Cranfield UNIVERSITY

Survey of irrigation of outdoor crops in 2005 - England and Wales.

-E K Weatherhead

August 2007

Contents

Contents....2
Tables....3
Figures....3
Executive Summary....4
Executive Summary....4
Introduction....5
Objectives....5
The 2005 survey....6
Allowing for the weather in 2005....7
The responses: England....9
The responses: Wales....14
The responses: regional and catchment level....14
Analysis of trends....18
Comparison of volume data against NALD data....19
Limitations in the methodology. 23
Recommendations for future surveys....24
Conclusion and recommendations....24
Acknowledgements....25
References....25
Appendix I: 2005 Questionnaire as sent....27

Tables

Table 1. Irrigated areas (ha) by crop category, 1982-2005. 11
Table 2. Volumes of water applied ('000m^3 or Ml) by crop category, 1982-2005. ... 11
Table 3. Volumes of water applied ('000m^3 or ML) by source, 1982-2005. 12
Table 4. Scheduling method (% of irrigated area), 2001-2005 12
Table 5. Irrigation method (% of irrigated area), 2001-2005 13
Table 6. Number of holdings and area (ha) equipped/used* for trickle irrigation, 1982-2005. 13
Table 7. Water resources and storage reservoirs, 2005. 13
Table 8. Irrigation in Wales in 2005 15
Table 9. Areas irrigated (ha) and volumes applied ('000m^3 or Ml) at Environment Agency Region level, by crop category. 16
Table 10. Scheduling and irrigation methods (% by area), trickle irrigation users (number), water sources and water resource position in 2005 (% by volume), and reservoir storage (number and % by volume), at EA Region level. 17
Table 11. Underlying linear growth rates (% per annum) in irrigated areas, volumes applied and average depths, for main crop types and in total, for 1982-2005, after allowing for annual weather variation. 18

Figures

Figure 1. Weighted irrigation needs (mm depth) at Silsoe, Bedfordshire, 1962 to 2006, with survey years highlighted. 8
Figure 2. Ranked weighted irrigation needs (mm depth) at Silsoe, Bedfordshire, 1962 to 2006, with survey years highlighted. 8
Figure 3. Comparison of the NALD data on total actual abstractions ('000m^3 or Ml per year) for agricultural spray irrigation, 1974 to 2005, and the total volumes reported by the irrigation of outdoor crop surveys, 1982 to 2005. 20
Figure 4. Licensed and actual abstractions ('000m^3 per annum) for spray irrigation for England and Wales, 1974 to 2005. (Source: Defra). 21
Figure 5. Licensed abstractions from surface water for agricultural spray irrigation in England and Wales, 1994 to 2004, at Environment Agency regional level. (Source: Environment Agency NALD). 22
Figure 6 Licensed abstractions from ground water for agricultural spray irrigation in England and Wales, 1994 to 2004, at Environment Agency regional level. (Source: Environment Agency NALD). 22

Executive Summary

This report presents and discusses the results of the Survey of Irrigation of Outdoor Crops in 2005 for England and Wales. The data includes areas irrigated and volumes of water used, by crop category, as well as information on irrigation scheduling, application methods, water sources and water resources.

The survey was sent to all registered agricultural holdings that irrigated at least 1 hectare, as reported to the 2005 June Agricultural Survey. It is estimated that responses were received for England from 21% of all irrigated holdings, representing 27% of the total irrigated area. For Wales, which contains less than 1% of the total irrigated area, the corresponding figures are lower, at 12% of holdings and 17% of the total irrigated area. In addition, all others who responded to the 2001 survey were surveyed, but are not included in the above figures.

Results are presented for England, Wales, the eight Environment Agency regions and 28 CAMS catchments, as far as confidentiality restrictions allow. When analysing results, it is important to consider the weather in each year. In irrigation terms, 2005 was a wet year, depressing the areas irrigated and water used.

The irrigated areas and volumes of water applied fell for almost all crop categories compared to 2001, and particularly for main crop potatoes. Nevertheless, potatoes, remained the dominant irrigated crop, followed by vegetables. Water use reduced from all sources, with a slight increase in the proportion from groundwater. The proportion of the area where irrigation is scheduled scientifically rose to 60%. Hose-reel irrigation systems remain the predominant irrigation method, with more fitted with booms. The proportion irrigated by trickle (drip) remained constant at 5%.

Just under half of the available water resources were reported used. Only 10% of holdings would have used more water if available, and only an additional 14% would have been used. Over 40% of holdings reported having some storage capacity.

If linear trends are assumed over 1982-2005, the growth in total irrigated area and total water use are lower than reported previously for 1982-2001. An alternative explanation is that there was a reduction in irrigation growth rates some time around 2000. This explanation is supported by the trend in actual abstractions for agricultural spray irrigation recorded in the Environment Agency NALD database.

A further survey is recommended for 2010.

Introduction

Irrigated agriculture is an important sector of the agricultural industry, and a small but significant user of water. Knowledge of current irrigation practices and water use is essential for agricultural policy implementation and water resource management.

Some of the most detailed information available is that collected for Defra (and previously MAFF) through the "Surveys of Irrigation of Outdoor Crops" (hereafter termed "the irrigation survey"). These provide data on items including areas irrigated and volumes applied (by crop category), irrigation practices, water resources and equipment usage. These surveys have been carried out intermittently, most recently in 1982, 1984, 1987, 1990, 1992 and 1995 by MAFF (MAFF 1983, 1985, 1988, 1991, 1993, 1996 and 1997), and in 2001 by Cranfield University for Defra (Weatherhead and Danert, 2002).

Since that 2001 survey, there have been changes to the abstraction licensing system, the introduction of CAMS and the implementation of the Water Act 2003, as well as changes in agricultural support and farming generally. This new survey was therefore commissioned by Defra to provide a continuation of the previous data sets, with some simple improvements to the questions asked and the data released.

Objectives

The overall objective was to conduct the survey and report the results to Defra.

The specific objectives, in summary, were:

a) to devise a new questionnaire and agree it with Defra and the Agricultural Water Resources Liaison Group;
b) to conduct the survey;
c) to normalise the survey results; and
d) to present the results to Defra and, after agreement, to publish them.

These results would include:

- a summary 2005 dataset at national level for general publication;
- a catchment level database, subject to necessary confidentiality restrictions;
- an analysis of trends by comparison with previous surveys; and
- a comparison with data held by the Environment Agency in its National Abstraction Licensing Database (NALD).

The 2005 survey

The format for the 2005 questionnaire was based on the 2001 version, to maintain continuity of wording and datasets. The question on the area the holding "would irrigate in a dry year" was dropped because of previous problems due to the subjective definition of a dry year and the poor response. The questions on reservoir capacity and area equipped for trickle irrigation were revised, and the questions limited to 2 sides of A4, both to try to get a better response to the later questions. The final version was agreed with Defra and the national Agricultural Water Resources Liaison Group, which includes representatives of the Environment Agency, NFU, CLA and UKIA as well as Defra. A copy of the questionnaire, as distributed, is in Appendix I.

The survey returns are subject to confidentiality constraints set by Defra policy, the Agricultural Statistics Act 1979 (as amended) and the Data Protection Act 1998. It was agreed to follow the confidentiality precedents of the previous irrigation surveys. No data from which individual returns can be identified, or tables containing figures relating to less than 5 agricultural holdings, would be released outside the survey team. This was made explicit to respondents and potential data users.

The irrigation survey forms are sent to agricultural holdings recorded as irrigators in the preceding June Agricultural Survey, previously called the June Agricultural and Horticultural Cropping Census (Defra 2007). For the previous irrigation survey years, that was a census of all agricultural holdings. However, except in every 10^{th} year, data is now sought from only a proportion of holdings. Sampling is stratified by farm "size" as indicated by SLR (Standard Labour Requirement), with the larger holdings more likely to be sampled. For 2005, the results related to only 27% of all holdings. This significantly limited the number of irrigators' addresses available for the 2005 irrigation survey, to 1783 in England and only 67 in Wales.

A number of these holdings had reported extremely small irrigated areas. To reduce farmer time spent completing forms unnecessarily, the survey was restricted to those irrigating at least 1 hectare. This removed 12 % of the holdings whilst reducing the total irrigated area and water use by less than 0.1%.

The remaining holdings were sent the questionnaire in May 2006.

For England, the response rate to the irrigation survey was 43%. Unexpectedly, the responses indicated that a number either hadn't irrigated in 2005 or had irrigated less

than 1 ha, despite their returns to the June Agricultural Survey. Excluding those left 35% of the original holdings in the dataset for analysis. Overall, combining the stratified sampling and response rates to the June Agricultural Survey and the response rate to this survey, it is estimated that for England usable responses to this survey were received from 21% of all holdings that irrigated more than 1 ha, representing 27% of the total irrigated area.

For Wales, the responses were far fewer, (possibly reflecting very low irrigation needs for the early potato crop). Overall, it is estimated that usable responses to the irrigation survey were received from only 12% of all holdings that irrigated more than 1 ha, representing 17% of the total irrigated area.

A further 893 farms who had reported irrigating more than 1 ha in the 2001 Irrigation Survey, but who were not already included in the above lists for 2005, were sent the form, producing a further 247 non-zero responses. Their returns have not been directly included in the national results for statistical correction reasons, but are available to expand the database for Regional and CAMS level data.

Allowing for the weather in 2005

When comparing survey returns from different years, all the results must be interpreted in relation to the weather in each year. The summer rainfall and evapo-transpiration directly influence the areas irrigated and volumes of water applied, and even how many and which holdings are included in the survey. (One consequence is that the numbers of irrigators appears reduced in wet years, and reservoirs on farms that did not irrigate that year can “disappear” temporarily).

The irrigation needs for the major irrigated crop categories have been modelled using the WASIM model (Hess and Counsell, 2000). The results for Silsoe, Bedfordshire, weighted between the crops in proportion to the volumes of water applied nationally in 2005, are shown in Figure 1. The same data is shown ranked in Figure 2. The survey years are highlighted. In irrigation need terms, 1990 and 1995 were dry years, 1982 and 1984 were average years, and 1987, 1992, 2001 were wet years. 2005 falls at the lower (wetter) quartile value, very slightly drier than 2001. However, some caution must be taken in making comparisons, particularly for crops with short irrigation periods such as early potatoes, which can experience short or localised dry

spells even in wet years. Superficially similar years may differ for particular crops. Furthermore there are significant regional variations in weather in any year.

Figure 1. Weighted irrigation needs (mm depth) at Silsoe, Bedfordshire, 1962 to 2006, with survey years highlighted.

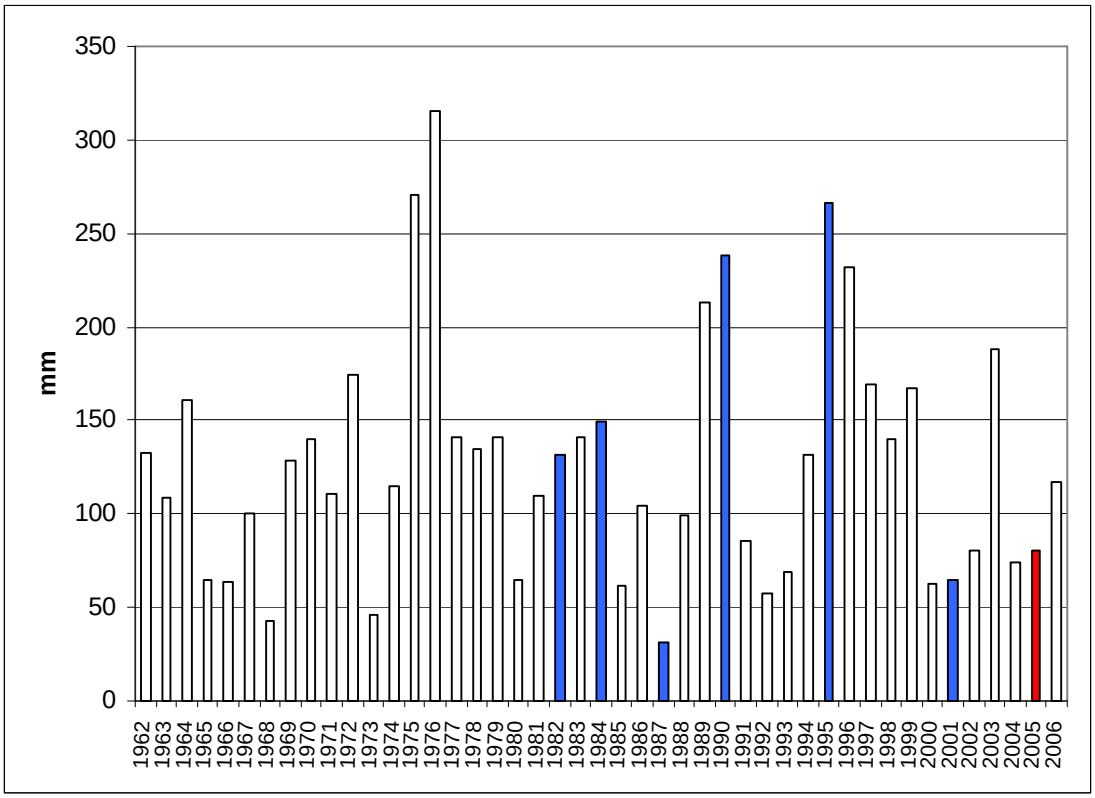
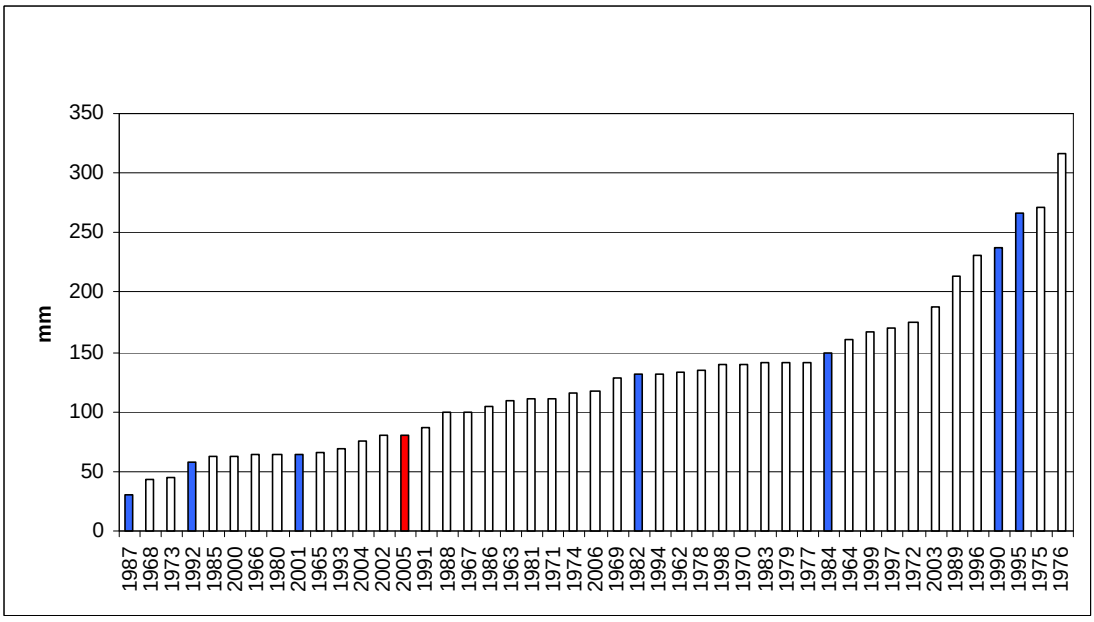


Figure 2. Ranked weighted irrigation needs (mm depth) at Silsoe, Bedfordshire, 1962 to 2006, with survey years highlighted.



The responses: England

The survey results for England, after adjusting for sampling rates and non-responses, are shown in the following tables. The published results for the 1982 to 2001 surveys are shown alongside for comparison.

The irrigated areas (Table 1) and volumes of water applied (Table 2) have fallen for almost all crop categories compared to 2001. Notably, the area and volume for irrigated main crop potatoes have fallen by over a third. This partly reflects the recent decline in the total area of potatoes grown in England; this has fallen by almost 19% between 2001 and 2005. Nevertheless, combining main crop and early varieties, potatoes continue to be the dominant irrigated crop, accounting for 43% of the irrigated area and 56% of the water use. Irrigated vegetables have increased slowly in relative share to 28% of the area and 27% of the water use. The remaining crops each have only minor shares. Cereals show an increase in irrigated area, but much less change in water use.

Water abstraction reduced from all sources compared to 2001 (Table 3). There was a slight increase in the proportion coming from groundwater (36% to 41%) and a corresponding reduction from surface water (58% to 54%). Re-used water increased significantly from a very small base, and now accounts for 1% of all water. Water from the mains supply and rainwater harvesting both fell sharply, by over 80% and 70% respectively.

There has been a continuing growth in the proportion of the irrigated area where the irrigation is scheduled following some form of scientific scheduling method (to 60%), particularly using in-field soil moisture measurement (Table 4).

Hose-reel irrigation systems remain by far the predominant irrigation method by area (86%), but the proportion of the area irrigated by hose-reels fitted with booms rather than guns has increased slightly (Table 5). The proportion of the area irrigated by trickle (drip) systems has remained constant at 5% (Table 5), so the total trickle-irrigated area has declined (Table 6). This conflicts with the previous growth reported in other studies (e.g. Knox and Weatherhead 2005). The absolute number of holdings recorded as using trickle irrigation has declined markedly, but this would have been affected by the restriction to holdings irrigating at least 1 hectare; many trickle users irrigate very small areas.

The water resource situation seems to have been fairly relaxed in 2005, as might be expected given the weather. Just under half of the available water resources were reported used (47%). Only 10% of holdings would have used more water if available, and only an additional 14% overall would have been used. Over 40% of the holdings reported having some reservoir storage capacity, which provided 30% of the total water used, accounting for 50% of the reported storage capacity. (This implies the total storage capacity equalled 60% of the water used, but this gives a misleading indication of the potential for reservoir storage to meet total needs, since the storage is not necessarily on the holdings where it is required in a given year, Furthermore, no irrigator would plan to totally empty the reservoirs given the uncertainty in end-of-season weather).

Table 1. Irrigated areas (ha) by crop category, 1982-2005.

Crop category	1982	1984	1987	1990	1992	1995	2001	2005
Early potatoes	8050	7720	5360	8510	8180	8730	7300	6415
Main crop potatoes	22810	34610	29520	43490	45290	53390	69820	43140
Sugar beet	15770	25500	10100	27710	10520	26820	9760	8487
Orchard fruit	3100	3250	1330	3320	2280	2910	1580	1468
Small fruit	3610	3560	2230	3470	2750	3250	3770	2631
Vegetables	14810	17460	11040	25250	20200	27300	39180	32202
Grass	16440	18940	6970	15970	7240	10690	3970	3671
Cereals	14800	24700	7510	28100	7160	13440	4620	10979
Other	4100	4890	2440	8650	4320	9120	7280	7280
Total	103490	140630	76500	164470	107940	155650	147270	116272

Summing errors due to rounding.
Data up to 1992 for England and Wales, data from 1995 for England only.

Table 2. Volumes of water applied ('000m^3 or Ml) by crop category, 1982-2005.

Crop category	1982	1984	1987	1990	1992	1995	2001	2005
Early potatoes	4680	4920	2350	6770	5590	9345	5710	6433
Main crop potatoes	15280	32730	14700	51170	38520	74460	69940	45637
Sugar beet	8260	17370	3430	20320	4860	21295	4630	3776
Orchard fruit	2180	2430	550	2930	1220	2445	900	731
Small fruit	1890	2660	970	3180	2000	4320	3370	2434
Vegetables	6830	11390	4640	18450	12180	25500	34120	24740
Grass	10030	13550	3550	13100	4280	9920	2320	1982
Cereals	5040	8300	2160	11830	2260	5625	1470	2394
Other	1020	4030	1270	6040	4160	11160	8840	4757
Total	55210	97380	33620	133790	75070	164070	131300	92883

Summing errors due to rounding.
Data up to 1992 for England and Wales, data from 1995 for England only.

Table 3. Volumes of water applied ('000m^3 or ML) by source, 1982-2005.

Source	1982	1984	1987	1990	1992	1995	2001	2005
Surface water	34390	57210	19250	74070	41820	91420	75760	50343
Ground water	16680	32420	11800	50540	28470	61390	47810	38184
Public mains	2040	3840	1100	3860	2620	4440	4300	813
Rain collected			included in other				2050	617
Re-used water			included in other				670	986
Other	1830	3540	1470	5330	2160	5890	710	1939
Total	54940	97730	33630	133790	75070	164140	131300	92883

Surface water includes ponds, lakes, gravel or clay workings, rivers, streams or other water courses.
Ground water includes wells, bore holes and springs rising on the holding.
Data up to 1992 for England and Wales, data from 1995 for England only.
1982 and 1985 totals differ slightly from table 2 due to data revisions.

Table 4. Scheduling method (% of irrigated area), 2001-2005

Scheduling method	2001	2005
Water balance calculations (by hand or by computer)	23	25
In-field soil moisture measurement (e.g. neutron probes, tensiometers)	29	35
Operator judgement not based on measurement (including feeling soil, crop inspection)	Included in other	34
Other	48	6
Total	100	100

Question not asked before 2001.
Data for England only.

Table 5. Irrigation method (% of irrigated area), 2001-2005

Irrigation method	2001	2005
Static or hand-moved sprinklers, spray lines	4	5
Hose reels with rain guns	72	67
Hose reels with booms	16	19
Centre pivots or linear moves	3	4
Trickle or drip	5	5
Other	<<1	<<1
Total	100	100

Question not asked in this format before 2001.
Data for England only.

Table 6. Number of holdings and area (ha) equipped/used* for trickle irrigation, 1982-2005.

	1982	1984	1987	1990	1992	1995	2001	2005
Number	890	640	490	600	720	820	910	425*
Area (ha)	2040	1550	1330	1420	1970	4120	7040	5444

Up to 1995 data refers to holdings and area equipped for trickle; for 2001 and 2005 data is for trickle systems used.
*Reduction in number in 2005 partly related to survey restriction to farms irrigating 1 ha or more.
Data for England only.

Table 7. Water resources and storage reservoirs, 2005.

	2005
Water resources:	
Proportion of available water resources used	47%
Proportion of holdings that would have used more if available	10%
Additional water that would have been used if available	14%
Reservoir storage:	
Proportion of holdings with reservoir storage capacity	42%
Proportion of total water used coming via storage reservoir	30%
Proportion of reservoir capacity used	50%

Question not asked in this format before 2005.
Data for England only.

The responses: Wales

With far fewer irrigators and the lower response rates, only limited data can be released for Wales nationally (Table 8). The results have been included in the regional data (for EA Wales) and in CAMS data.

The results show that less than 1% of all irrigation occurred in Wales, as found in previous year. The majority of the respondents were from Pembrokeshire, reflecting the concentration of early potato growers there. Nationally for Wales, over 75% of the water was reported to be used on potatoes. Most water came from surface abstraction and was applied by hose reel systems. Some 70% of holdings had reservoir storage, which provided two-thirds of the water used in 2005. Most scheduling was by judgement, rather than scientific methods.

The responses: regional and catchment level

The holdings were aggregated to Environment Agency Region and CAMS areas using the Defra grid reference of the holding (Defra 2007) where available. Other holdings (those identified only from the 2001 survey) were aggregated on the basis of the holdings' postcode, using a Geographical Information System (GIS). It should be noted that neither method necessarily corresponds to the location of the irrigated fields or the water abstraction points, which may be significant when allocating holdings to regions and particularly CAMS.

The statistical corrections for the June Agricultural Survey stratified sampling and response rates were the same as those already used at national level, since correction factors were unavailable at EA Regional or CAMS levels. The results were then corrected for differences in (non-stratified) response rates to the irrigation survey at regional and CAMS level and normalised for consistency with national totals.

The regional results are shown in Table 9 and Table 10. Definitions are consistent with the national level data and in the questionnaire (Appendix I). Some data again has had to be withheld ("w"), mostly relating to relatively small areas and volumes.

Responses were received from 72 of the CAMS defined catchments, but only 28 contributed sufficient responses to publish data; even this is incomplete for most CAMS and of much lower statistical accuracy than regional and national data. This data is available from the author subject to appropriate restrictions.

Table 8. Irrigation in Wales in 2005

Wales			
Areas irrigated (ha):		Irrigation method (% of area):	
early potatoes	624	sprinklers	w
maincrop potatoes	242	reel-gun	42
sugar beet	w	reel-boom	w
orchards	w	pivot/linear	w
small fruit	w	trickle	w
vegetables	w	other	w
grass	w	trickle users (number)	w
cereals	w		
other	w	Water Source (% by volume):	
total	1023	surface water	38
		groundwater	w
Volumes ('000m^3 or Ml):		mains water	w
early potatoes	286	harvested	w
maincrop potatoes	134	re-use	w
sugar beet	w	other	w
orchards	w		
small fruit	w	Water resources:	
vegetables	w	% of water resources used	22
grass	w	% of holdings short of water	w
cereals	w	% more that would have been used	w
other	w		
total	557	Reservoirs:	
		% of holdings with reservoirs	70
Scheduling method (% of area):		% of water from reservoirs	67
water balance	w	% of reservoir storage used	7
soil measurement	w		
judgment	82%		
other	w		

Note: "w" signifies data withheld due to confidentiality constraints
See England data and questionnaire (Appendix I) for definitions.

Table 9. Areas irrigated (ha) and volumes applied ('000m^3 or Ml) at Environment Agency Region level, by crop category.

REGION:	Northeast	Anglian	Midlands	Thames	Southern	Southwest	EA Wales (E&W)	Northwest
Areas irrigated (ha):								
early potatoes	314	3630	1126	w	w	w	816	w
maincrop potatoes	6026	25455	7342	304	1549	399	1470	837
sugar beet	w	4516	3588	w	w	w	w	w
orchards	w	195	w	w	892	w	w	w
small fruit	w	1082	474	w	618	346	w	w
vegetables	468	18803	5043	w	6760	126	w	w
grass	w	1048	1285	w	w	w	w	w
cereals	w	8686	1741	w	w	w	w	w
other	154	3786	1878	425	811	w	w	w
total	8293	67001	22950	2161	10773	1916	2628	1573
Volumes ('000m^3 or Ml):								
early potatoes	118	3881	1329	w	w	w	449	w
maincrop potatoes	4473	29373	8307	101	1748	103	1308	358
sugar beet	w	1735	1831	w	w	w	w	w
orchards	w	92	w	w	436	w	w	w
small fruit	w	792	438	w	649	496	w	w
vegetables	343	16431	5433	w	2056	w	w	w
grass	w	366	448	w	w	w	w	w
cereals	w	1923	368	w	w	w	w	w
other	64	1498	1365	457	1189	w	w	w
total	5736	55769	19774	1659	6341	1495	1951	715

Note: “w” signifies data withheld due to confidentiality constraints
See national data and questionnaire (Appendix I) for definitions.
EA Wales Region includes some holdings in England.
Totals may not agree with national totals due to rounding and statistical corrections

Table 10. Scheduling and irrigation methods (% by area), trickle irrigation users (number), water sources and water resource position in 2005 (% by volume), and reservoir storage (number and % by volume), at EA Region level.

REGION:	Northeast	Anglian	Midlands	Thames	Southern	Southwest	EA Wales (E&W)	Northwest
Scheduling method (% of area):								
water balance	28%	25%	37%	41%	5%	w	w	w
soil measurement	30%	39%	15%	w	52%	w	w	w
judgment	39%	28%	43%	59%	37%	74%	70%	71%
other	w	7%	5%	w	w	w	w	w
Irrigation method (% of area):								
sprinklers	w	3%	5%	18%	19%	6%	7%	w
reel-gun	96%	68%	64%	22%	41%	74%	76%	91%
reel-boom	w	21%	19%	w	20%	w	w	w
pivot/linear	w	6%	w	w	w	w	w	w
trickle	w	2%	6%	8%	20%	15%	2%	w
other	w	0%	w	w	w	w	w	w
trickle users (number)	w	149	77	28	103	46	62	w
Water source (% by volume):								
surface water	48%	50%	58%	60%	72%	65%	79%	57%
groundwater	52%	45%	41%	23%	19%	24%	11%	w
mains	w	0%	w	12%	7%	w	w	w
harvested	w	1%	w	w	w	w	w	w
re-use	w	w	w	w	w	w	w	w
other	w	3%	w	w	w	w	w	w
Water resources:								
% of water resources used	38%	52%	41%	61%	37%	42%	35%	27%
% of holdings short of water	w	10%	7%	w	16%	w	w	w
% more that would have been used	25%	12%	17%	w	19%	w	w	w
Reservoirs:								
% of holdings with reservoirs	14%	43%	43%	44%	55%	33%	63%	55%
% of water from reservoirs	9%	32%	22%	48%	46%	13%	30%	23%
% of reservoir storage used	51%	53%	49%	63%	40%	w	7%	w

Note: “w” signifies data withheld due to confidentiality constraints
See national data and questionnaire (Appendix I) for definitions.
EA Wales Region includes some holdings in England.
Totals may not agree with national totals due to rounding and statistical corrections

Analysis of trends

It is important to separate the impacts of annual weather variation from underlying changes.

Previous studies (e.g. Weatherhead and Knox 1999, Downing et al 2003) analysed underlying growth rates in irrigated areas and depths as linear functions over time after allowing for the annual weather variation, using multiple regression techniques. The results of applying the same methodology to the full 1982 to 2005 dataset, using the weighted irrigation need at Silsoe (Figure 1) to represent the annual weather variation, are shown in Table 11.

Table 11. Underlying linear growth rates (% per annum) in irrigated areas, volumes applied and average depths, for main crop types and in total, for 1982-2005, after allowing for annual weather variation.

	Linear growth trends, 1982-2005		
	area	volume	depth
Early potatoes	0.3%	2.1%	2.1%
Maincrop potatoes	3.0%	3.5%	1.6%
Sugar beet	-1.6%	-1.2%	-0.2%
Orchard fruit	-2.5%	-2.7%	-0.5%
Small fruit	0.3%	2.6%	2.4%
Vegetables	3.0%	3.9%	2.0%
Grass	-7.1%	-4.8%	0.3%
Cereals	-2.4%	-2.9%	-0.8%
Other crops		not analysed	
Totals (overall)	0.9%	2.1%	1.7%

These results for 1982 to 2005, assuming linear growth, suggest that the total irrigated area and total water use was growing less strongly than previously reported for just the 1982 to 2001 period. For individual crop types, irrigation of early potatoes was growing less strongly, while irrigation of sugar beet, orchard fruit and grass was declining more rapidly. In contrast, water use on small fruit was increasing more rapidly. The growth in the total volume applied (2.1% pa) is more than double the growth in the area irrigated (0.9% pa), confirming the increasing depths being applied,

which grew at 1.7% pa. The statistical significance of these linear trends for 1982 to 2005 however is generally lower than when calculated for 1982 to 2001.

It should be noted that this methodology assumes there has been no significant climate change over the period analysed.

An alternative explanation, and perhaps a better one, is that the underlying growth rates have changed. There are insufficient data points to fit non-linear trends to the raw survey results with any degree of confidence. However, using the weather corrections from the above linear analysis, a set of adjusted "dry year" results was calculated, i.e. the areas that would have been irrigated or volumes applied if that year had been a dry year. In each case, the 2005 dry year estimates fall well below the linear trend line. The result is particularly marked for main crop potatoes. These results are consistent with a downturn in irrigation growth rates since some time around 2000.

Comparison of volume data against NALD data

The trends discussed above for the total volume of water used can be compared with trends in the total volumes of licensed and actual abstractions for agricultural spray irrigation reported to the Environment Agency and held in the National Abstraction Licensing Database (NALD). The two datasets are not identical; for example the irrigation survey data is limited to the irrigation of outdoor crops on registered agricultural holdings, while the NALD data is only for licensed agricultural spray irrigation abstraction, which omits trickle irrigation, abstractions of less than 20 m^3/d (from 2005), mains water, harvested rainwater and re-used water. Nevertheless, there is substantial overlap, and the NALD data has the advantage of being collected annually.

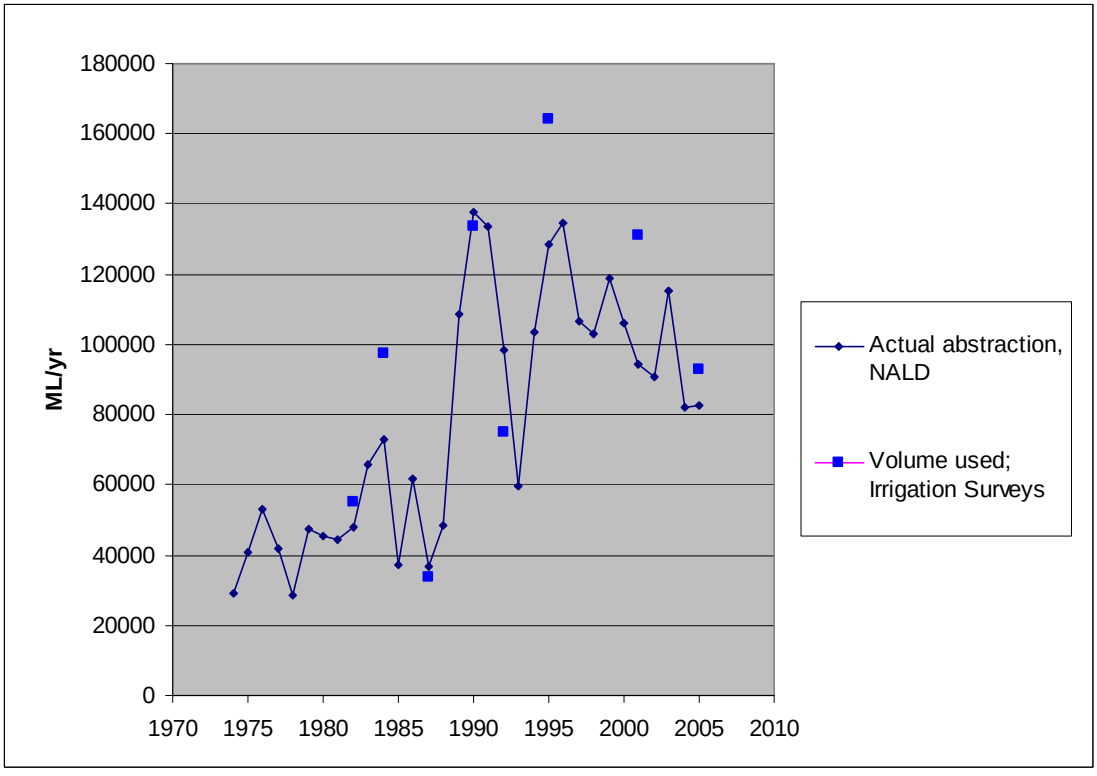
Furthermore, the NALD data only refers to water volumes applied, and does not include data on irrigated areas, which crops are irrigated, application methods, scheduling methods or water resources. It could however provide a more continuous dataset on irrigation water use, with the periodic irrigation surveys providing the additional detail.

Actual abstractions

Figure 3 compares the total volumes recorded in the irrigation surveys with the total volumes of actual abstractions for agricultural spray irrigation in England and Wales from 1974 to 2005. There appears to be a reasonable correlation between the datasets.

The total actual abstractions vary substantially between years, as might be expected due to variation in summer weather. Actual abstractions have been generally falling over the last ten years, which have been mainly low demand weather years (see Figure 2). However, even after adjusting for these weather variations, using the same methodology as before, there appears to be at least a slowing in the annual growth rate, and possibly a levelling since the late 1990s.

Figure 3. Comparison of the NALD data on total actual abstractions ('000m^3 or Ml per year) for agricultural spray irrigation, 1974 to 2005, and the total volumes reported by the irrigation of outdoor crop surveys, 1982 to 2005.



Licensed abstraction

Figure 4 compares the total volumes of water licensed for abstraction with the actual abstraction, again for agricultural spray irrigation in England and Wales from 1974 to 2005. The trend in the licensed volumes shows a very clear break point around 1998. Prior to that year, licensed volumes were increasing annually at about 9400 m^3/year, equivalent to about 2.7% pa of its 1998 value. Subsequently, the total volume licensed has remained roughly constant. However, this disguises some continued change at regional level. Data at EA Region level (Figure 5 and Figure 6) show that the total volumes licensed from surface waters have continued to grow slowly in Anglian Region, but declined slightly in Midlands Region. The decline has come from groundwater licences; these have declined markedly in Anglian Region and in North East Region, while the previous growth in Midlands Region has been halted.

This NALD data thus supports the indications from the irrigation surveys that the growth in irrigation has declined.

Figure 4. Licensed and actual abstractions ('000m^3 per annum) for spray irrigation for England and Wales, 1974 to 2005. (Source: Defra).

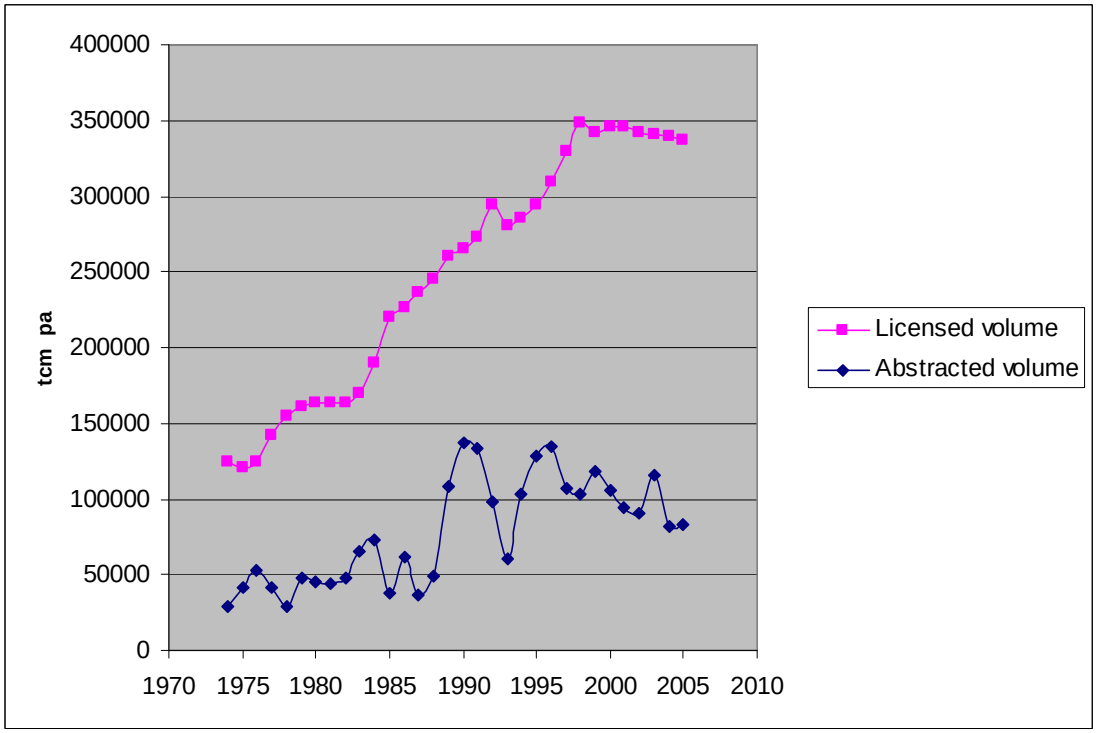


Figure 5. Licensed abstractions from surface water for agricultural spray irrigation in England and Wales, 1994 to 2004, at Environment Agency regional level. (Source: Environment Agency NALD).

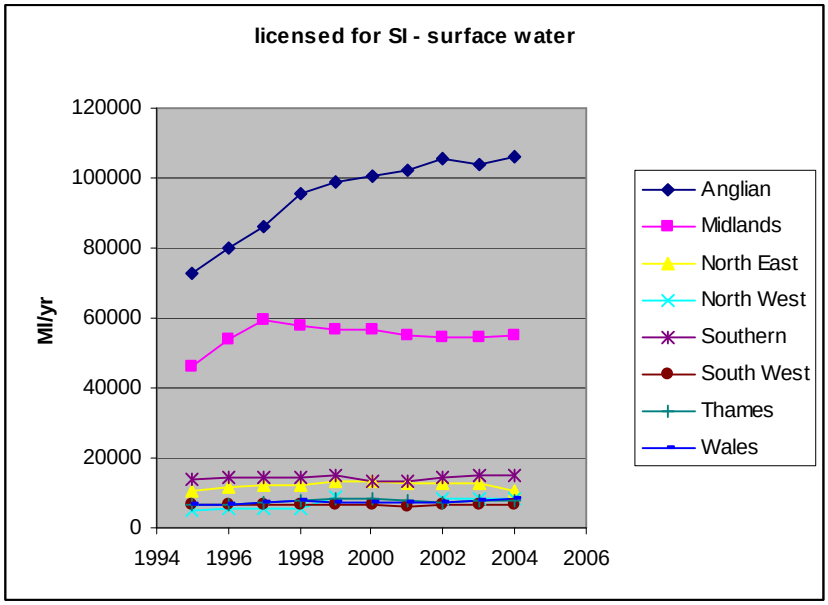
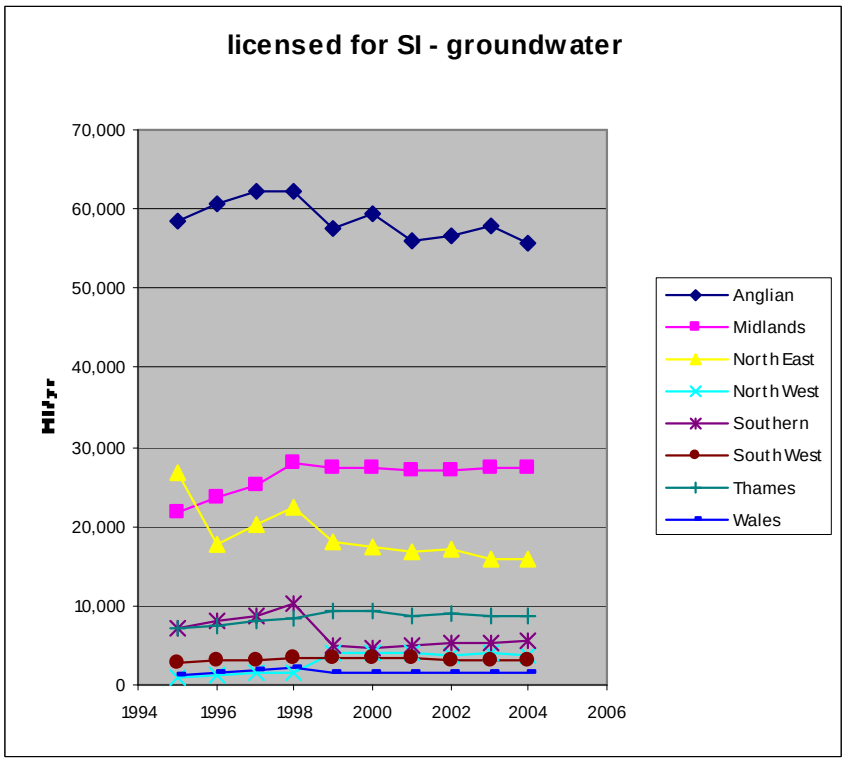


Figure 6 Licensed abstractions from ground water for agricultural spray irrigation in England and Wales, 1994 to 2004, at Environment Agency regional level. (Source: Environment Agency NALD).



Limitations in the methodology.

As in all surveys, there are limitations to the accuracy of the data reported.

Statistical uncertainty arises from the sampling and corrections for response rates. The survey results were corrected for the sampling and response rates to the stratified June Agricultural Survey, and the response rates to the Irrigation Survey, calculated at national level for each strata. The June Agricultural Survey was stratified by SLR, with the larger farms more likely to be included. This does mean that responses from smaller farms have a disproportionate influence on numbers of irrigators, though not on areas or volumes. The results for scheduling method and irrigation method have therefore been calculated and presented as percentages of the total area irrigated, and the results on water sources as percentages of the total volumes applied.

This stratification also makes it difficult to include the results from the other farms identified from the 2001 responses, since equivalent size data for 2005 is not available. Furthermore, simply adding them in would create double counting, since the missing holdings have already been allowed for statistically.

Response rates to the irrigation survey itself are considered reasonable for England, given that completing the survey form is voluntary. This was not obvious to respondents until the 2001 survey. In 1995, the response rate was reported to be 77%. In 2001, the response fell to 41%. In 2005, the response rate was 43%. In contrast, response rates for Wales were poor.

A significant proportion (20%) of those who indicated they irrigated more than 1 ha in the June Agricultural Survey subsequently contradicted this in the irrigation survey, and were removed from the analysis. The discrepancies were largest for the smaller farms, so the impact is greater on absolute numbers than on areas and volumes. It is not known how many holdings irrigating more than 1 ha are missing because of incorrect responses to the June Agricultural Surveys.

Obvious errors in responses were removed by internal data cross-checking. Many related to incorrect conversion of units by the respondents, particularly for reservoir capacity. However, smaller errors would have remained undetected.

Some respondents did not respond to all of the later questions on reservoirs; the results on reservoir capacity and usage are therefore less reliable.

Recommendations for future surveys

The 2005 survey was based on a June Agricultural Survey that was itself only a stratified sample. Whilst statistical corrections can be made, it would clearly be beneficial to work from a full survey, with a corresponding larger dataset. The next full June Agricultural Survey (Census) is scheduled for 2010, and should form the basis of an irrigation survey for that year.

Surveying additional respondents from previous years provides additional data, but these are very hard to combine with a stratified dataset without distorting the correction factors. Emphasis should be placed on the current irrigators.

An additional annual dataset on the number of irrigators and the total areas irrigated could be obtained directly from the June Agricultural Surveys. The discrepancies between areas reported in that survey and in the irrigation survey create some doubts as to its absolute accuracy and need investigating, but the trends are likely to informative.

There are difficulties matching Defra data (based on agricultural holdings) with Environment Agency data (based on licences) at holding level. However, the use of GIS methods to aggregate and analyse both at catchment and regional level does produce useful comparisons.

A further survey for 2010, following the next full June Agricultural Survey (census) in 2010, is recommended.

Conclusion and recommendations

Results for the irrigation survey have been presented for England, Wales, the eight Environment Agency regions and 28 CAMS catchments, as far as confidentiality restrictions allow. The data includes areas irrigated and volumes of water used, by crop category, as well as information on irrigation scheduling, application methods, water sources and water resources.

The results of the irrigation survey, supported by NALD abstraction data, suggest there was a reduction in irrigation growth rates some time around 2000.

A further survey for 2010, following the next full June Agricultural Survey (census) in 2010, is recommended.

Acknowledgements

Firstly it is necessary to thank all the respondents, who gave freely of their time at a very busy period in the agricultural calendar, many writing helpful comments as well as supplying the data requested.

The assistance and advice of numerous government staff including members of Defra Farming Statistics, the Welsh Assembly Government, and the Environment Agency, is gratefully acknowledged.

Finally thanks are due to Dr Monica Rivas-Casado for managing the date entry and preliminary error checking.

References

Defra (2007) The June Agricultural Survey www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/ (accessed 7/6/07)

Downing, T, Butterfield, B, Edmonds, D, Knox, J W, Moss, S Piper, B and Weatherhead, E K. (2003). CCDeW: Climate change and demand for water revisited. Final Research Report to DEFRA. Stockholm Environment Institute Oxford Office, Oxford.

Hess, T.M, and Counsell, C. (2000). A water balance simulation model for teaching and learning - WaSim. Paper presented at the ICID British Section Irrigation and drainage research day, 29 March 2000. HR Wallingford, Wallingford, UK.

Knox, J.W., and Weatherhead, E.K. (2005) The growth of trickle irrigation in England and Wales: data, regulation and water resource impacts. Irrigation and Drainage 54(2) 135-143.

MAFF (1983). Irrigation of outdoor crops - England and Wales. Special Enquiry - 1982 Season. Statistics Notice 217/83. Ministry of Agriculture, Fisheries and Food, Guildford.

MAFF (1985). Irrigation of outdoor crops - England and Wales. Special Enquiry - 1984 Season. Statistics Notice 148/86. Ministry of Agriculture, Fisheries and Food, Guildford.

MAFF (1988). Irrigation of outdoor crops - England and Wales. Special Enquiry - 1987 Season. Statistics Notice 132/88. Ministry of Agriculture, Fisheries and Food, Guildford.

MAFF, (1991). Survey of irrigation of outdoor crops in 1990 – England and Wales. Statistics Notice 157/91. Ministry of Agriculture, Fisheries and Food, Guildford.

MAFF (1993). Survey of irrigation of outdoor crops in 1992 – England and Wales. Statistics Notice 106/93. Ministry of Agriculture, Fisheries and Food, Guildford

MAFF (1996). Survey of irrigation of outdoor crops in 1995 – England. Statistics Notice 222/96. Ministry of Agriculture, Fisheries and Food, Guildford. (Note revisions in MAFF 1997)

MAFF (1997). Survey of irrigation of outdoor crops in 1995 PSM Statement. Ministry of Agriculture, Fisheries and Food, York.

Weatherhead EK and Danert K. (2002). Survey of irrigation of outdoor crops in 2001 – England; Statistical Notice. Cranfield University, Silsoe.

Appendix I: 2005 Questionnaire as sent

DEFRA
Department for Environment, Food & Rural Affairs

Cranfield UNIVERSITY
Silsoe

SURVEY OF IRRIGATION OF OUTDOOR CROPS IN 2005

April 2006

Dear Sir/Madam

I know your time is valuable, but I would be very grateful for your help.

Adequate water resources are vital for growers who irrigate, but are increasingly scarce. To meet future needs, planners require accurate information on water use and trends. The previous irrigation survey was for 2001. I have therefore been asked by the Agricultural Water Resources Liaison Group, comprising the NFU, CLA, UKIA, Environment Agency, Defra and ADAS, to repeat this survey for irrigation last year, 2005, funded by Defra.

Your address was either supplied confidentially by Defra because the June 2005 crop census database indicates that you irrigated outdoor crops or you were included in the previous survey.

Completing the survey should take less than 10 minutes; please estimate where necessary. The survey is voluntary, but **every return is important statistically** (even if you didn't irrigate in 2005). Your individual data will remain **strictly confidential** within my university survey team. Only aggregated data, from which your own responses cannot be identified, will be released to Defra and the Liaison Group or published.

Details of how to obtain a copy of the published results are given on the last page.

I enclose a **Freepost** envelope for returning the form – **no stamp needed**.

Thank you again for your help,

Keith Weatherhead, Project leader, Cranfield University at Silsoe.

WIN £50 for yourself or your favourite charity. To encourage a quick response and reduce follow-up costs, I am pleased to offer two prizes of £50 to be drawn from all responses returned by the end of May and the end of June.

IMPORTANT POINTS:

PERIOD & CROPS	For irrigation of **outdoor crops** only, in **2005** only.
HOLDING	Replies should preferably relate to the **holding named above** only. (If records are only available for combined holdings, please note in Section D)
RENTED LAND	Include irrigation on any part of this holding rented out, and any irrigated crops grown on contract on this holding.
UNITS	If possible, please give: • areas in hectares. (one acre ~ 0.4 ha) • depths in millimetres. (one inch ~ 25 mm) • volumes in cubic metres (one thousand gallons ~ 4.5 cubic metres)
ESTIMATES	Where data is not easily available, please give your best **estimates.**
HELP	If you need any help, please contact me, Keith Weatherhead, via the FREEPOST address, email k.weatherhead@cranfield.ac.uk or telephone 01525 863336.

Section A. Irrigation

1. Do you <u>normally</u> irrigate outdoor crops? | 1 | **YES / NO** | (delete one)

If no, go straight to section **D**; please return the form anyway.

2. Did you irrigate any outdoor crops <u>in 2005</u>? | 2 | **YES / NO** | (delete one)

If no, go straight to section **C**; please return the form anyway**.**

Section B. Irrigation in 2005

3. Which outdoor crops did you irrigate in 2005, and how much water did you apply to each?

- Exclude irrigation for frost protection or for spreading liquid manure.
- Show the amounts of water either as a depth **<u>or</u>** a volume.
- Ignore areas of less than 1 hectare.

:		**AREA**	**WATER APPLIED**				
		AREA (ha)	**AVERAGE DEPTH** (mm)		**OR**	**VOLUME** (m^3)	
Potatoes harvested by 31st July	3		13		or	23	
Potatoes harvested after 31st July	4		14		or	24	
Sugar beet	5		15		or	25	
Orchard fruit	6		16		or	26	
Small fruit	7		17		or	27	
Vegetables for human consumption	8		18		or	28	
Grass	9		19		or	29	
Cereals	10		20		or	30	
Other crops grown in the open	11		21		or	31	
TOTAL	12		22		or	32	

4. How did you decide when to irrigate?

Enter the area predominantly scheduled by each method in 2005 (as % of the total area irrigated) and whether you used external specialists/advisers for scheduling (e.g. for taking measurements).

		Percentage of total		**External advisor?** (delete one)
Water balance calculations (by hand or computer)	33	%	37	yes / no
In-field soil moisture measurement (e.g. neutron probes, tensiometers, capacitance probes)	34	%	38	yes / no
Judgement not based on measurement (including feeling the soil, crop inspection)	35	%	39	yes / no
Other (please specify):	36	%	40	yes / no
TOTAL		100 %		

5. Which irrigation method(s) did you use?

Enter the area irrigated by each method (as % of the total area irrigated in 2005)

		Percentage of total
Static or hand-moved sprinklers, spray lines	41	%
Hose reels with rain guns	42	%
Hose reels with booms	43	%
Centre pivots or linear moves	44	%
Trickle or drip	45	%
Other (please specify):	46	%
TOTAL		100%

What is the total outdoor area that you are equipped to irrigate by trickle (drip) irrigation?	47		hectares

Section C. Water resources

6. What source(s) of water did you use for irrigation?

Enter the amount from each source (as % of the total water used in 2005)

		Percentage of total
Surface Water (including ponds, lakes, gravel or clay workings, rivers, streams or other water courses)	48	%
Ground Water (including wells, bore holes and springs rising on the holding)	49	%
Public mains water supply	50	%
Rainwater collected on site	51	%
Re-use of water from other purposes	52	%
Other (please specify):	53	%
TOTAL		100%

Were you short of water in 2005?	54	YES / NO	(delete one)
How much of your available water resources did you use?	55	%	% of volume available
If available, how much more water would you have used?	56	%	% of volume used

Winter storage reservoirs

How much came from winter storage reservoirs?	57	%	% of total
What is the total volume you can store in winter storage reservoirs?	58		Cubic metres

Section D. Comments (if any)

Please include any comments you may have on the data provided.

RESULTS

The national results from the 2001 survey can be seen on
http://www.silsoe.cranfield.ac.uk/iwe/projects/irrigsurvey/irrig_survey.htm

The national results from this survey will also be made available from the Cranfield University site.
If you would prefer a printed copy, please tick this box, and check your address is correct.

59	

If you are willing to help us with any clarifications needed, please give your own name and contact details:

Name (PLEASE PRINT) .....

Telephone number.....

E-mail .....

Address (if different to holding):

Please **return** the completed form in the envelope provided, or post it to **Freepost** RLZZ-TECS-AUCY, Cranfield University (Silsoe), Barton Road, Silsoe, BEDFORD, MK45 4DT

NB FREEPOST - No stamp required

All data provided is subject to the Data Protection Act 1998, under Cranfield University's registration Z4926282. Individual replies will be treated as strictly confidential, and used only for statistical and research purposes and to provide you with requested information. Individual data will not be released to any party outside the university survey team without your consent. Aggregated data (only) will be supplied to DEFRA and published.

Thank you again for your help

Keith Weatherhead

https://dspace.org/

Survey of Irrigation of Outdoor Crops in 2005 - England and Wales

Weatherhead, E. K.; Rivas Casado, Monica

2007-08-01T00:00:00Z

https://dspace.lib.cranfield.ac.uk/handle/1826/2867

E. K. Weatherhead and M. Rivas-Casado, Survey of Irrigation of Outdoor Crops in 2005 - England and Wales. August 2007, Cranfield Universtiy.

Downloaded from a DSpace repository. https://dspace.org/