weeks from 18 February 1993 until it was decided that it was appropriate to treat the river. In the laboratory, the simuliid larvae were identified and the number of *S. posticatum* larvae were recorded separately from the number of other simuliid larvae. First and last instars were recorded. The wet weight of each sample of weed was recorded and the density of larvae was determined as numbers per gram of weed.

2.3 Results

2.3.1 Overwintering species of *Simulium* present in the river Stour at the sampling sites

At Blandford the dominant species in terms of numbers was *Simulium equinum* whereas at Longham the main species present were *Simulium lineatum* and *Simulium ornatum*.

2.3.2 Density of larvae

S. posticatum was present in the river at both Blandford and Longham on the first sampling date (Table 1, Fig 1). Larvae were small compared with those from the overwintering population of simuliids which were more numerous. During the following weeks the numbers of *S. posticatum* larvae increased whilst those of other species of simuliids decreased (Table 1, Fig 1). By 18 March, the density of other species was very low at both sites (3.7 ± 2.6 g^{-1} at Blandford and 0.6 ± 0.8 g^{-1} at Longham). On this date, 4 larvae at Blandford and 6 larvae at Longham were found to be last instars of *S. posticatum*, indicating that they were about to pupate.

Table 1 Mean density ± 95% CL (number per gram of weed) of *S. posticatum* in the R. Stour at Blandford and Longham.

Date	*S. posticatum*	Others
<u>Blandford</u>		
18 February 1993	18.5 ± 8.9	22.7 ± 11.4
3 March 1993	52.1 ± 26.8	13.3 ± 7.1
18 March 1993	59.8 ±23.7	3.7 ± 2.6
30 March 1993	50.5 ± 11.9	0
<u>Longham</u>		
18 February 1993	81.3 ± 19.0	38.7 ± 9.8
3 March 1993	55.0 ± 11.4	13.0 ± 5.4
18 March 1993	90.7 ± 21.9	0.6 ± 0.8
30 March 1993	329.8 ± 42.7	0

No first instar larvae were found in these reconnaissance surveys. It is likely that this stage of the life cycle lasts for only a matter of hours, and that any first instars collected would have moulted before the samples were processed in the laboratory. Although some very small larvae were still present on 18 March, perhaps indicating that hatching from eggs was still occurring, the presence of last instar larvae showed that pupation and emergence was about to commence. As a result of this and the virtual absence of larvae of other species, it was decided to treat the river as soon as possible after consideration of river conditions and the preparation of the sampling programme. The date of treatment was 31 March 1993.

3. FULL RIVER SURVEY

3.1 Introduction

This survey was designed to assess the extent of the population of *S. posticatum* downstream of Durweston (NGR ST864086), 5 km upstream of Blandford, and to identify areas expected to have high densities of larvae in order to determine sites for treatment with *Bti*. As permission had been given to treat a greater length of the river, the survey was extended both upstream and downstream of that reported in 1992. In order to avoid confusion, the map reference numbers given in 1992 have been retained. This has necessitated using reference numbers of 0 and -1 in this report.

3.2 Methods

The survey was conducted by boat down the whole length of river between Durweston and Throop (NGR SZ113958) on 23 and 26 March 1993 (Fig. 2). Depths were recorded as above or below one metre and presence or absence of larvae was recorded. Areas having high densities of larvae were also recorded.

3.3 Results

Areas with high densities of larvae are shown on the maps (Maps -1 to 17). Above Blandford most of the river is deep and slow flowing and entirely unsuitable for simuliid larvae. One small area below Durweston Bridge was found to contain a high density of larvae (Map -1). The three sites identified at Blandford were the same areas that have contained high densities in previous years (Map 1). High densities were also found at Langton Long and at two further sites upstream of Charlton Marshall (a previous treatment site) where large areas of the river were shallow with fast flow and had high densities of larvae (Map 3). Between Charlton Marshall and Spetisbury (a treatment site in previous years), the river is braided due to the presence of mills. Above, the water is slow moving and deep and thus unsuitable for simuliids but below the obstructions and in certain carriers there is shallow fast water and high densities of larvae were found (Map 3). At Spetisbury there was a large area downstream of the road bridge with high densities of larvae and further sections below this were also found to contain high densities (Map 4). Three short areas at and below Shapwick were identified and downstream of this, at Millmore Farm a larger area of infestation was found. Many of these sites are associated with islands which create shallower faster flowing water on either side (Map 5). Moderate densities were found at two sites upstream of White Mill Bridge (Map 6). Below this bridge the river was deep and slow moving and only two more suitable areas for simuliid larvae (both below weirs near Corfe Mullen (Map 7) and Little Pamphill (Map 9)) were found above Wimborne where high densities were present (Map 11). High densities of larvae were found at Canford School, the lowest treatment site in previous years due to the water intake at Longham (Map 12), and in four other small areas between the school and Longham (Map 14). At Longham, downstream of the treatment works, the river is wide, shallow and fast flowing and there was a high density of larvae present. A further suitable area was found at Muscliffe (Map 17). The survey finished at Throop Mill where access was denied to lower stretches of the river which looked suitable for blackflies (Map 17).

3.4 Treatment sites

Nineteen sites were identified that had significant populations of *S. posticatum* larvae (Table 2). Site 1 was fairly small and did not have a suitable control site. It was decided to use Site 3 (Blandford main river) as the upstream control site and therefore treatment of Sites 1 and 2 was necessarily postponed and scheduled for one week after the main treatment. The areas near Shapwick, White Mill Bridge and Little Canford were not treated due to access problems. The site near Corfe Mullen downstream of the weir was not treated as on treatment day it was found that the NRA had diverted the river to repair the weir. In all, 13 sites were treated with *Bti* (Table 2). Heavy rain on and after treatment day caused the river to flood and conditions were unsuitable for treating Sites 1 and 2 before the appearance of the next generations of larvae of other species of *Simulium*.

Table 2 Sites containing large populations of *S. posticatum*

Site	NGR	Treated
Durweston	ST 864086	x
Blandford carrier	ST 886062	x
Blandford main river	ST 886061	✓
Langton Long	ST 895058	✓
Charlton Marshall	ST 901042	✓
Clapcott's Farm		
middle channel	ST 913032	✓
west channel	ST 912030	✓
Spetisbury	ST 919020	✓
Shapwick	ST 936018	x
Millmore Farm	ST 945004	✓
White Mill Bridge	ST 955008	x
Corfe Mullen	SY 969988	x
Little Pamphill	ST 996001	✓
Wimborne	SZ 004999	✓
Canford School		
main river	SZ 031989	✓
carrier	SZ 032989	✓
Little Canford	SZ 045999	x
Longham	SZ 065973	✓
Muscliffe	SZ 095960	✓

4. DISCHARGE AND VELOCITIES

Discharge values were required for calculation of *Bti* dilution factors.

4.1 Methods

The Wessex region of the National Rivers Authority were unable to provide discharge values at the prescribed sampling/application points as there are only two continuous gauging stations on the Stour, one at Hammoon a considerable distance upstream of Blandford and a second at Throop many kilometres downstream of the bottom site. The NRA were, however, extremely helpful and supplied maps and graphs which established that approximate interpolation between gauging stations is reasonable. Last year, this information was supplemented by discharge measurements taken by IFE staff at Blandford and Wimborne. With the experience gained from previous years and the fact that more sites were to be treated making discharge measurements at each site unfeasible, it was felt that interpolation of the NRA gauging stations results was adequate for calculating quantities of *Bti* to be added at each site.

4.2 Results

The discharge of the river Stour at Hammoon and Throop is given in Table 3 and graphically represented in Fig. 3. It can be seen that there was a massive increase in discharge following treatment and that the river did not return to treatment day levels for a considerable period of time.

Table 3 Mean discharge (cumecs) of the R. Stour at the NRA gauging stations, Hammoon (NGR 820147) and Throop (NGR SZ 113958).

Date	Hammoon	Throop	Date	Hammoon	Throop	Date	Hammoon	Throop
March			April			May		
1	2.2	10.72	1	30.75	22.31	1	2.31	9.99
2	2.08	10.35	2	15.96	32.88	2	2.06	9.48
3	2	10.4	3	12.55	19.11	3	1.86	9.22
4	1.8	10.19	4	12.74	20.93	4	1.76	8.94
5	1.76	9.97	5	38.97	28.23	5	1.71	8.69
6	1.77	9.87	6	16.78	38.63	6	1.62	8.62
7	1.8	9.71	7	6.87	16.7	7	1.58	8.34
8	1.77	9.41	8	6.17	13.15	8	1.48	8.45
9	1.67	9.38	9	36.75	24.81	9	1.55	8.51
10	1.67	9.17	10	19.63	39.45	10	1.62	8.41
11	1.6	8.87	11	18.81	22.69	11	1.49	8.21
12	1.6	8.66	12	15.05	25.89	12	1.48	8.05
13	1.58	8.5	13	13.68	20.78	13	1.45	8.04
14	1.59	8.34	14	13.03	22.14	14	1.46	7.98
15	1.53	8.05	15	7.44	17.34	15	1.5	7.81
16	1.48	7.81	16	4.76	13.74	16	1.74	7.8
17	1.5	7.72	17	4.55	12.55	17	1.79	8.17
18	1.46	7.53	18	4.07	12.04	18	2.14	7.97
19	1.44	7.71	19	3.56	11.56	19	1.65	8.03
20	1.4	7.69	20	3.25	11.17	20	1.56	8.59
21	1.52	7.87	21	2.98	10.87	21	1.55	7.76
22	1.23	8.24	22	2.76	10.38	22	1.42	7.44
23	1.85	8	23	3.84	12.11	23	1.28	7.16
24	1.56	7.39	24	4.32	12.67	24	1.27	6.93
25	1.44	7.08	25	3.25	12.05	25	1.2	7.12
26	1.4	7.05	26	6.07	13.12	26	1.71	8.34
27	1.4	7.07	27	6.62	15.53	27	2.29	7.57
28	1.41	7.02	28	3.89	13.62	28	1.61	7.67
29	1.41	6.98	29	3.13	11.43	29	1.37	7.19
30	1.54	7.18	30	2.65	10.47	30	1.51	6.85
31	3.08	9.13				31	1.71	6.66

5. *BTI* APPLICATION

5.1 Methods and quantities

The quantities of TEKNAR HP-D required, in litres, to achieve concentrations of 0.8 mg l^{-1} over ten minutes was calculated from the manufacturer's formula:

Volume (litres) = 0.48*Flow (cumec) and was as follows -

- Blandford main river	2 l
- Langton Long	2 l
- Charlton Marshall	2 l
- Clapcott's Farm	
Middle channel	1 l
West channel	1 l
- Spetisbury	3 l
- Millmore Farm	3 l
- Little Pamphill	3 l
- Wimborne	3 l
- Canford School	
Main river	3 l
Carrier	1 l
- Longham	4 l
- Muscliffe	4 l

A total of 31 l was added to the river on treatment day, 31 March 1993.

The TEKNAR HP-D was carried to the sites as measured doses in closed containers and mixed in 20 l knapsack sprayers with seived river water. The material was sprayed, by a qualified operative, who traversed the river approximately ten times during the application period. The jet of the spraying equipment was totally submerged beneath the water surface to avoid spray drift or loss. The sites were treated sequentially starting at Blandford, the furthest upstream at 0900 hr and ultimately treating Muscliffe, the lowest site on the river at 16.30 hr.

6. MONITORING THE EFFECTS OF *Bti* ON *SIMULIUM POSTICATUM*

6.1 Methods

Thirty weed samples were taken from each of the control and treatment sites at both Blandford and Longham on pre-treatment day (30 March 1993). At Blandford, the weed samples at the treatment site were taken 50 m below the proposed application point and at Longham this distance was 20 m. The sites chosen were dependent on site conditions such as presence of weed and larvae and accessibility.

Sampling was repeated on 1 April 1993, the day after treatment.

Samples were transported to the laboratory and the number of living larvae on each piece of weed was counted after identification into *S. posticatum* and other simuliid species. Weed samples were weighed after blotting dry.

6.2 Results

6.2.1 Dead larvae

At Blandford, 153 dead *S. posticatum* larvae were recorded from the 30 weed samples at the treatment site on 1 April 1993. The number from the equivalent samples at Longham was 70. Little interpretation of these results is possible as it is not known what proportion of dead larvae remain attached to the weed. It does show, however, that larvae were indeed killed by *Bti*.

6.2.2 Density of living larvae

The density of living *S. posticatum* larvae at each sampling site before and after the application of *Bti* are depicted in Fig. 4.

The density at the four sites on pre-treatment day shows the patchiness in distribution of larvae. Control and treatment sites were within 50 m of each other at both sites but despite this there was a 3-fold variation in density of larvae between them (Table 4). There was also a 3-fold difference between Blandford and Longham (Table 4).

Table 4 Mean density ± 95% CL (number per gram of weed) of *S. posticatum* in the R. Stour at Blandford and Longham and percentage change before and after application of *Bti*.

	Blandford		Longham	
Date	Control	Treatment	Control	Treatment
30 March 1993	50.5 ± 11.9	131.8 ± 25.7	92.6 ± 25.6	329.8 ± 42.7
1 April 1993	48.4 ± 8.6	27.7 ± 8.5	117.0 ± 23.9	64.3 ± 21.9
% change	-4.2	-79.0	+26.3	-80.5

The mortality at each site was about 80% between pre- and post-treatment. The change in densities at the control sites over the same period was -4.2% at Blandford and +26.3% at Longham (Table 4).

These changes in density were tested statistically to see if they were significant. Initially the odds ratio method was applied and a t test used to compare means. A non-parametric method comparing medians was used as confirmation.

6.2.3 Odds ratio method

This works on the premise that the ratio of the larval density before and after the treatment date should be the same at the control and treatment sites if there is no effect of the *Bti*, thus q, the 'odds ratio' coefficient, is determined as follows;

$$q = R_T/R_C = 1 \quad \text{where } R_T = \bar{x}_{ca}/\bar{x}_{cb} \text{ and } R_C = \bar{x}_{ta}/\bar{x}_{tb}$$

$\bar{x}_{ca}$ = mean density in the control site after treatment

$\bar{x}_{cb}$ = mean density in the control site before treatment

$\bar{x}_{ta}$ = mean density in the treatment site after treatment

$\bar{x}_{tb}$ = mean density in the treatment site before treatment

The data is log transformed as it is not normally distributed and the logarithm of x+1 is taken (where x is the density) owing to the presence of zero counts in some samples, giving $y = \log_{10}(x+1)$. The ratio now becomes the difference between before and after, D, (because we are dealing with logs), simply

$$D_C = \bar{y}_{ca} - \bar{y}_{cb} \text{ for the control sites}$$

and $D_T = \bar{y}_{ta} - \bar{y}_{tb}$ for the treatment sites.

If no treatment effect exists then, on average, $D_C = D_T$ or

$$Q = D_T - D_C = 0$$

Mathematically, $D_C = \log_{10} R_C$, $D_T = \log_{10} R_T$ and $Q = \log_{10} q$
so testing $Q = 0$ is equivalent to testing $q = 1$.

In practice the two tests are not the same since $\bar{y}_{cb}$ does not equal $\log_{10} \bar{x}_{cb}$, etc.,because they are geometric means. However, the test of $Q = 0$ is preferable because it is effectively a test of differences rather than ratios, the latter being difficult to analyse.

$$Q = (\bar{y}_{ta} - \bar{y}_{tb}) - (\bar{y}_{ca} - \bar{y}_{cb})$$

and the standard error of Q is given by

$$SE(Q) = \sqrt{(SE_{TA}^2 + SE_{TB}^2 + SE_{CA}^2 + SE_{CB}^2)}$$

The test of Q = 0 is

$t = Q/SE(Q)$ with 116 degrees of freedom (n-1 for each of the four sites)

If densities have changed at the control site from before to after then the best estimate of the proportion of pre-treatment density left after application of *Bti* at the treatment site is

$q = R_T/R_C$

which is estimated by q_1 to q_2, where

$(q_1,q_2) = 10^{(Q \pm tSE(Q))}$ = antilog $(Q \pm t\ SE(Q))$

The log x+1 values for mean density are given in Table 5.

Table 5 Mean density (as $\log_{10} x + 1$) of *S. posticatum* larvae at each site and the t statistic to test for significant differences between before and after treatment with *Bti*. NS = not significant, * = significant at the 95% level, *** = significant at the 99.9% level.

	Before	After	t	p	Significance
Blandford control	1.547	1.621	-0.68	0.5	NS
Blandford treatment	2.062	1.248	7.40	<0.001	***
Longham control	1.738	2.003	-2.15	0.04	*
Longham treatment	2.491	1.591	8.43	<0.001	***

For Blandford, the initial regression analysis shows no significant difference in the control before and after *Bti* addition at the treatment site (p = 0.502)
Then

$Q = (1.2482-2.0623)-(1.6206-1.5473)$
$= -0.8874$

The proportion of pre-treatment density remaining is
antilog Q = 0.13 or 13%.
Thus the percentage kill at Blandford was 87%.

Limits can be calculated from the formula, antilog $(Q \pm t\ SE(Q))$
The SE(Q)= 0.1539, therefore the limits are .185 and .091 (or 18.5% and 9.1%). **The limits of the percentage kill are therefore 81.5% and 90.9%.**

t = -0.8874/0.1539 = -5.765 with 116 df. p<0.001 ***

This shows that the reduction in density at the Blandford treatment site is highly significant.

At Longham, the initial regression analysis shows a significant increase in density in the control before and after *Bti* addition at the treatment site (p = 0.023, significance *).

$$Q = (1.5909-2.4908)-(2.0030-1.7377)$$
$$= -1.1652$$

$$SE(Q)= 0.1631$$

and **t = -1.1652/0.1631 = -7.142 with 116 df. p = <0.001 *****

This shows that the reduction in density at the Longham treatment site is highly significant.

As the densities have changed at Longham control, the best estimate of the proportion of pre-treatment density left after application of *Bti* at the treatment site is

$$\text{antilog } (Q \pm t\ SE(Q)) = \text{antilog } (-1.1652 \pm 1.98*0.1632)$$
$$= 0.069 \text{ with limits of } 0.033 \text{ and } 0.117$$

As a percentage this equates to 6.9% with limits of 3.3% and 11.7%. **Thus the best estimate of mortality of larvae at Longham is 93.1% with limits of 88.3% and 96.7%.**

6.2.4 Two sample t test

The t value tests for significance between two means. Samples are assumed to be independent and to come from normal distributions. As this is not the case the data requires log transformation. The calculations were performed twice, firstly assuming unequal within-time variability in log density and secondly assuming equal variances. The resultant t statistic was the same and is given in Table 5. At Blandford, there was no change in the control whilst there was a highly significant decrease in density at the treatment site (Table 5). At Longham, the density at the control increased significantly whilst at the treatment site there was a highly significant decrease (Table 5).

6.2.5 Non-parametric method

The Mann-Whitney test is a two sample rank test for the difference between population medians. It assumes that the data are independent random samples from two populations that have the same variance. There was no difference in the control sites at either Blandford or Longham between the densities before and after treatment day (Table 6), however there were highly significant decreases in density over the same time period at both localities at the treatment sites (Table 6).

Table 6 Median values of density of *S. posticatum* larvae at each site and the Mann-Whitney statistic, W, to test for significant differences between before and after treatment with *Bti*. NS = not significant, *** = significant at the 99.9% level.

	Before	After	W	P	Significance
Blandford control	45.40	47.75	912.5	0.98	NS
Blandford treatment	116.55	24.60	486.0	<0.001	***
Longham control	81.65	105.80	1021.0	0.12	NS
Longham treatment	310.65	48.20	481.5	<0.001	***

6.2.6 Other periphyton

Only two families of periphyton invertebrates were found on the weed samples; Chironomidae and Ephemeroptera. Numbers were low at Blandford both before and after treatment. Chironomids were more numerous at Longham with numbers remaining constant in the controls and increasing in the treatment samples (Table 7). Densities were not calculated due to the low numbers involved.

Table 7 Numbers of periphyton species found in 30 weed samples at each sampling site on the River Stour. C = chironomid, E = *Ephemera danica*, B = *Baetis* sp.

	Blandford		Longham	
	Control	Treatment	Control	Treatment
30 March 1993	2C	3C	33C	3C
1 April 1993	4C, 1E	4C	27C, 1B	23C

7. EMERGING ADULTS

7.1 Introduction

In order to try to quantify the emerging adults it was suggested by the HSE advisers that the production of pupae should be monitored given that all pupae would be expected to emerge as adults.

7.2 Methods

30 weed samples were taken from each of the four sites used in the larval monitoring survey. Many larvae migrate from the leaves to the stems of the weed to pupate, sections of stem between two nodes plus one branch with leaves were taken as the sample units and the number of pupae were counted. Sampling was continued every two weeks until numbers of full *S. posticatum* pupae found were low indicating that emergence was almost complete.

7.3 Results

Pupae of *S. posticatum* were first found on 30 March at both Blandford and Longham in very low numbers. The pattern of pupation was similar at three of the four sites, differences being noted at Blandford control only. Numbers were at high levels by the middle of April and were starting to fall by late April; by early May numbers were low (Fig 5). At all sites except Blandford control, numbers increased again to higher levels than the previous peaks by the middle of May before falling again. By the end of May numbers were very low and sampling was stopped.

The percentage of full pupae was also monitored. This showed a similar pattern with an increase in percentage full in the middle of May (Fig 6). By the end of May most of the pupae present were empty.

Pupae other than *S. posticatum* were noted. These were mainly *S. equinum* and *S. lineatum*. Those present on 30 March were the last of the overwintering generation. Pupae of this species were recorded on 22 April and numbers increased from that date (Fig. 5).

8. DISCUSSION

The monitoring of pupal numbers is an effective way of predicting when adults will be on the wing and when the worst of the infestation will occur. It is not, however a good predictor of the number of adults that emerge as this would require a calculation involving areas of weed. The amount of weed in the river is so enormous that the multiplication factor from the number of pupae per sample to the total number of flies is many orders of magnitude. The calculation also depends on the pupae being distributed evenly on the weed. This is not the case, pupae are highly aggregated and to determine the amount of weed suitable for pupae is a very time consuming task which would first involve research into the factors affecting the suitability as a pupal attachment site. This would have to be quantified in terms of individual weed beds and then the number of weed beds in the river would have to be quantified. The variation both within and between weed beds would make the calculation subject to such large errors as to render it meaningless. The only obvious way of assessing the effect of the treatment is to monitor the biting incidence. This is not an easy task.

The bimodal pattern of pupal density seen at all sites except Blandford control may indicate that there were two periods of hatching from the eggs. Immediately following treatment on 31 March there was a flood and the oviposition sites of the insect were again wetted. It is probable that this caused a second hatching and release of first instars into the river. The second pupal peak was 6 weeks after treatment which is enough time for larvae to reach pupation. Even though the percentage kill was high it might be necessary, in future, to monitor the water level in the river and if possible to treat for a second time if oviposition sites are rewetted within a short time after treatment.

Acknowledgements

Our thanks go to R.T. Clarke for statistical advice, Diana Morton for typing the report and Sue Smith for drawing the maps. Discharge data was supplied by the NRA (Wessex Region).

Fig. 1 Mean density ± 95% CL of larvae on the R. Stour at Blandford and Longham.

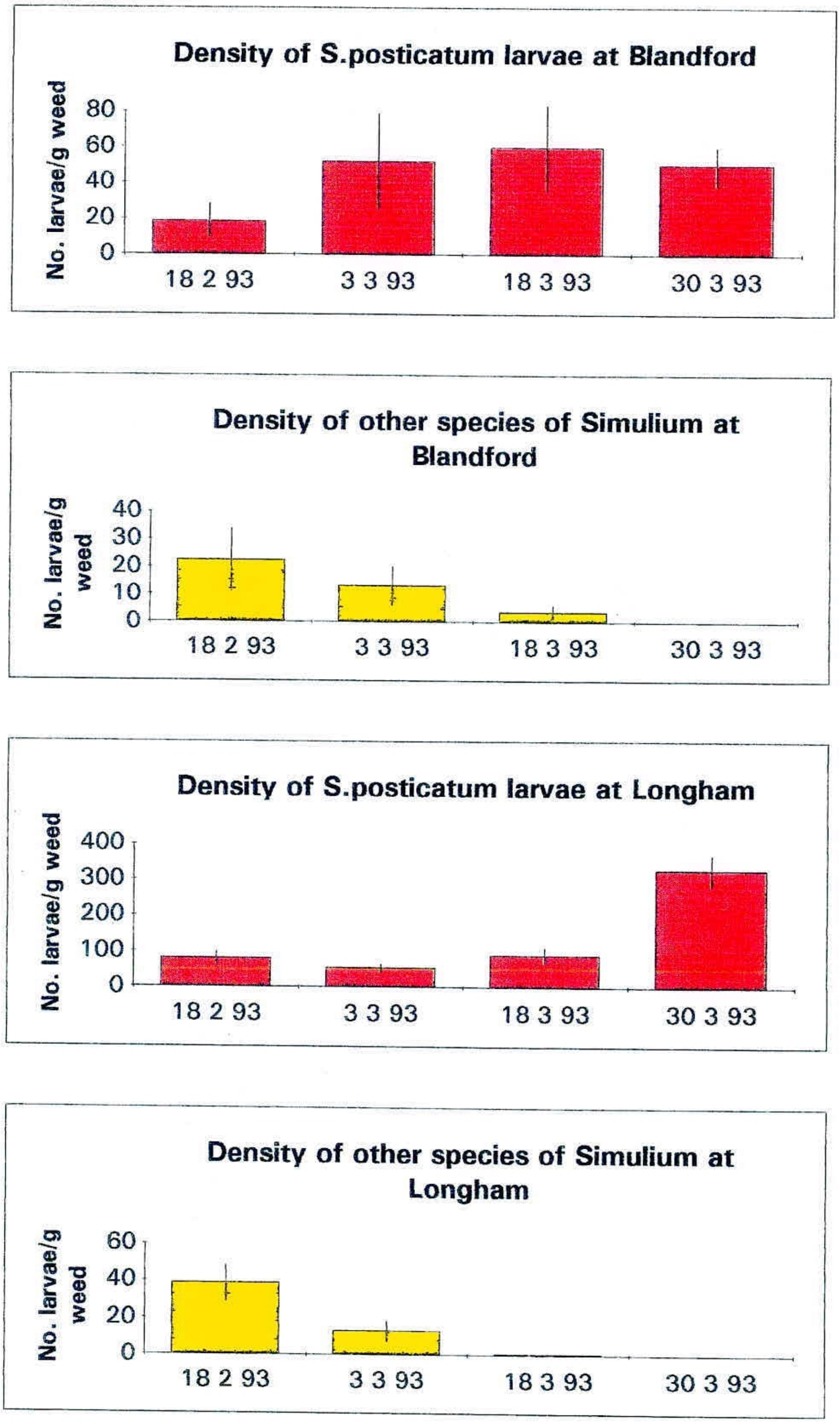


Fig. 2 Map of the R. Stour

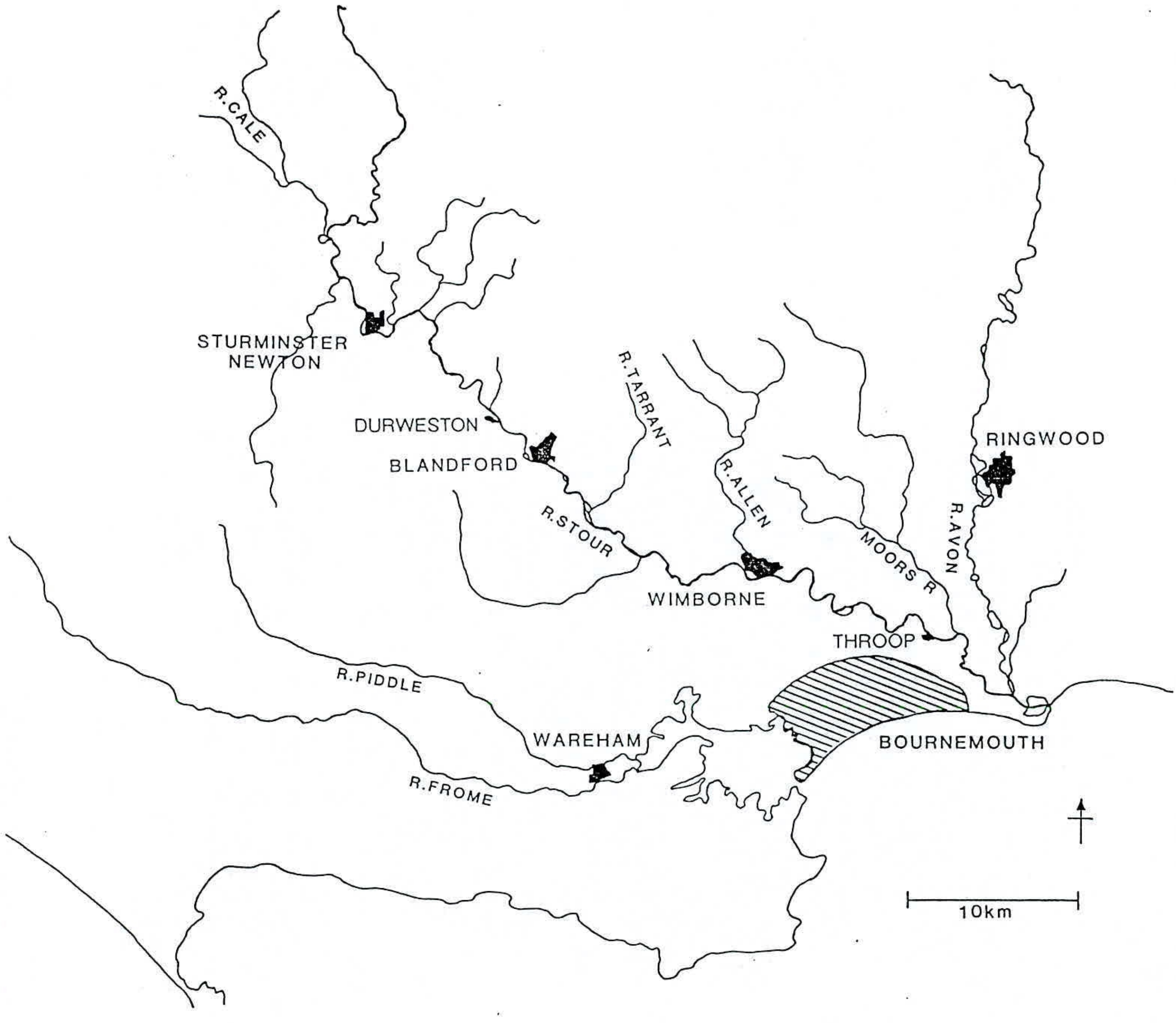


Fig. 3 Mean discharge (cumecs) of the R. Stour at the NRA gauging stations, Hammoon (NGR ST 820147) and Throop (NGR SZ 113958)

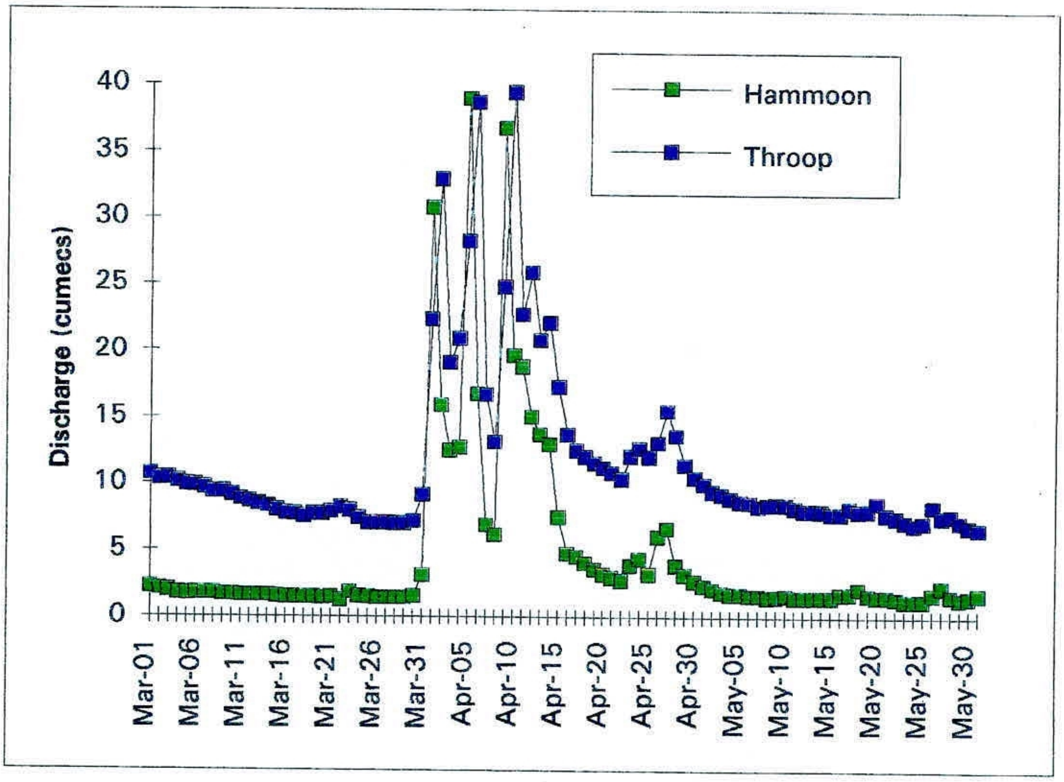


Fig. 4 Mean density ± 95% CL of *S. posticatum* larvae at each site before and after the application of *Bti*.

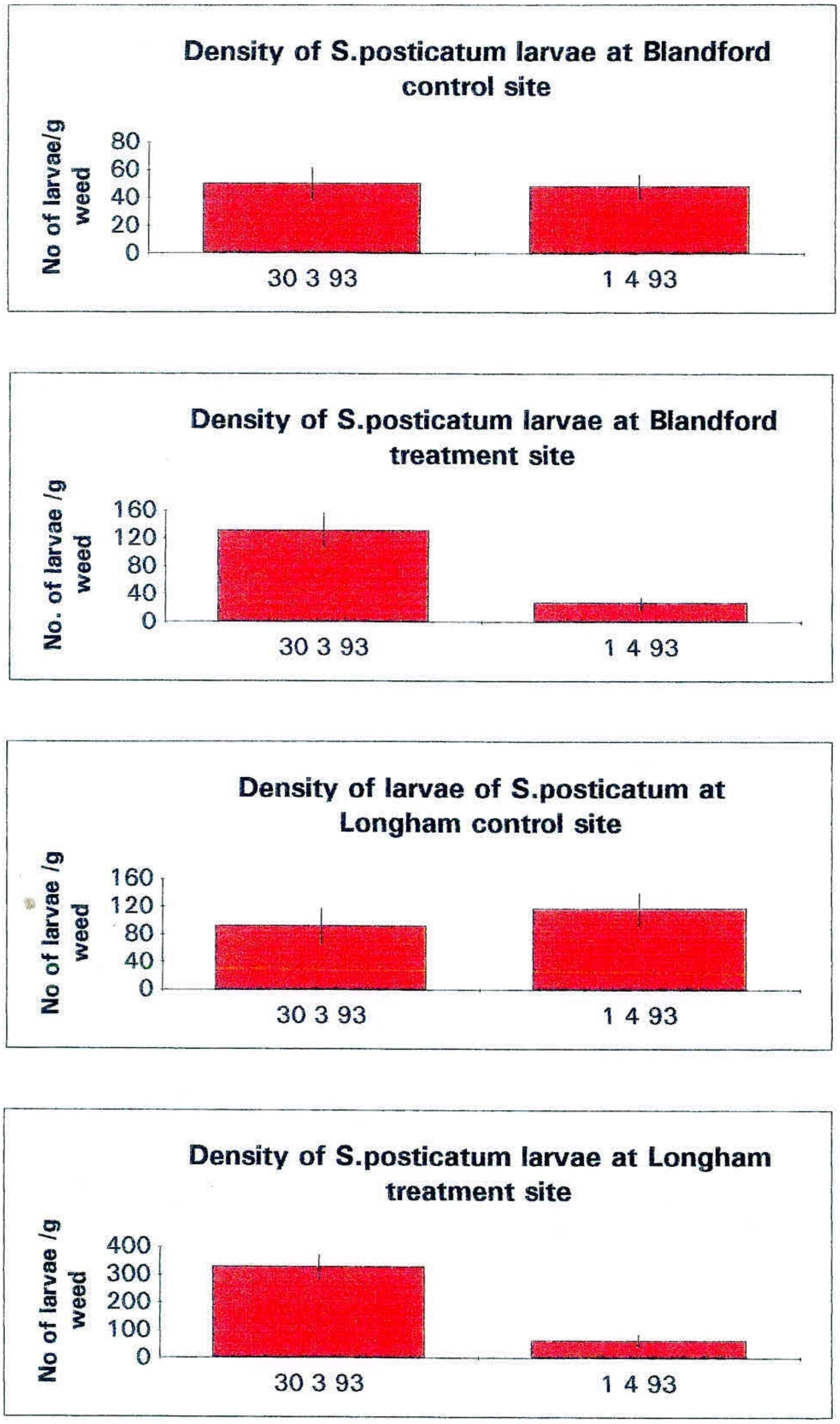
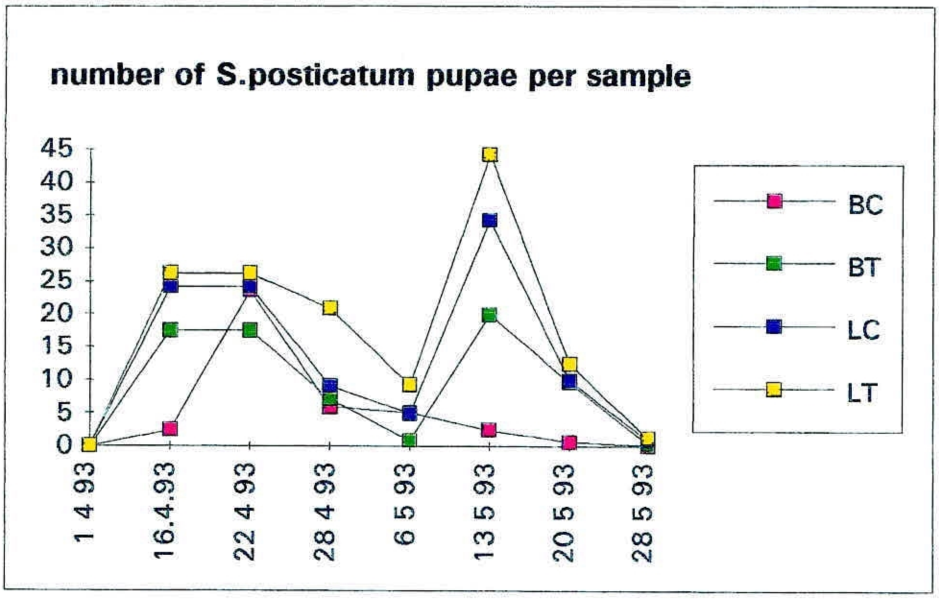


Fig. 5 Mean number of pupae/sample at the four sites on the R. Stour. BC = Blandford control, BT = Blandford treatment, LC = Longham control, LT = Longham treatment.



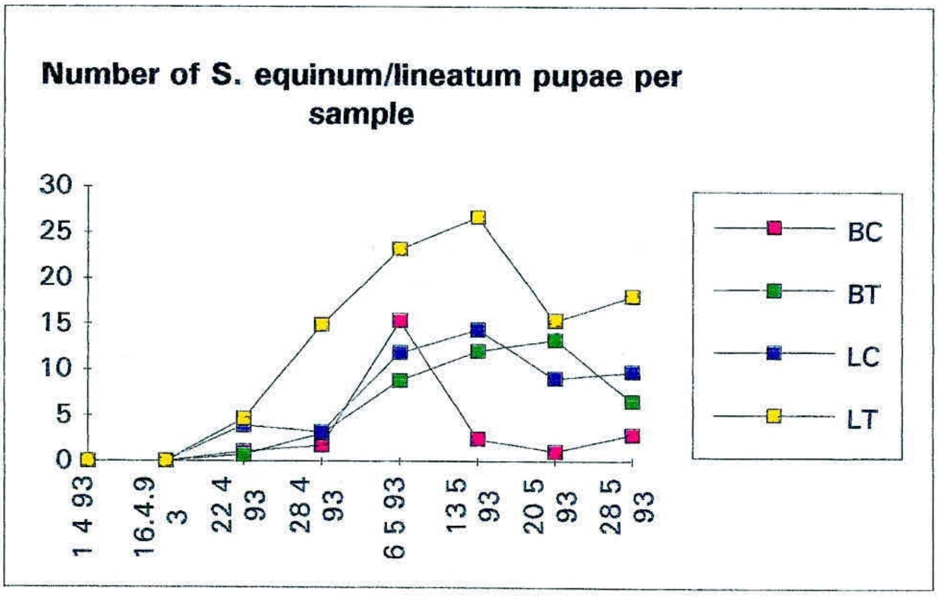
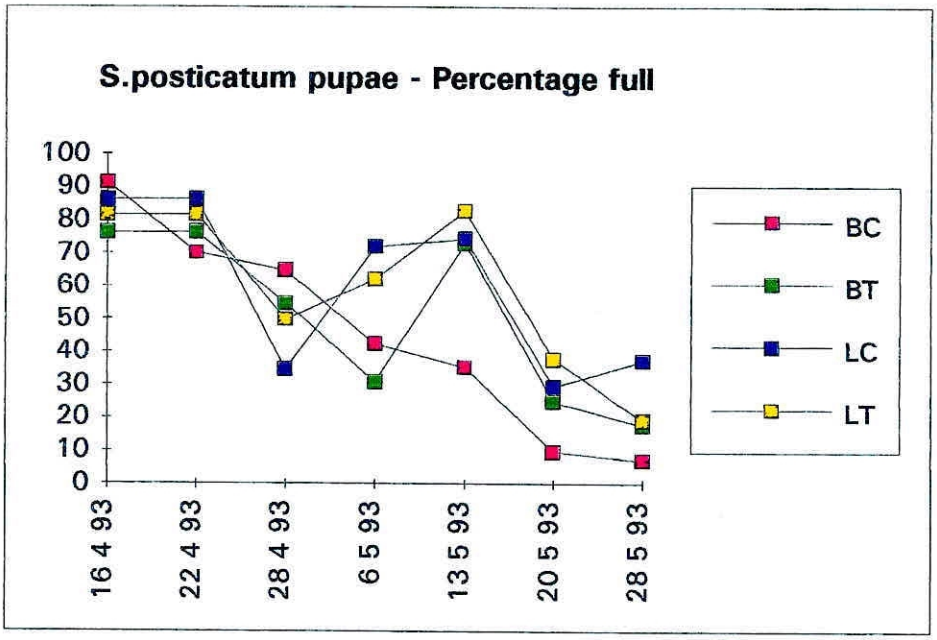


Fig. 6 Changes in percentage full composition of pupae of *S. posticatum* at the four sites on the R. Stour. BC = Blandford control, BT = Blandford treatment, LC = Longham control, LT = Longham treatment.



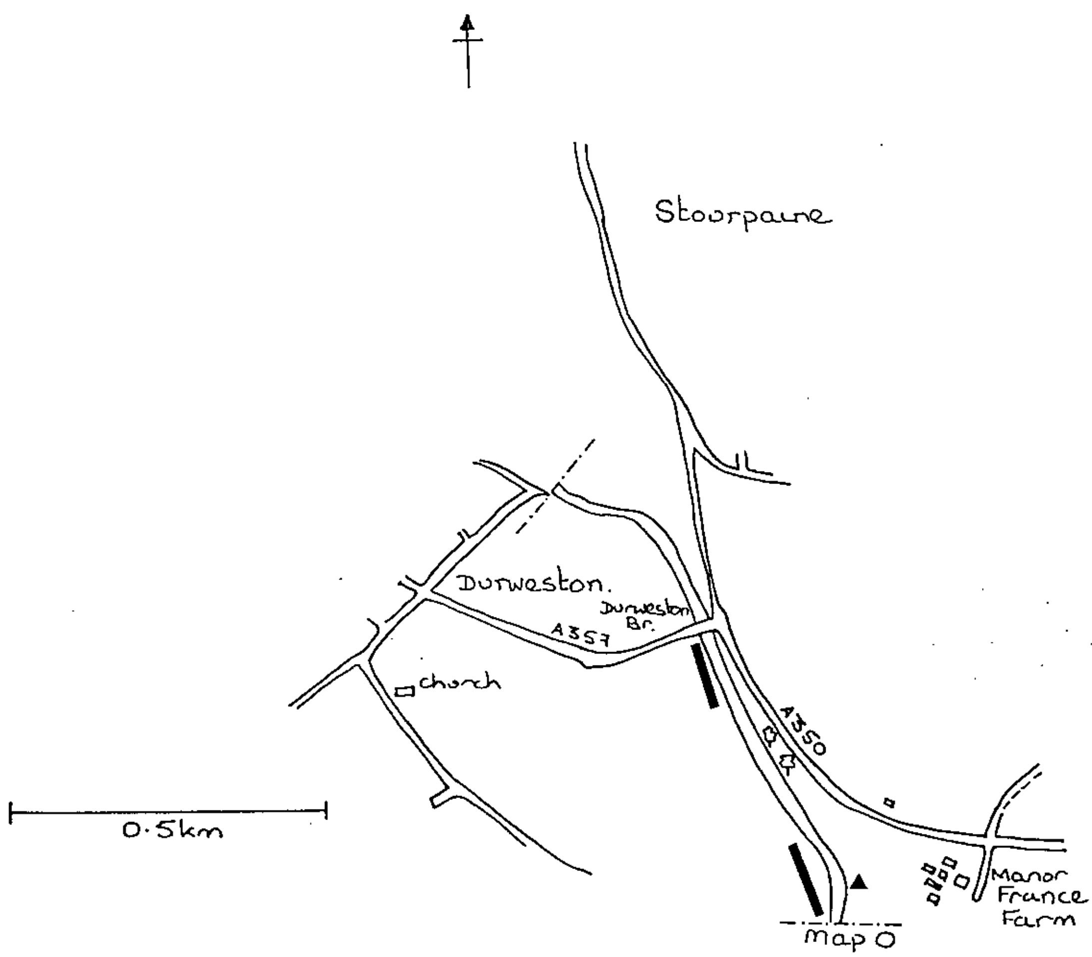
Detailed maps of the R. Stour showing sites where

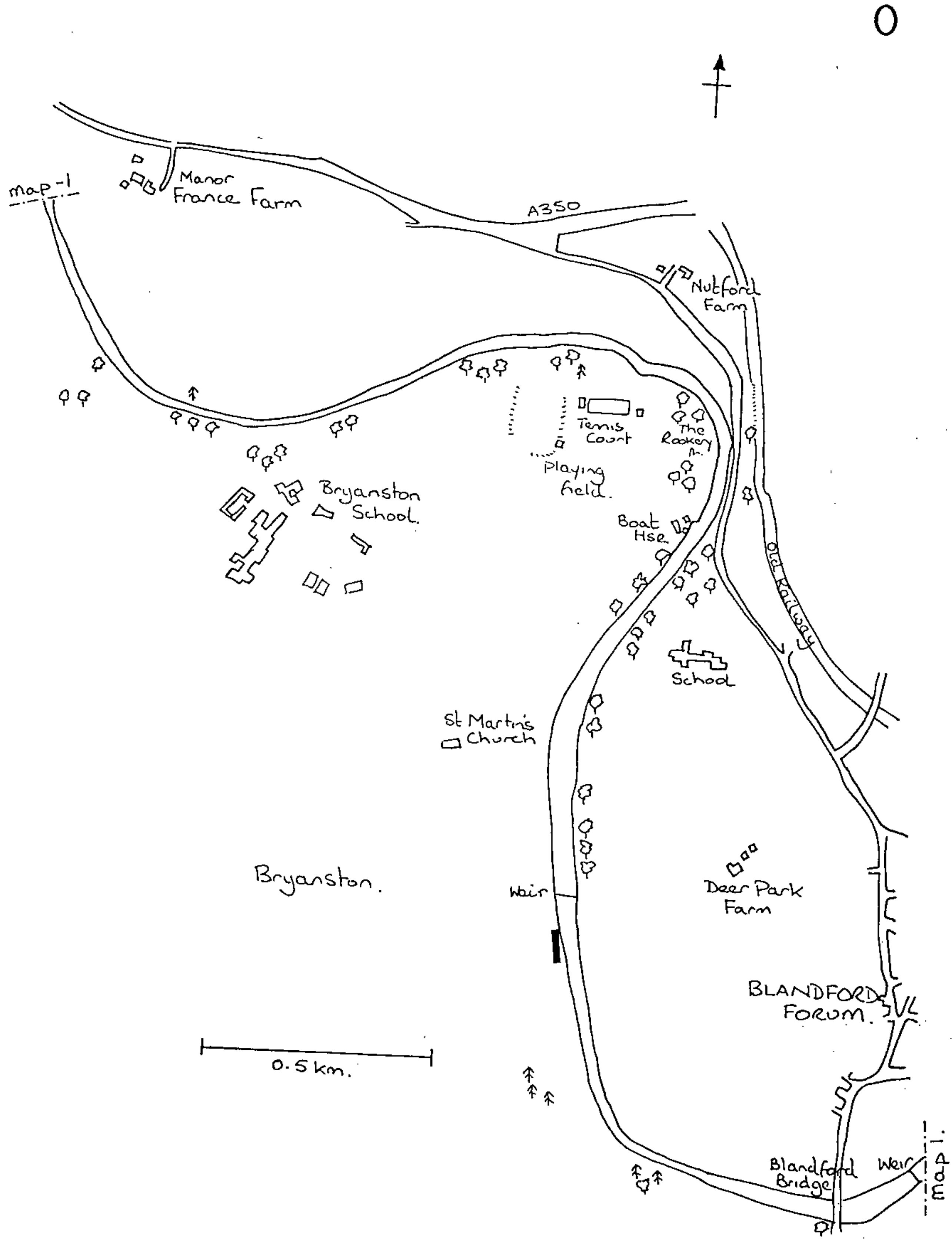
S. posticatum larvae were found

-1

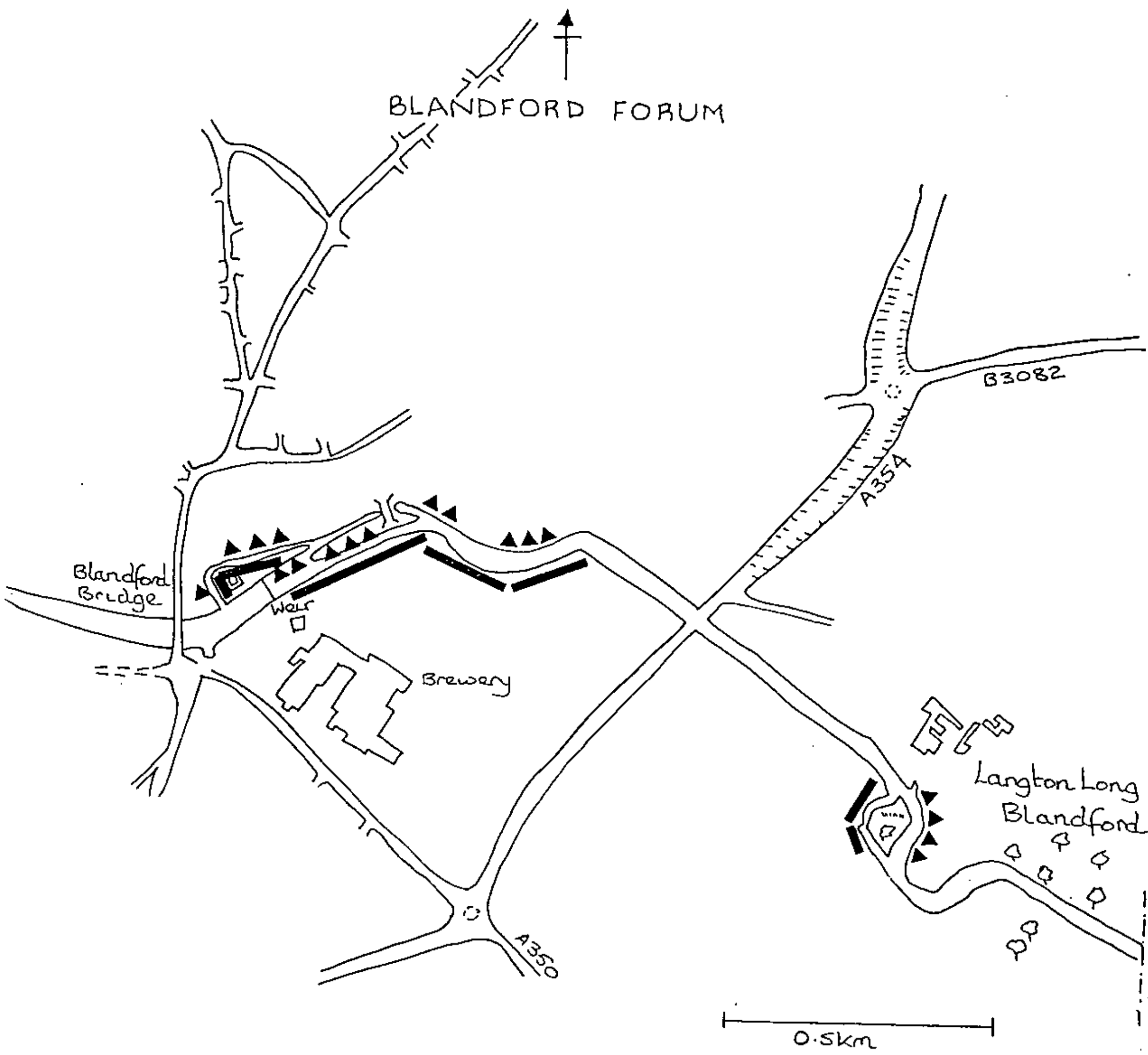
KEY : ▬▬ RIVER DEPTH OF ≤ 1m

▲▲▲ SITES WHERE S. posticatum LARVAE WERE FOUND



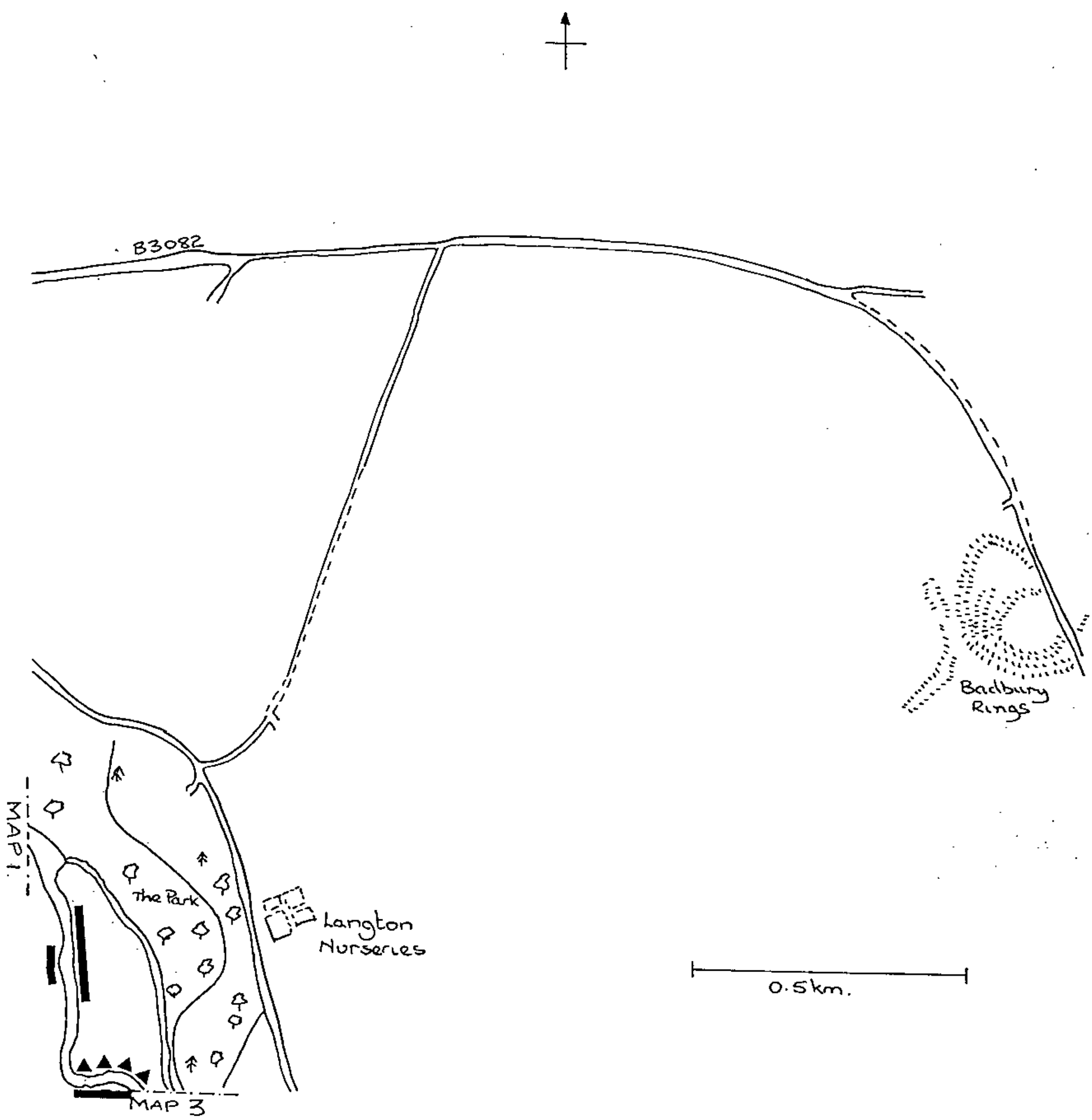

Manor
France Farm
map-1
A350
Nutford
Farm
Tennis
Court
The
Rookery
Playing
field.
Bryanston
School.
Boat
Hse
Old Railway
School
St Martin's
Church
Bryanston.
Weir
Deer Park
Farm
BLANDFORD
FORUM.
0.5 km.
Blandford
Bridge
Weir
map 1.

1

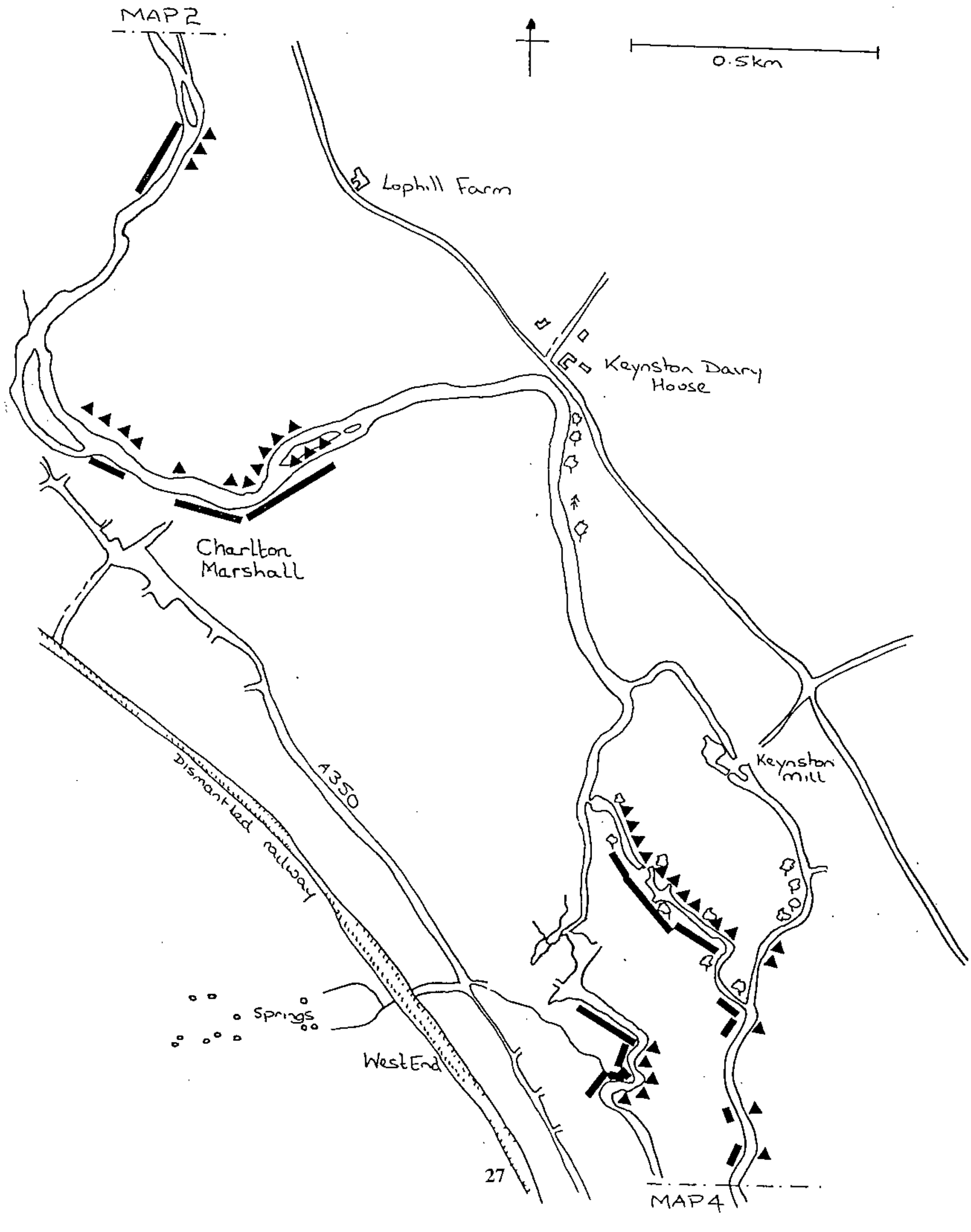


BLANDFORD FORUM
B3082
A354
Blandford Bridge
Weir
Brewery
Langton Long Blandford
A350
MAP 2
0.5km

2

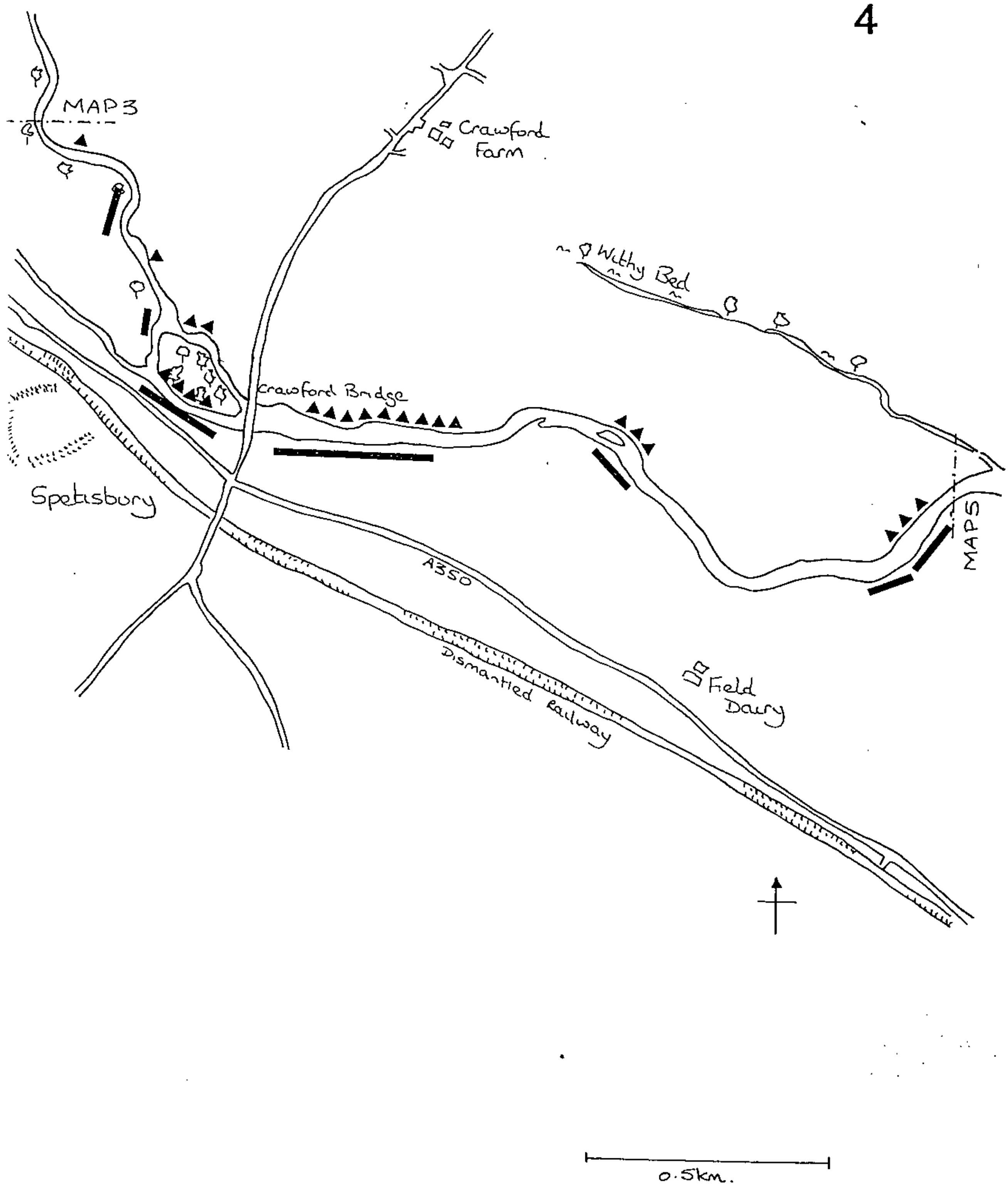

B3082
Badbury Rings
MAP 1.
The Park
Langton Nurseries
0.5km.
MAP 3

3

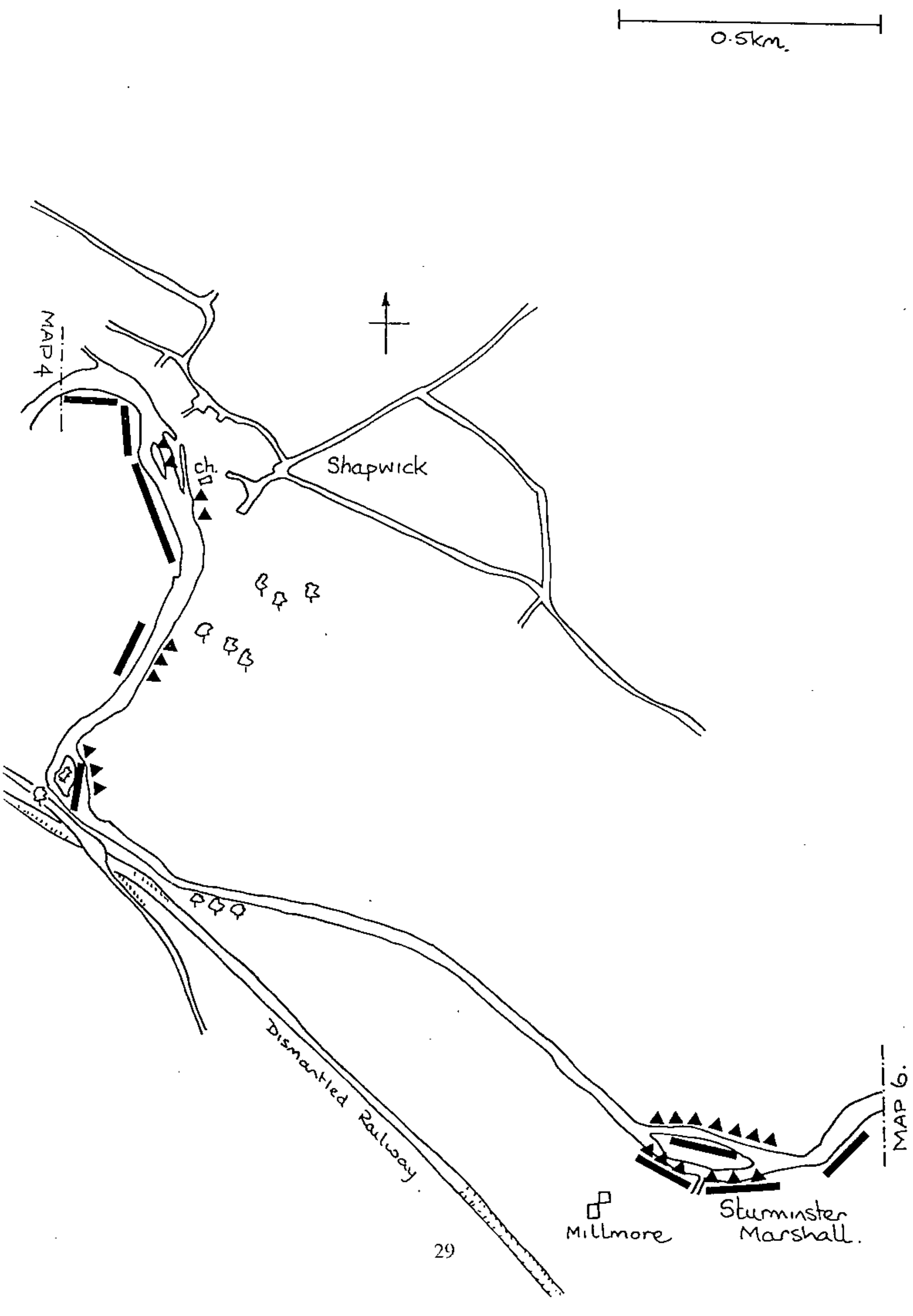


MAP 2
0.5km
Lophill Farm
Keynston Dairy House
Charlton Marshall
A350
Dismantled railway
Keynston Mill
Springs
West End
MAP 4

4

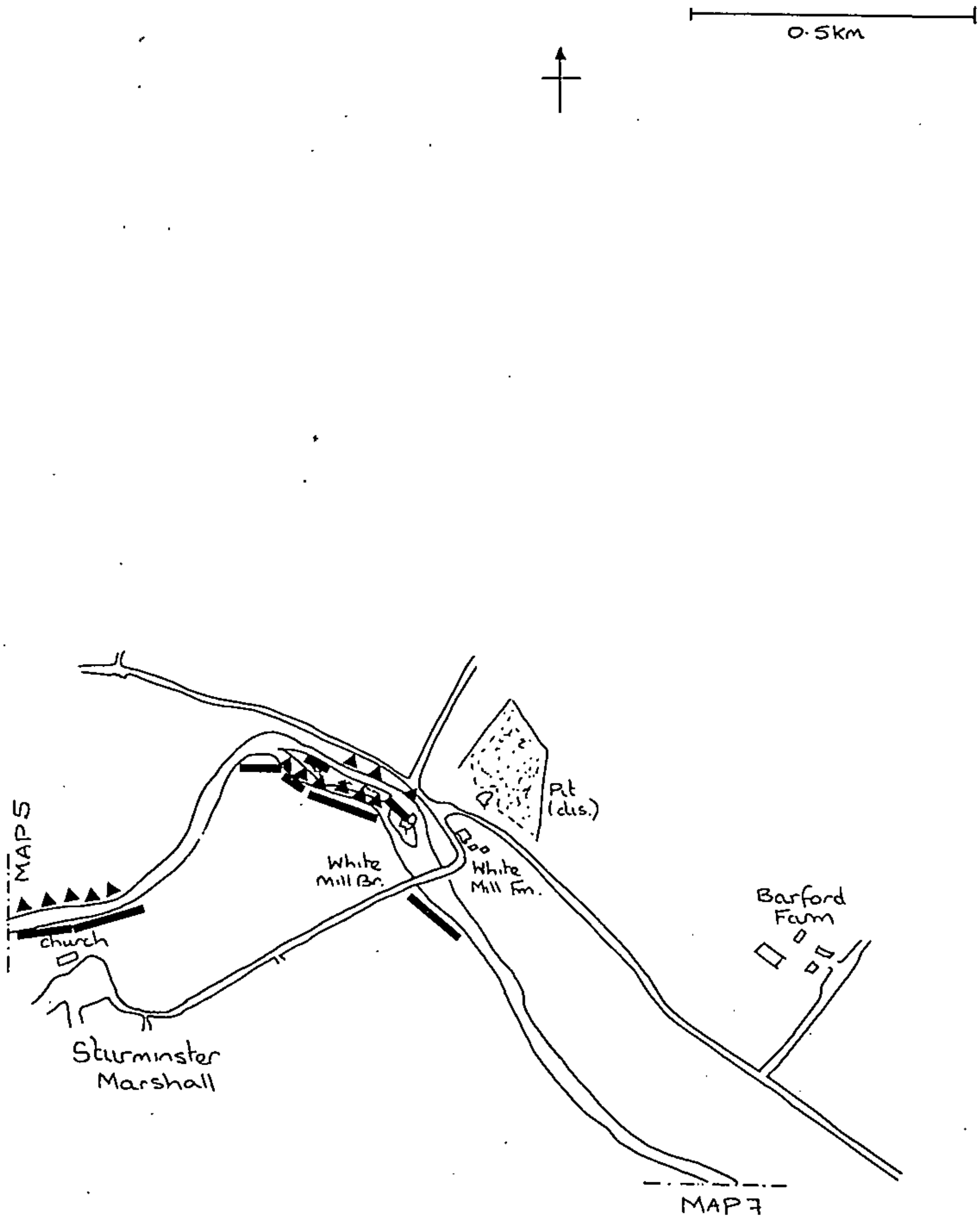

MAP 3
Crawford Farm
Withy Bed
Crawford Bridge
Spetisbury
A350
Dismantled Railway
Field Dairy
MAP 5
0.5km.

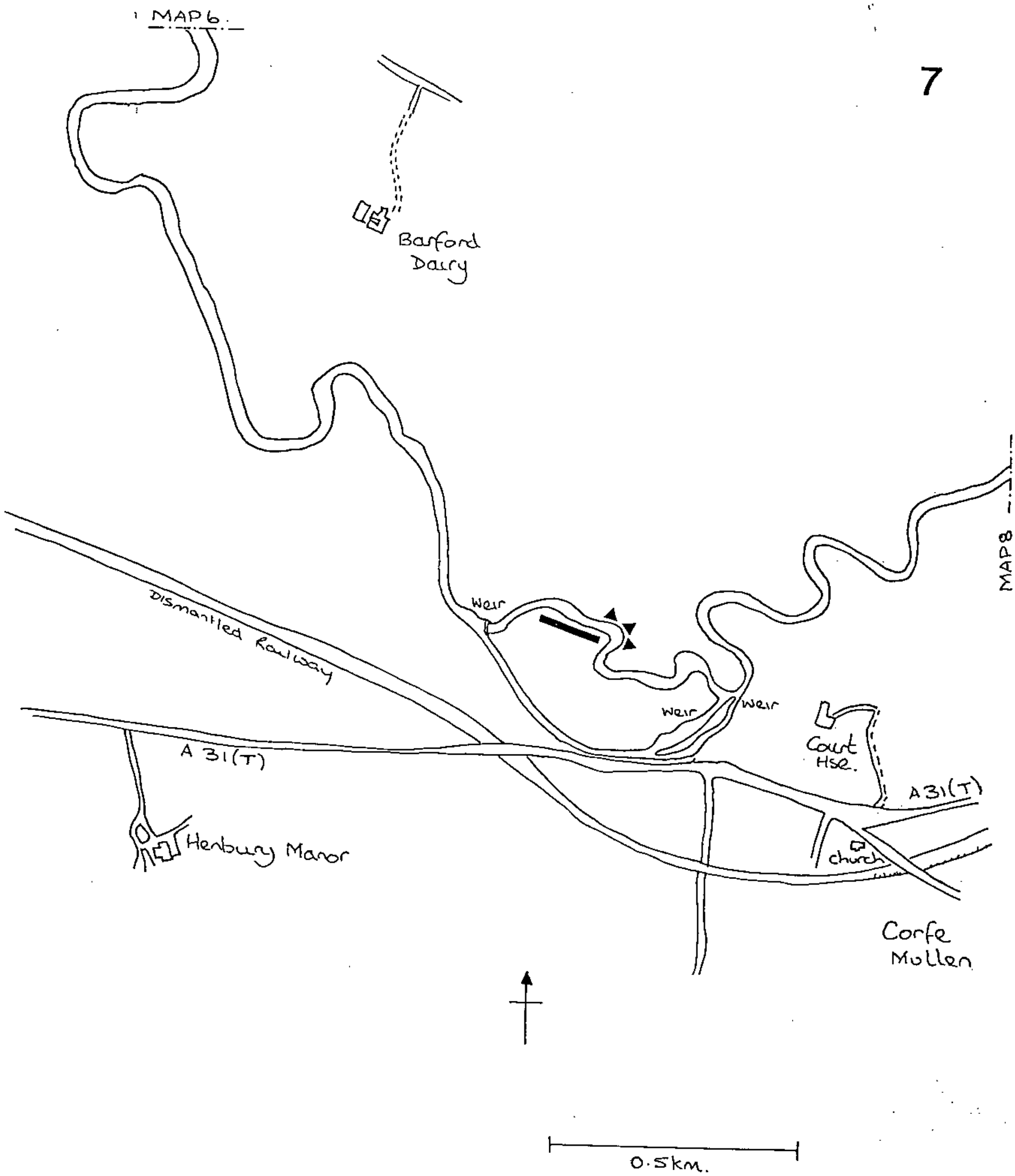
5

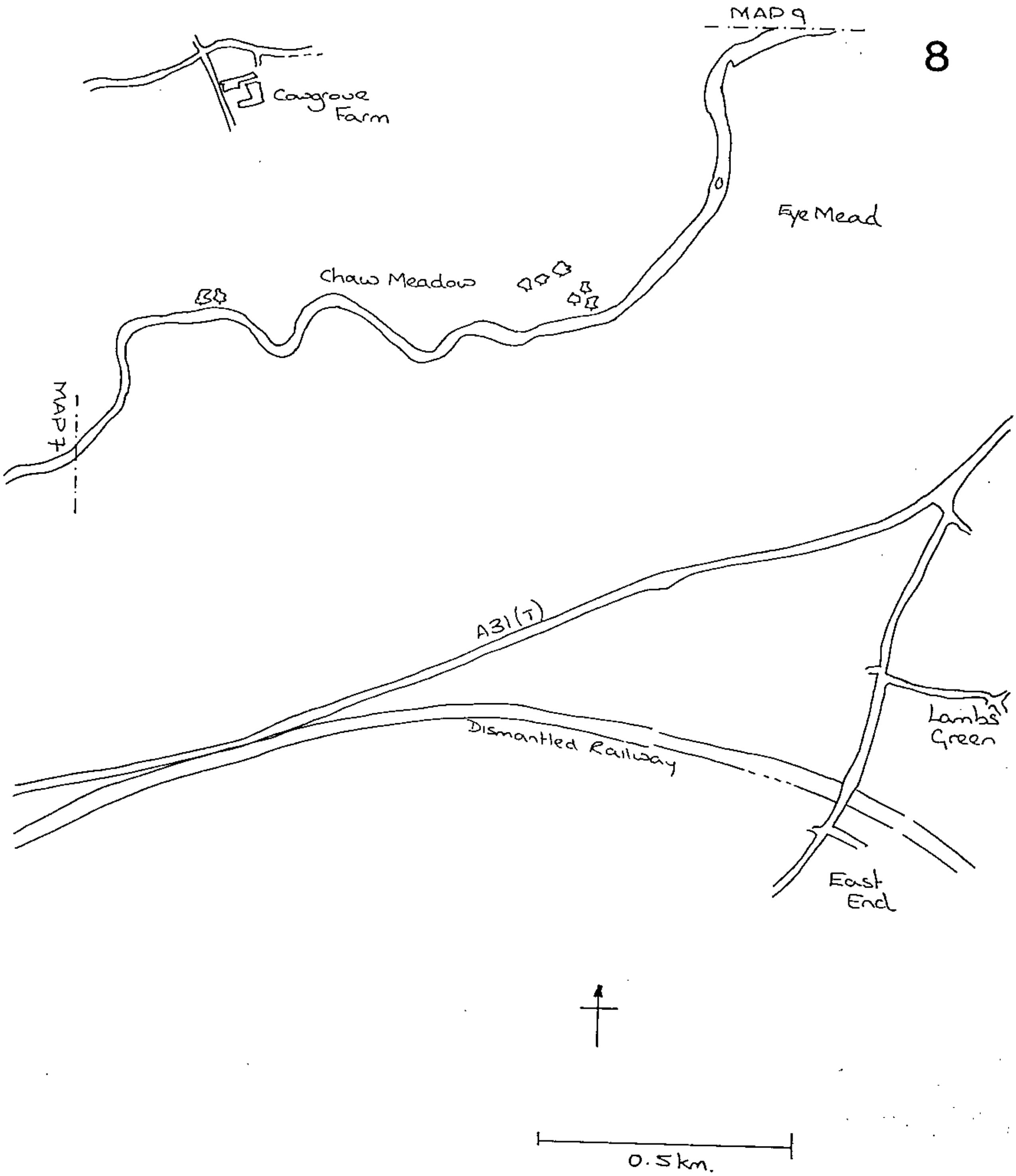


0.5km.
MAP 4
ch.
Shapwick
Dismantled Railway.
MAP 6.
Millmore
Sturminster
Marshall.

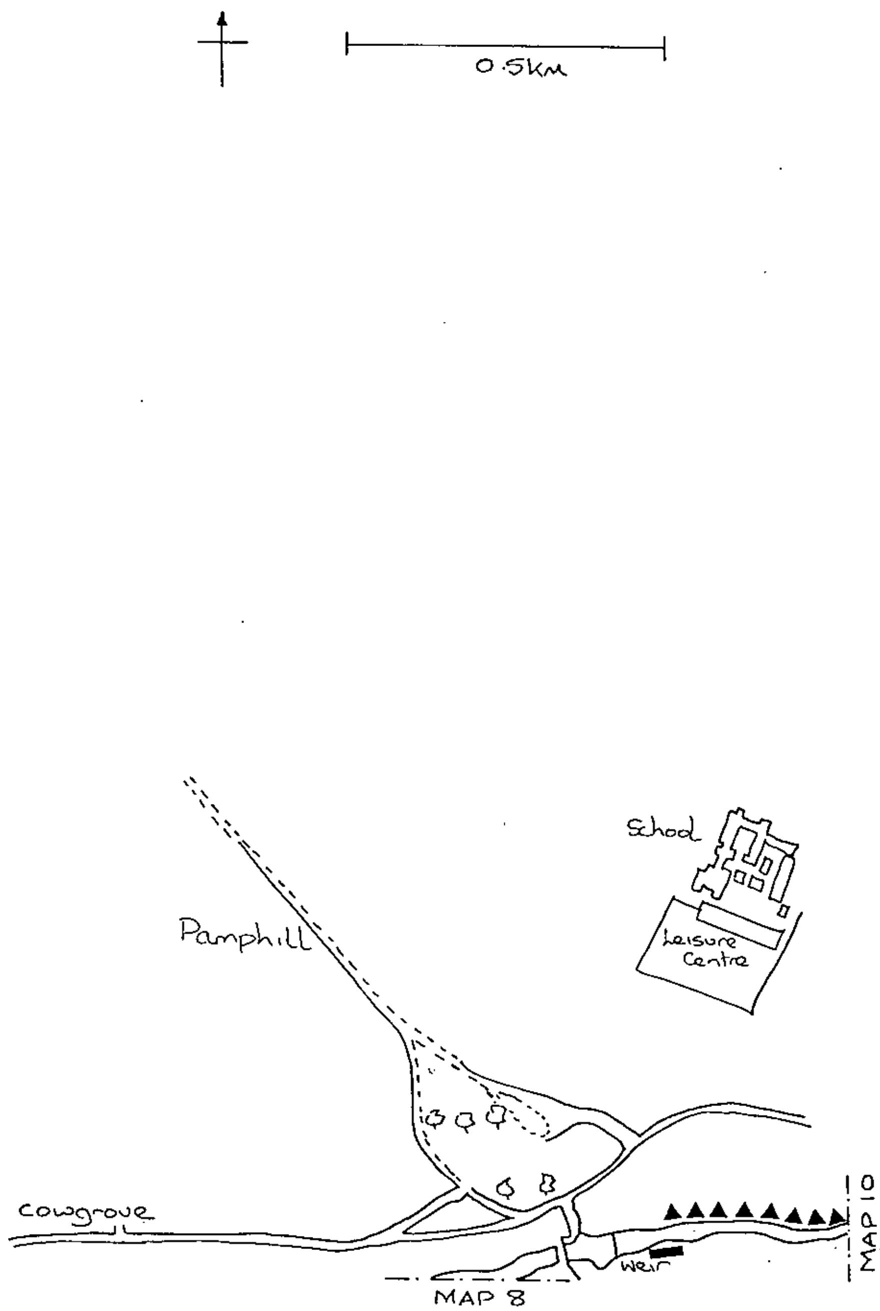
6


0·5km
Pit
(dis.)
White
Mill Br.
White
Mill Fm.
Barford
Farm
MAP 5
church
Sturminster
Marshall
MAP 7

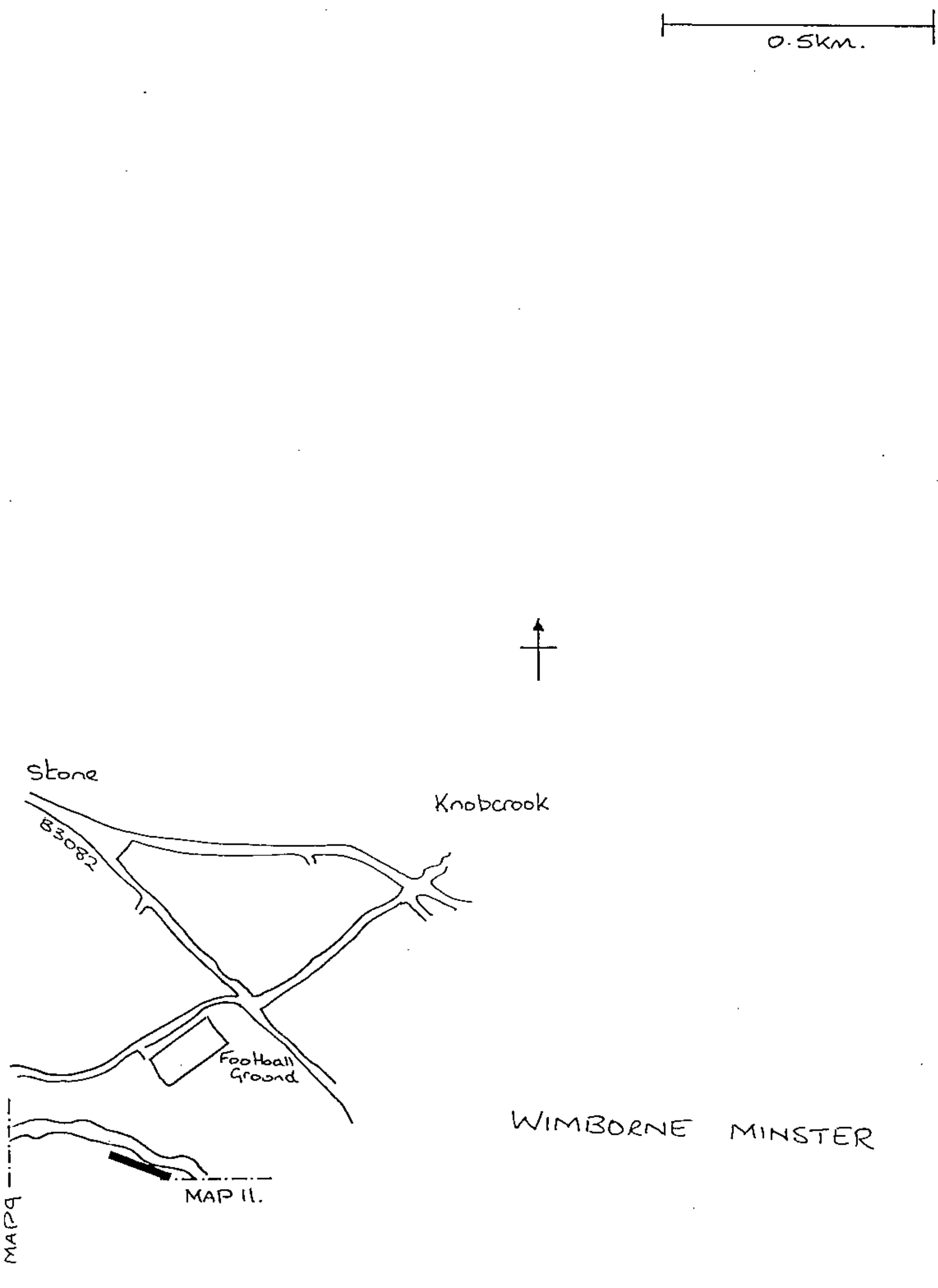

MAP 6
7
Barford Dairy
MAP 8
Weir
Dismantled Railway
Weir
Weir
Court Hse.
A 31 (T)
A 31 (T)
Henbury Manor
church
Corfe Mullen
0.5 km.

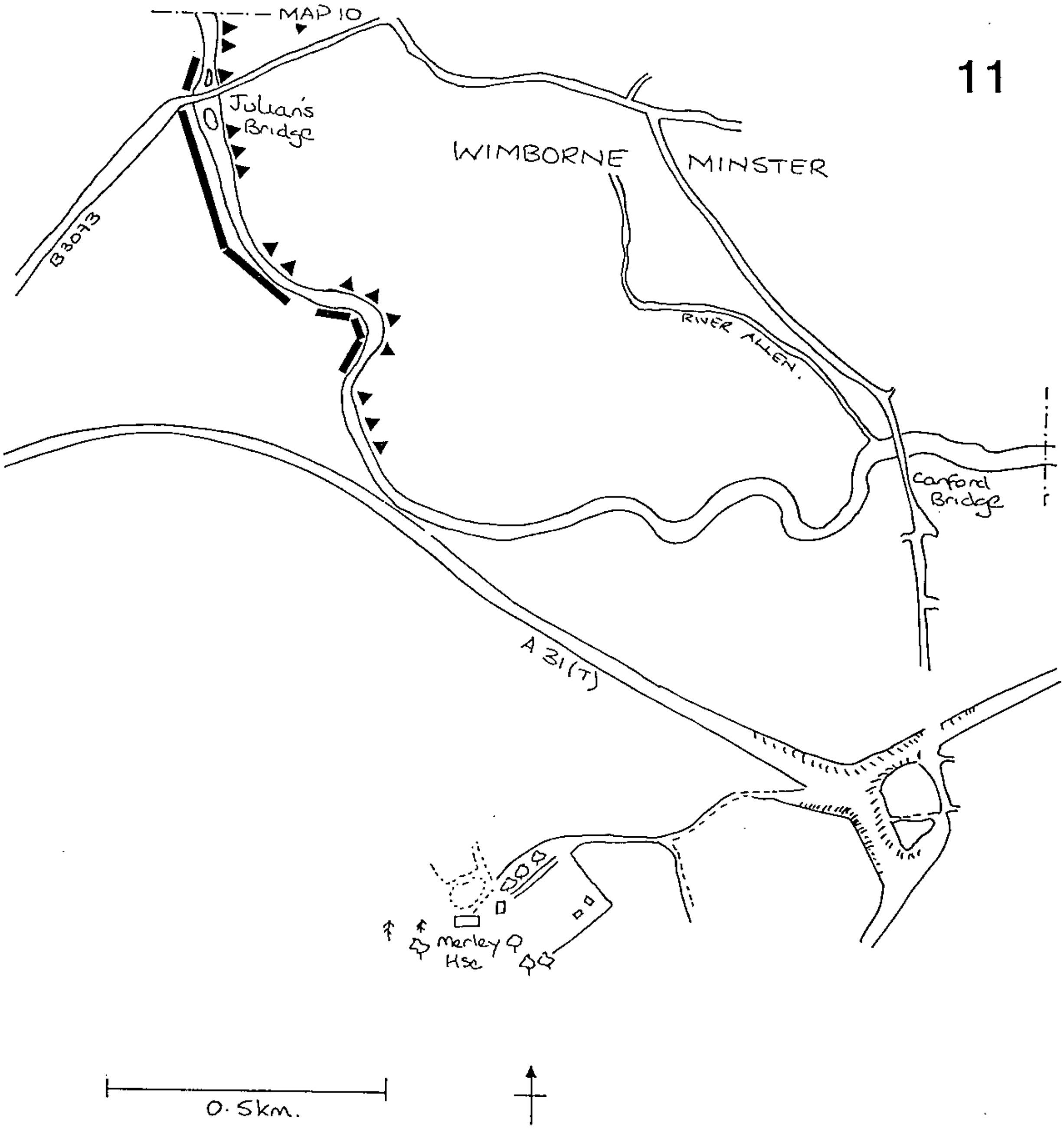

8
MAP 9
Cowgrove Farm
Eye Mead
Chaw Meadow
MAP 7
A31(T)
Dismantled Railway
Lambs' Green
East End
0.5km.

9

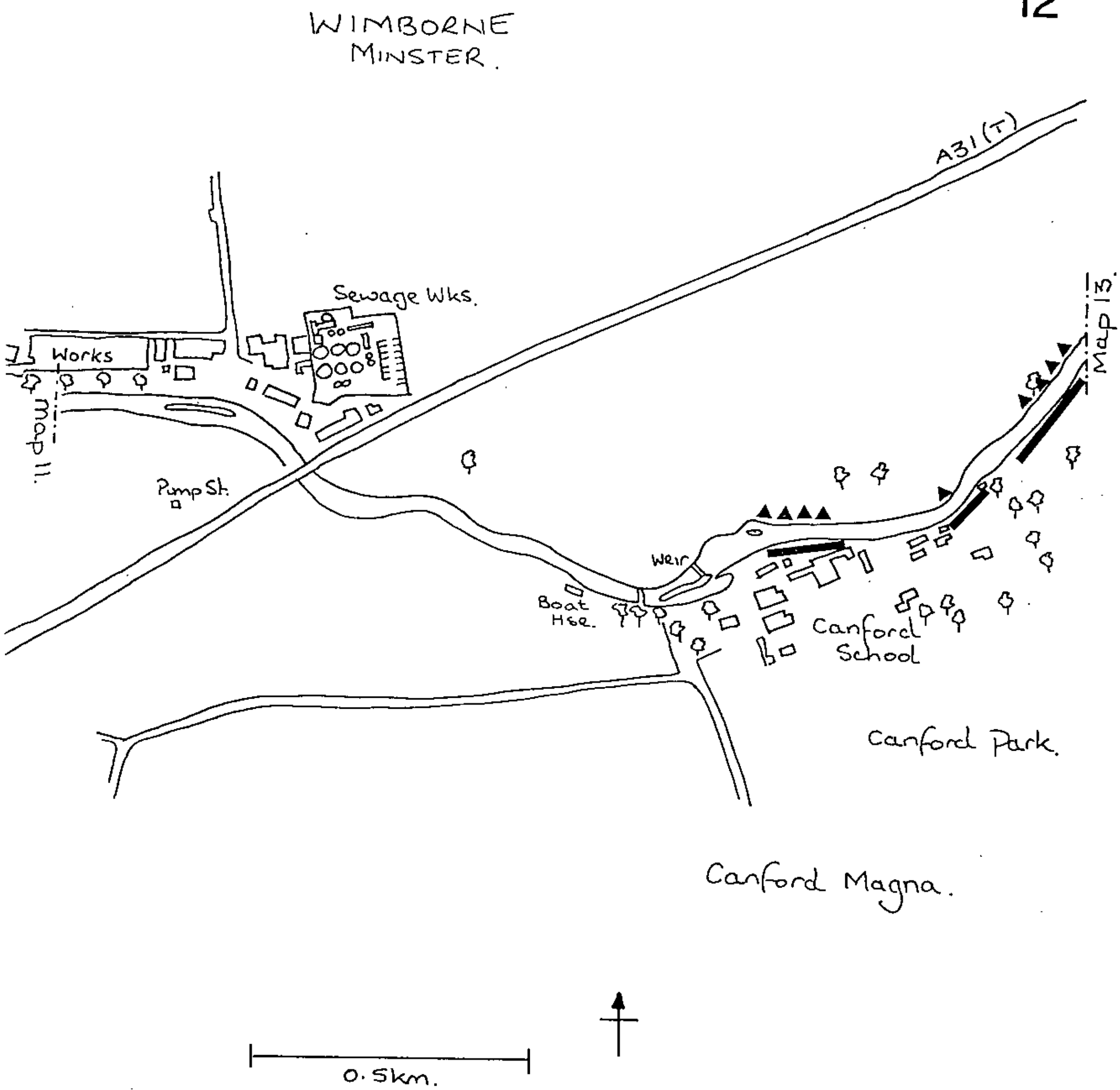

0.5km
School
Leisure Centre
Pamphill
Cowgrove
Weir
MAP 8
MAP 10

10

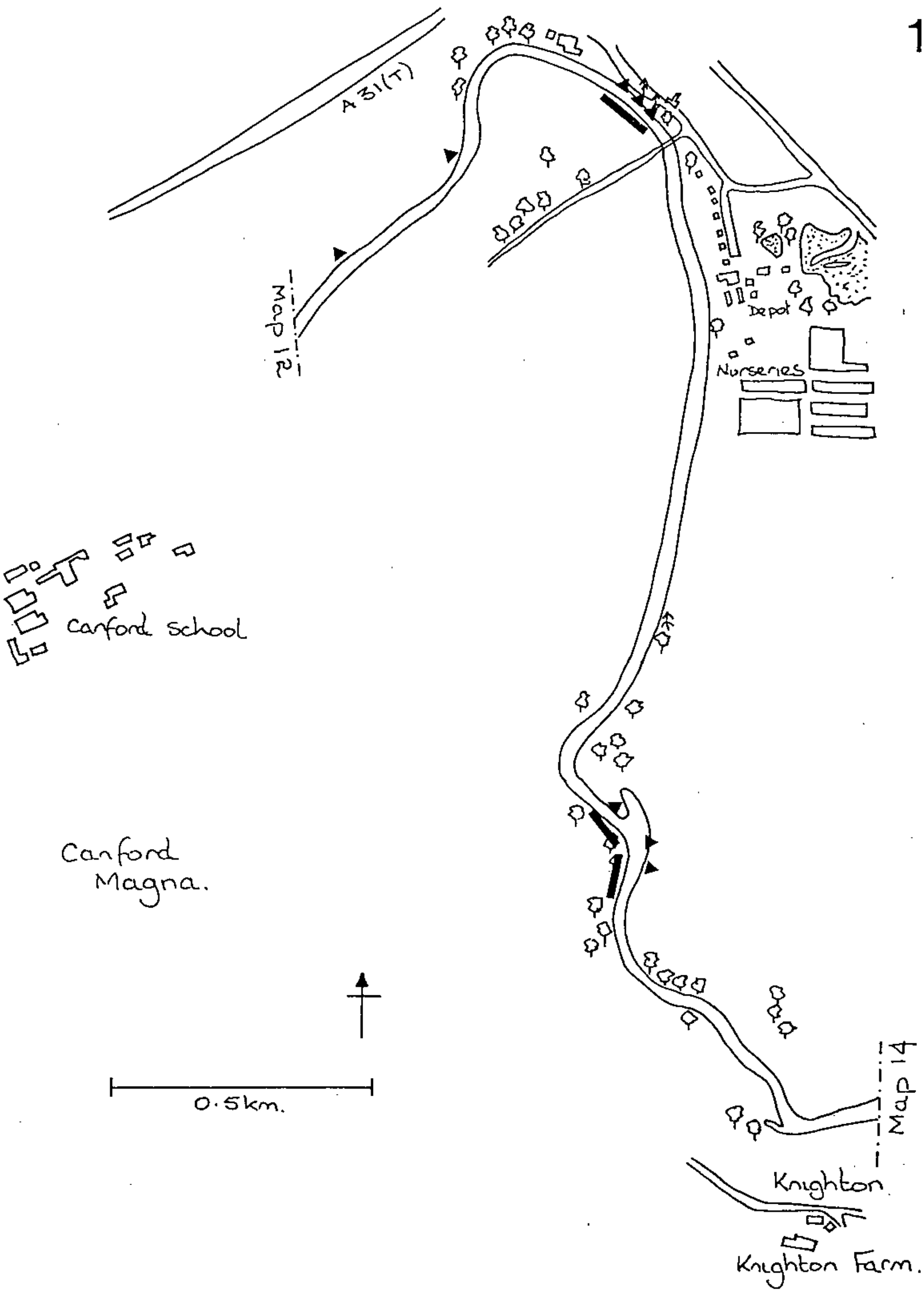

0.5km.
Stone
Knobcrook
B3082
Football Ground
WIMBORNE MINSTER
MAP 11.
MAP 9


MAP 10
11
Julian's Bridge
WIMBORNE MINSTER
B3073
RIVER ALLEN
Canford Bridge
A 31(T)
Merley Hse
0.5km.

12

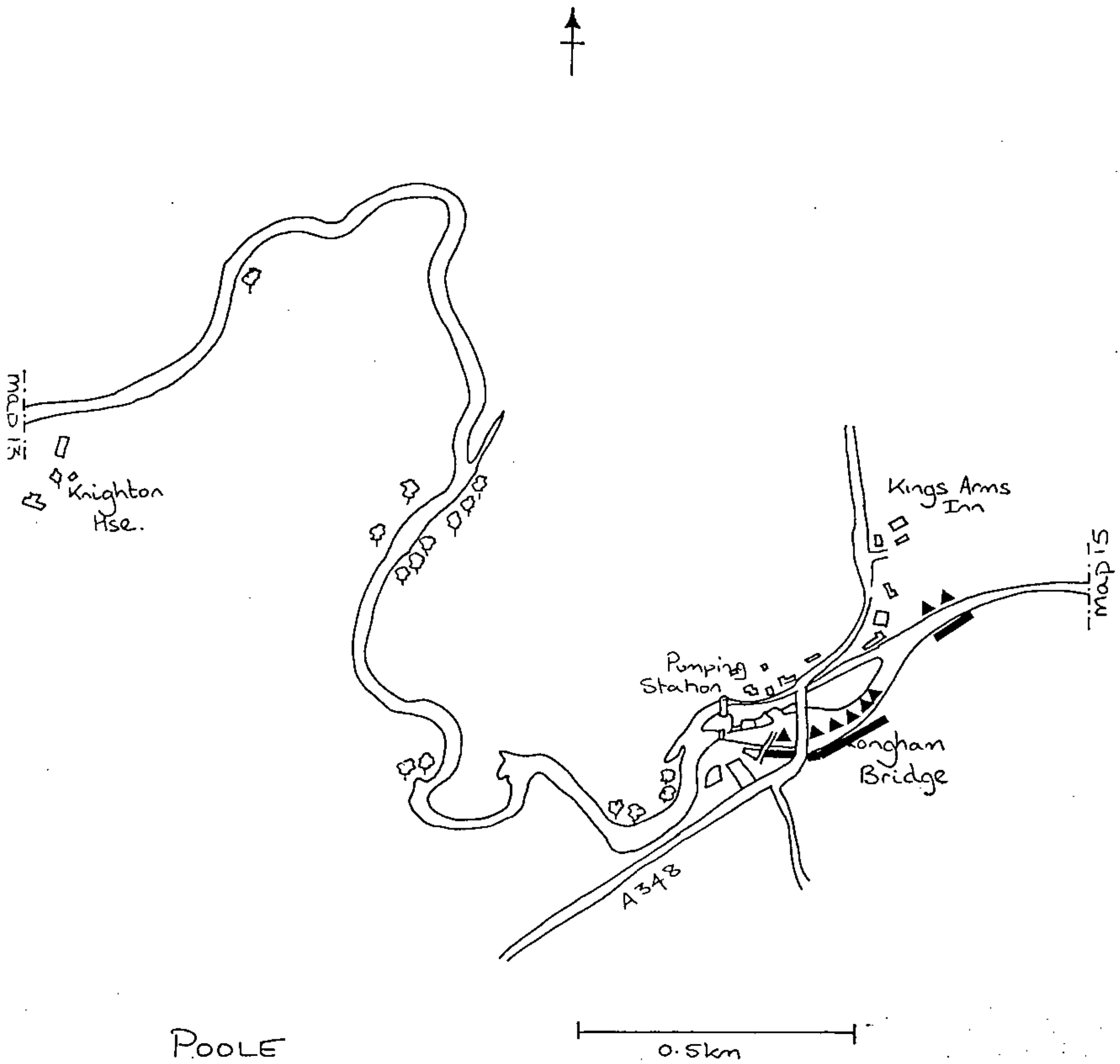

WIMBORNE
MINSTER.
A31 (T)
Sewage Wks.
Works
Map 11.
Pump St.
Map 13.
Weir
Boat
Hse.
Canford
School
Canford Park.
Canford Magna.
0.5km.

13

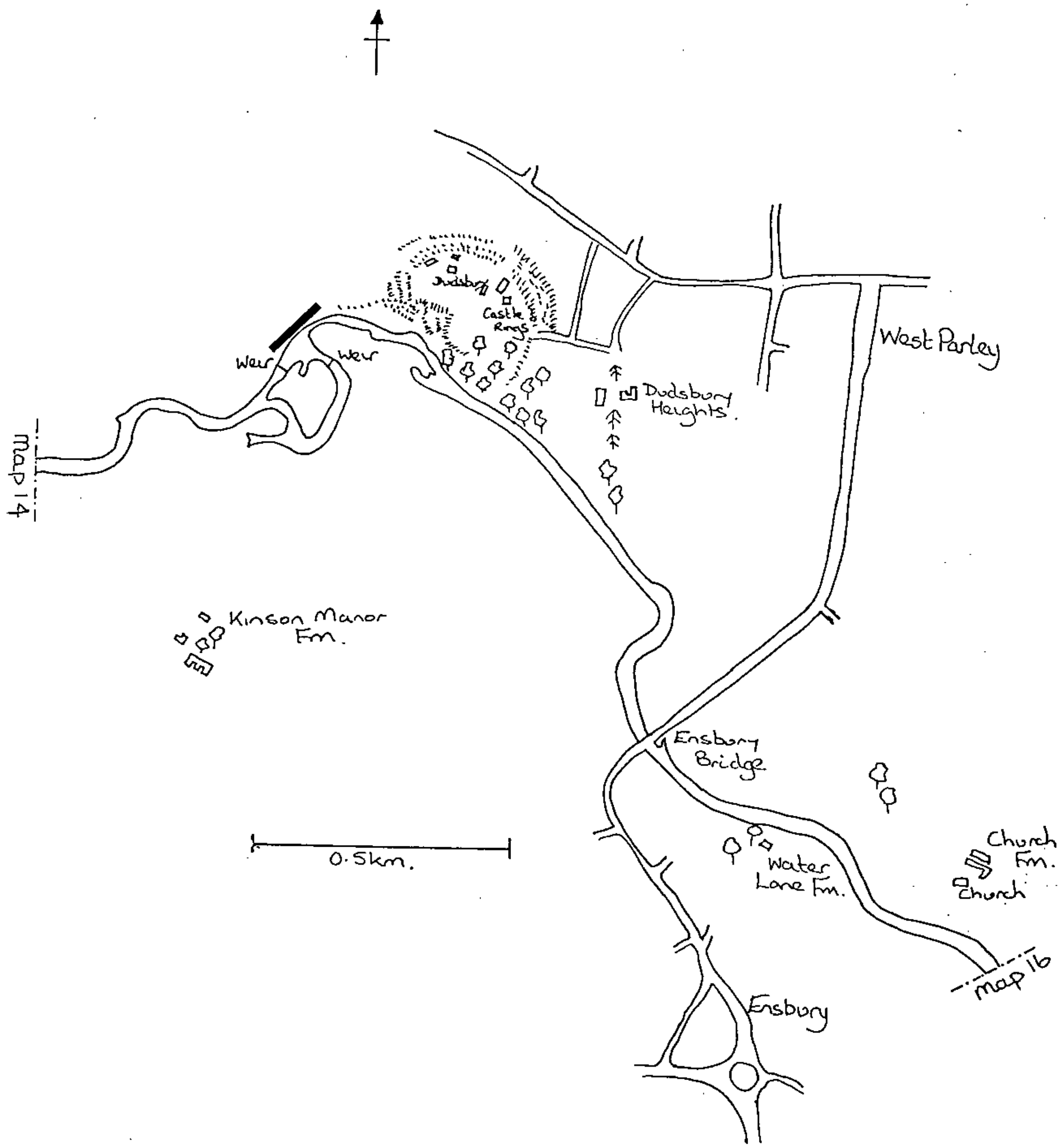


A31(T)
Map 12
Depot
Nurseries
Canford School
Canford
Magna.
0.5km.
Map 14
Knighton
Knighton Farm.

14

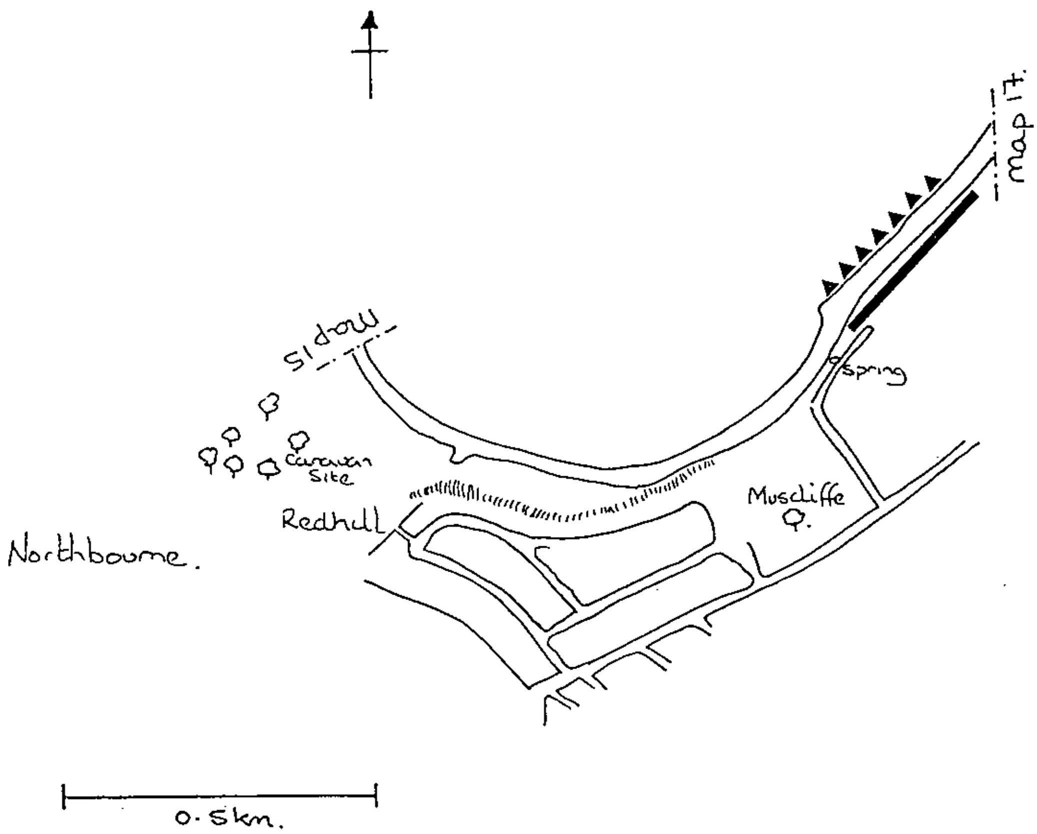

Knighton Hse.
Kings Arms Inn
Map 15
Pumping Station
ongham Bridge
A348
Poole
0.5km

15



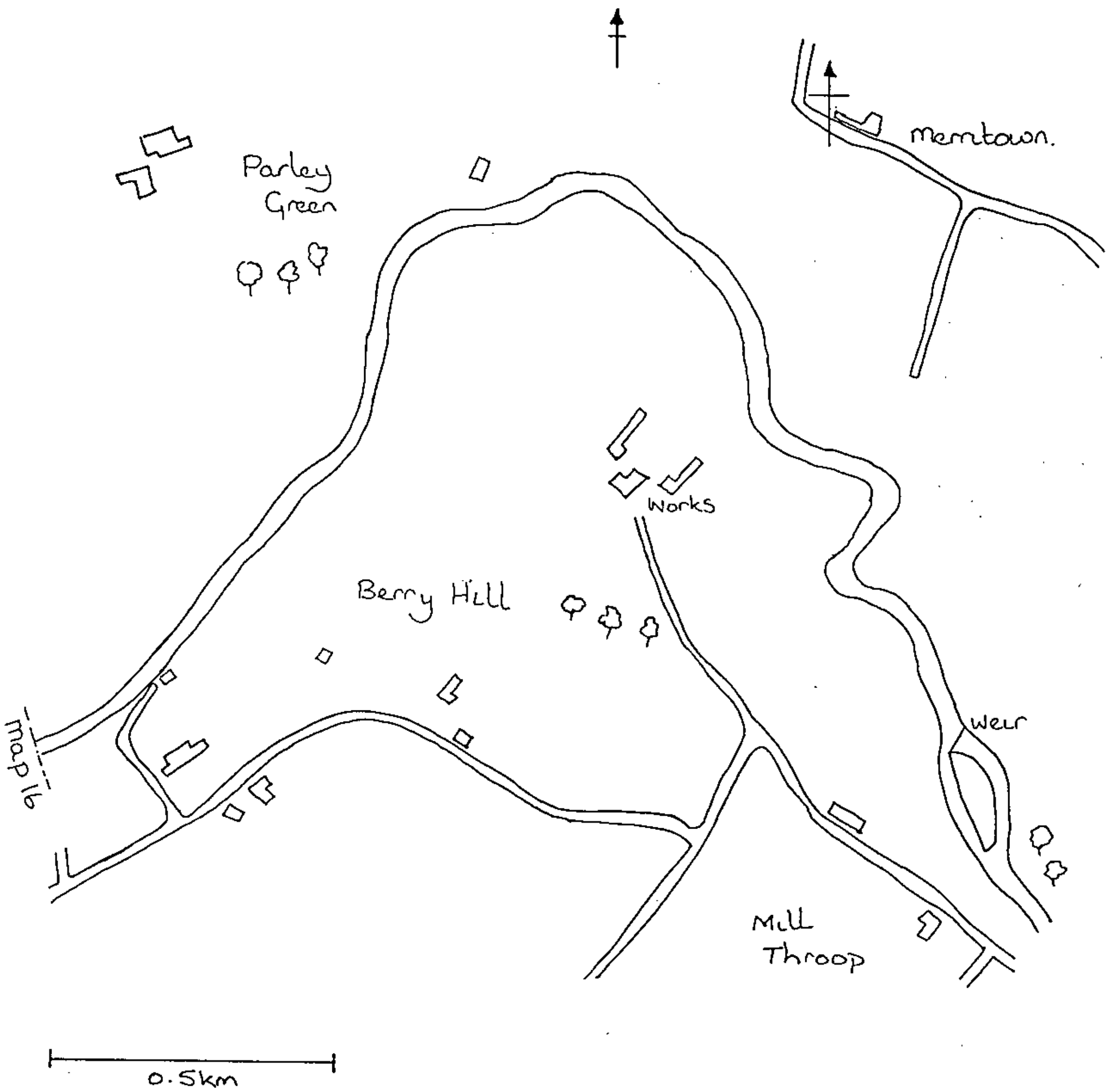
Dudsbury
Castle Rings
Weir
Weir
map 14
Dudsbury Heights
West Parley
Kinson Manor Fm.
Ensbury Bridge
0.5km.
Water Lane Fm.
Church Fm.
Church
map 16
Ensbury

16



Map 17.
Map 15
Spring
Caravan Site
Redhill
Muscliffe
Northbourne.
0.5km.

17


Merritown.
Parley Green
Works
Berry Hill
Weir
map 16
Mill Throop
0.5km