Title

The gross- and net-irrigation requirements of crops and model farms with different root zone capacities at ten locations in Denmark 1990-2015

Authors

Loraine ten Damme
Mathias Neumann Andersen

Den Europæiske Landbrugsfond for Udvikling af Landdistrikterne: Danmark og Europa investerer i landdistrikterne

Miljø- og Fødevareministeriet
Landbrugsstyrelsen

Den Europæiske Landbrugsfond for Udvikling af Landdistrikterne

LDP 2020

Se EU-Kommissionen, Den Europæiske Landbrugsfond for Udvikling af Landdistrikterne

Preface

According to statistics, about 464,000 ha are practically irrigable in Denmark, mostly in the western parts of the country. Irrigation contributes essentially to climate resilience of farms by stabilising crop and animal production in these areas with predominantly sandy soils. Our report presents updated figures on irrigation requirements in Denmark – considering various locations, climatic conditions, root zone capacities, and crops for the period 1990-2015. The previous Danish studies dates back to 1980ties and beginning of the 90ties and since then both the methods for measuring and calculating evapotranspiration and precipitation have changed. Also, during the past 30 years there has been climatic changes most clearly exhibited in a pronounced increase in annual precipitation. The study was requested by SEGES in order to have as precise and recent figures as possible as a basis for issuing groundwater abstraction permits for irrigation. We would like to thank Søren Kolind Hvid and Finn Plauborg for providing comments and input to the report.

Loraine ten Damme and Mathias Neumann Andersen

08-01-2018

Table of contents

1 Summary

One of the most important aspects of crop production is the control of soil water deficit, among others via supplemental irrigation. Danish counties have used the long-term average gross irrigation water requirement (GIWR) as published by Gregersen and Knudsen (1981) as a basis for the allocation of water quantities when issuing water abstraction permits. The objective of this study is to present updated values for the irrigation requirement in Denmark.

The irrigation decision support system *Vandregnskab* was used as the main modelling tool. We simulated 26-years of climatic data (1990-2015) with and without irrigation for each combination of six root zone capacities (RZC) ranging from 60 to 160 mm and 11 crops. Climatic data was obtained from the Danish Meteorological Institute from ten locations. The main analyses focussed on the GIWR and the increase of drainage as a result of irrigation, at crop and farm-level. For the latter, three model-farm crop rotations were designed: dairy, arable/pig, and potato. Additional analyses of the practical irrigation capacity (PIC) accounted for a farms limited irrigation capacity of either 3 or 4 mm $ha^{-1}day^{-1}$.

A validation test with independent field trials supported the simulated GIWR (r^2 = 0.67). The slope of the trend line indicated a tendency to irrigate more in the experiments than the model suggested in dry years, whereas in wet years actual irrigation was less than simulated.

The GIWR varied between crops, but always decreased nearly linearly with increasing RZC. The variation between crops was related to (i) the length of the growing season and (ii) the precipitation patterns within their different growing seasons. The GIWR also showed big spatial variation, which reflects the different climatic conditions: Jyndevad tended to be the location with the lowest GIWR, while Flakkebjerg often had the highest GIWR at similar RZC. No correlation was found between the GIWR and drainage. The return flow related well to general expectations: typically 25-30 % at RZC 60, compared to a reference of 30 %.

The GIWR varied tremendously from year to year. The use of an average GIWR is therefore not suitable as a basis for issuing annual irrigation permission: it would only meet the crop requirements in 50 % of the years. A permit covering the maximum demand could be desirable from an agricultural point of view, yet this could be incompatible with environmental goals for stream flows. Moreover, it neglects the fact that farmers are typically restricted by the irrigation capacity of their irrigation systems. Considering an irrigation permit based on the 80th percentile GIWR, i.e. the level sufficient to meet the GIWR in 80 % of the years, and the irrigation capacity of 3 mm $ha^{-1}day^{-1}$, the model dairy farm would not be able to fully exploit its permit in five years out of 26 with. The model

arable/pig farm would not in six years, and the model potato farm would not in eight years, all given the conditions of Jyndevad and RZC 60. Compared to the average GIWR, the 80th percentile GIWR accordingly fits better to a farm's needs.

In comparison with the earlier studies we found higher values of the GIWR. The causes of these increases may be several, including the improved method of calculating evapotranspiration, the use of higher crop coefficients as well as climatic changes over the 40-year period since the last calculations.

2 List of Abbreviations

A_F	Relative allowable water deficit
ΔD	The effect of the GIWR on drainage
DMI	Danish Meteorological Institute
ET_A	Actual evapotranspiration
ET_P	Potential evapotranspiration
ET_0	Reference evapotranspiration
FC	Field capacity
GIWR	Annual gross irrigation water requirement
IC_B	Irrigation capacity buffer
LU	Livestock unit
NIWR	Annual net irrigation water requirement
PAW	Plant available water
PIC	Practical irrigation capacity
RZC	Root zone capacity
SWD	Soil water deficit
WP	Wilting point

3 Introduction

One of the most important aspects of crop production is water management, in particular the control of soil water deficit (SWD). When SWD reaches a certain level (Denmead and Shaw, 1962), a drought stress reaction is triggered, which decreases the growth of crops, hence their potential yield (e.g. Legg *et al.*, 1979). In such situations, too little water is transported from the roots to the leaves, where water vapour transpires through the stomates in exchange for carbon dioxide: the primary processes for plant growth called photosynthesis. A shortage on soil water reduces a crop's ability to meet its potential transpiration, which ultimately results in both reduced quantity and quality (Perry *et al.*, 2009).Not all water taken up by the roots and transported through the plant is used for transpiration, but a small fraction is used within the plant (Allen *et al.*, 1998). Water also evaporates from surfaces, mainly from soil and wet leaves. The processes of evaporation and transpiration are difficult to distinguish from each other, and are therefore generally known together as evapotranspiration.

Susceptibility of crops to drought stress varies between species and between stages of crop development. Generally spoken, the actual yield loss due to SWD is relative small when SWD occurs in the vegetative and ripening stages, but is large during flowering and yield formation (e.g. Andersen *et al.*, 2002). Drought stress can arise from both insufficient amount and timing of precipitation, and can be counteracted by supplemental irrigation. Reducing the occurrence of stress caused by SWD is therefore the most important motive to apply irrigation. In Denmark, about 464,000 ha are practically irrigable (Danmarks Statistik, 2010), meaning equipped with irrigation facilities. Irrigation water is generally applied by irrigation guns which use groundwater extracted from wells.

The aim of irrigation is to increase a crop's actual evapotranspiration (ET_A) during the growth stages where SWD limits the growth of crops by replenishing soils' plant available water (PAW) – preferably up to the crops potential evapotranspiration (ET_P). The quantity of supplemental water necessary for a crop to reach its ET_P and potential growth is known as the net irrigation water requirement (NIWR). The NIWR is thus the amount of water that is extracted from the source but does not return to the deeper groundwater bodies, which is therefore of interest from an environmental point of view. During irrigation, losses via increased drainage (percolation through the soil profile) can usually not be avoided (Foster and Perry, 2010). The quantity of supplemental water that also accounts for this loss is called the gross irrigation water requirement (GIWR).

Soil water is generally plant available between field capacity (FC) and wilting point (WP). The soil water contents at these two matric potentials (often taken to be -1 m and -150 m of water column, respectively) vary between soils (Fig. 1.1) due to differences in texture, structure, and other constituents (e.g. organic matter) (Tuller and Or, 2004). The amount of soil water which can be utilised by a plant before wilting is represented by the root zone capacity (RZC), i.e. the difference between soil water content at FC and WP multiplied by the effective rooting depth. Where rooting is dense enough, all PAW is utilised up to WP (Madsen and Platou, 1983). Using the simulation model *Heimdal* (Hansen, 1975, 1987), Allerup and Madsen (1979) and Madsen and Platou (1983) determined that the effective rooting depth corresponds approximately with the thickness of soil layers with root densities greater than 0.1 cm root/cm^3 soil. The RZC varies from crop to crop and between soil types, however soil type and RZC are not interchangeable (Madsen and Holst, 1990). Therefore, it is recommended that the irrigation requirement is related to the RZC rather than to the topsoil soil class.

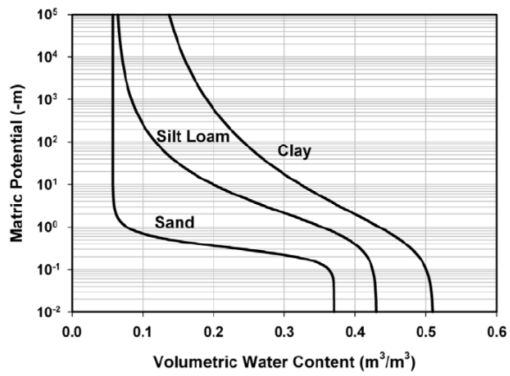


Fig. 1.1 *Typical soil water characteristic curves for soils of different texture. (Tuller and Or, 2004)*

Irrigation requirements in Denmark have been studied before, among others by Gregersen and Knudsen (1981) and Madsen and Holst (1990). Madsen and Holst (1990) calculated the GIWR of grass and spring barley at their various RZC based on an empirical model, using daily values of ET_P and precipitation of four different climatic zones (1956-1985). Gregersen and Knudsen (1981) calculated the GIWR for six groups of crops at six different RZCs, based on climatic data of 12 regions (1957-1976).

The long-term average GIWR as published by Gregersen and Knudsen (1981) has been used by the Danish counties as a basis for the allocation of water quantities when issuing water abstraction permits. Since their publication however, the methods for modelling evapotranspiration have changed. Also, it is characteristic that the GIWR varies greatly from year to year depending on weather conditions. An irrigation permission based on an average requirement is only sufficient in half of the years, and will thus statistically result in yield loss caused by SWD every other year. Yet, irrigation becomes more profitable when the requirement is high, i.e. when irrigation prevent big yield losses. Therefore, it is needed to apply other guidelines for the allocations of water abstraction – assuming it is practically possible to water the crops closer to optimal. A permit covering the maximum demand could be desirable from a productional point of view, but this could result in very high water extraction in some years, incompatible with environmental goals for stream flows: one should also consider among others the scarcity of water and the effects of both water extraction and water application on the groundwater level. Moreover, it may not actually be possible for a farmer to irrigate these amounts. The irrigation capacity of farms is limited among others by the capacity of the irrigation system, the location of the well, and the time it takes the famer to circulate his equipment between the fields that require irrigation. The effective irrigation capacities of farms are not well documented. When dimensioning an optimal irrigation system, a capacity of 4 mm $ha^{-1}day^{-1}$ is used, but most farms more likely have an effective irrigation capacity of 3 mm $ha^{-1}day^{-1}$ or less (Kolind Hvid, personal communication April 2017). A more realistic optimum of water extraction permissioned for irrigation may be found between the maximum and average requirement. An example is the approach of *The Environmental Agency* in Southern England. Here, the abstractions are allowed up to 80th percentile of the expected requirements – if actual abstraction can allow for it (Jensen *et al.*, 2013). This approach will result in statistically yield loss due to SWD every fifth year, and whether this is acceptable is of course debatable. How much yield loss due to SWD is acceptable, remains hard to quantify.

The objective of this study is to present updated values for the irrigation requirement as a basis for issuing abstraction permits for irrigation in Denmark. We have focussed on crops commonly irrigated in Denmark at six different root zone capacities using climatic data from ten different stations (representing ten locations) during the period 1990-2015. We made a validation test vis-a-vis fully irrigated experiments in Jyndevad (chapter 3), and calculated the average gross irrigation water requirement, the average effect of this requirement on drainage, and the average net irrigation water requirement at crop-level (chapter 4). Because permits are issued at farm-level, we continued with similar calculations for three model farms, but expanded with the 80th percentile gross irrigation water requirement and considerations on the limitations posed on water abstraction by an irrigation capacity of either 3 or 4 mm $ha^{-1}day^{-1}$ (chapter 5). Finally, we compared our results with previously published values of gross irrigation water requirement presented by Gregersen and Knudsen (1981) and of net irrigation water requirement calculated by Madsen and Holst (1990).

4 Methods and Study design

4.1 Vandregnskab

The irrigation decision support system *Vandregnskab* was used as the main modelling tool in this study. Irrigation support systems have been used before in estimating the irrigation water requirement over longer periods, for example by Doll & Siebert (2002) who used WaterGAP (Water-Global Assessment and Prognosis), and Fischer *et al.*, (2007) who used an agro-ecological zone assessment model, to predict irrigation under climate change.-*Vandregnskab* is a water balance model and decision support tool for farmers for tactical irrigation planning at present and near-future time (up to five days ahead). The system is an internet application based on *MARKVAND:* an irrigation decision support system which was developed since 1996 and since then improved through user-feedback (Thysen and Detlefsen, 2006).

Vandregnskab uses a specified farm design (soils and crops) and a climatic dataset to simulate the soil water status and the GIWR (Plauborg and Olesen, 1991; Olesen and Plauborg, 1995). More specifically, it combines a dynamic *water balance model* and a *crop model* to generate information for use in the *irrigation decision model* for each combination of crop, RZC and climatic dataset. It is up to the user of *Vandregnskab* to choose to simulate with or without irrigation, or to specify actual irrigation. An overview of the use of *Vandregnskab* in the present study is shown in Fig. 2.1.

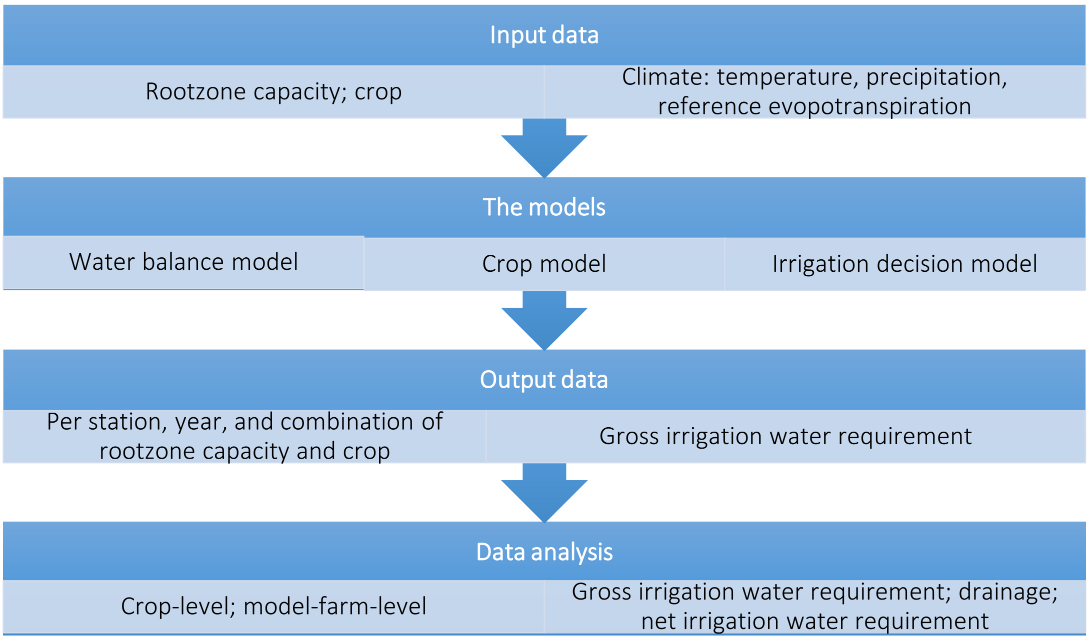


Fig. 2.1 Overview of the present study

4.1.1 The water balance model

The water balance model contains several interconnected water reservoirs and flows (Fig. 2.2). The water reservoirs are the consumption reservoirs (the interception reservoir (crop) and the evaporation reservoir), the root zone, and the subzone. Their relationship is thoroughly described in Plauborg & Olesen (1991, in Danish), and in Olesen & Plauborg (1995, in English). The water flows in the model are precipitation and irrigation, ET_A, and drainage. ET_A is derived from the crop model. The rate of drainage is a constant related to the soil type specified in the set-up (Olesen and Plauborg, 1995). *Vandregnskab* offers the possibility to visualise the soil water balance as simulated from March 1 until August 31, as presented in Fig. 2.3.

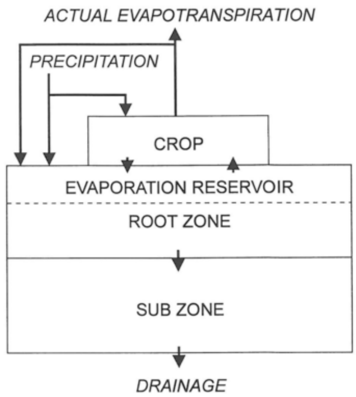
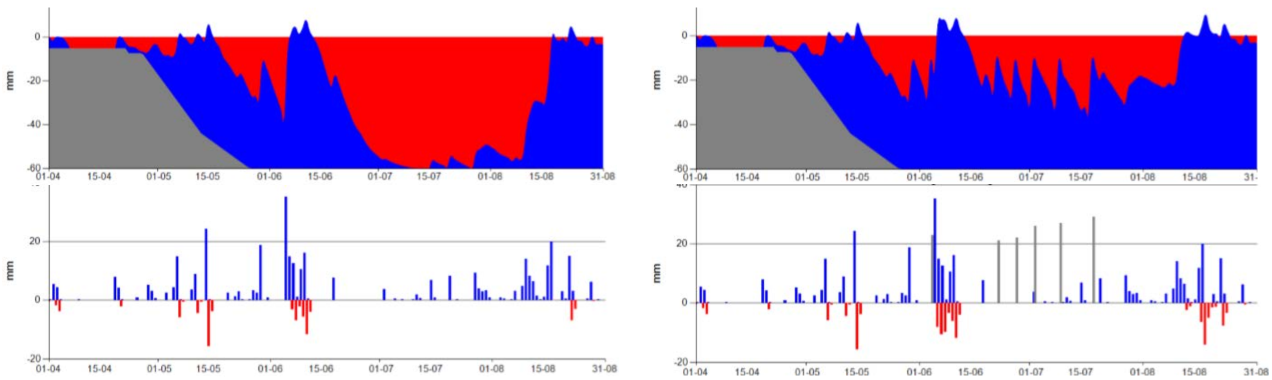


Fig. 2.2 *The conceptual water balance model (Olesen and Plauborg, 1995)*

Because *Vandregnskab* is designed to support short-term daily irrigation decision making, it is possible to take the weather forecast for the next five days into account. However, when doing retrospective simulations using historic climatic data as in the present study, this is not feasible. Irrigation was thus triggered even when precipitation was forecasted. To decrease a possible overestimation of the irrigation water requirement, simulations were done so that each simulated irrigation was 10 mm less than the actual soil SWD; allowing interception of rainfall by this soil buffer. This buffer has no negative effect on a crop's yield in the present study: as reviewed by Mogensen and Hansen (1978), yields do not significantly decrease until SWD exceeds about half of the RZC (which would be about 30 mm for RZC 60 – the lowest RZC in the present study).



NB. In top: blue: water in root zone; red: used water in root zone; grey: subzone, and in bottom: blue: precipitation; red: drainage; grey: irrigation.

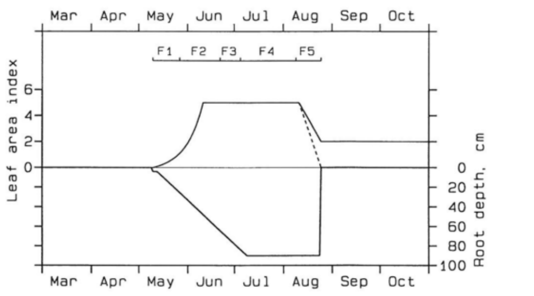
Fig. 2.3 *The visualisation of the simulated soil water balance for spring barley at root zone capacity 60 given the climactic conditions of Årslev 2010, without irrigation (left) and with irrigation (right).*

4.1.2 The crop model

The water balance is crop-sensitive because of ET_A. A crops ET_A is influenced by the development of leaf area, roots, and phenology. These aspects are all modelled using the temperature sum from the start of development: for spring sown crops the date of emergence and for winter sown crops and grass the date where the temperature sum after March 1 reaches 142 °C (Olesen and Plauborg, 1995). The maximum ET_A, i.e. ET_P, is a function of the leaf area index (Eq. 1), in which ET_0 is reference evapotranspiration, k_p an extinction coefficient, L the leaf area index, and Kc a crop coefficient. The Kc has a value of either 0.04 or 0.02. As Kc is it multiplied by the leaf area index (with a maximum value of 5), reaches ET_p 1.2*ET_0 for potatoes and 1.1*ET_0 for all other crops.

$$ET_P = ET_0 \exp(-k_P L) + ET_0[1 - \exp(-k_P L)] * (1 + Kc*L) \qquad \text{Eq. 1}$$

The leaf area development is described by the sum of the green leaf area index and the yellow leaf area index. These indices represent the one-sided area of both green (alive) and yellow (dead) crop parts per unit ground area, and are calculated from the temperature sum and growth phases (for a detailed description see Olesen and Plauborg, 1995). Root development is assumed to increase linearly until maximum rooting depth is reached, and then remains constant. An example of leaf and root development is shown in Fig. 2.4, whereas Fig. 2.5 shows the leaf area index as modelled in *Vandregnskab*. Phenological characteristics are used to distinguish different growth phases for both winter and spring sown crops (the number of phases can vary between crops). In each growth phase the crops are assumed to have specific drought tolerances (or relative allowed water deficit, A_F, Table 2.1, after Plauborg & Olesen, 1991), which thus influences the daily irrigation water requirement. The transition from one growth phase into another is defined by the temperature sum from the date of start of development. Grass has no other growth phase than the vegetative phase (F1) and starts growing again after harvest after a dormant period corresponding to a temperature sum of 50 °C (Olesen and Plauborg, 1995).



NB. F1, vegetative 1; F2, vegetative 2; F3, heading; F4, grain filling; F5, ripening

Fig. 2.4 *Example of leaf area- and root development of spring barley during a normal Danish year (from Olesen and Plauborg, 1995)*

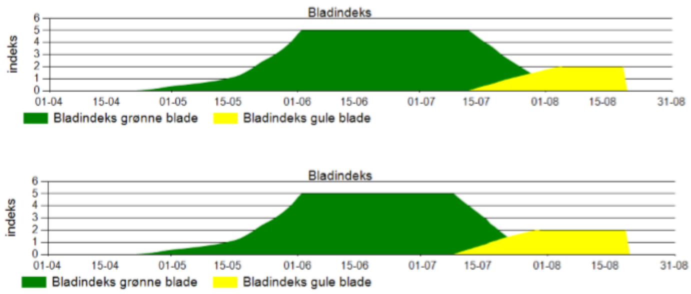


Fig. 2.5 *Visualisation of the simulated green- and yellow leaf area index for spring barley at root zone capacity 60 given the climactic conditions of Årslev 2010.Without irrigation (top), and with irrigation (bottom).*

Table 2.1 Relative allowed water deficit A_F (%) per growth phase (after Plauborg & Olesen 1991)

	Crop / growth stage	A_{F1}	A_{F2}	A_{F3}	A_{F4}	A_{F5}
	Grass-clover for silage	50	-	-	-	-
Spring crop	Spring barley	999	50	50	60	999
	Potato (consumption)	999	35	35	45	999
	Starch potato	999	35	35	45	999
	Maize	999	60	50	60	999
	Beetroot	999	70	45	55	-
Winter crop	Winter barley	60	50	60	999	-
	Winter wheat	65	45	60	999	-
	Winter rapeseed	65	50	65	999	-
	Winter rye	70	55	70	999	-

4.1.3 The irrigation decision model

In *Vandregnskab*, the user can choose to simulate with or without irrigation as applied in the current study, or choose to specify the irrigation. In the simulation with irrigation, irrigation was triggered when the SWD in the upper root zone reservoir and in the root zone approached the specific A_F for each crop in each growing phase (according to Table 2.1). Ideally however, the trigger is dynamic and dependent on actual climatic data, as a high ET_P causes stress at smaller SWD (Denmead and Shaw, 1962). The amount of irrigation is defined by the crop demand, limited by a maximum irrigation of 30 mm per day (irrespectively of soil type and RZC) and the buffer leaving 10 mm until FC after irrigation, to decrease the overestimations of the irrigation water requirement as explained previously. Rooting depth and RZC were set for the fields irrespectively of the crop, even though they are related (Madsen and Platou, 1983); the focus remained on the relation between climate and irrigation at different, predefined, RZCs.

4.2 Study design

The simulation setup in *Vandregnskab* requires specification of climatic data, the soil and crop. In total, six root zone capacities and 11 crops were used to simulate 66 different combinations, representing typical Danish crops and soils, given ten different climatic conditions.

4.2.1 Climatic data

Climatic data of a 26-year period (1990-2015) was collected from the Danish Meteorological Institute (DMI) for eight stations and two grid cells (Table 2.2, hereafter only referred to as locations). These locations were selected to represent the irrigated areas in Denmark as well as a few locations outside these areas. Additionally, climatic data of Jyndevad 1980-1989 was collected from DMI to carry out a validation test. The climatic files contained daily values of precipitation, temperature, and reference evapotranspiration (ET_0). All files were corrected to make them suitable for usage in *Vandregnskab*. First, precipitation was corrected. For the files in which precipitation was measured at 8 AM (the years 1990-2013), the value of precipitation was brought one day forward (e.g. from March 2 to March 1), because the majority of the measurement's timespan (16 out of the 24 hours) belongs to the day before the registration. Then, precipitation was adjusted from gauge to field level with the correction factors for moderate shelter (Table 2.3) which are also used by the DMI (Allerup, Madsen and Vejen, 1998, p. 15) and by *Vandregnskab* when using weather observations from within the programme (feasible up to three years back) (Thysen, Andersen and Plauborg, 2006). ET_0 was calculated by a simplification of *Makkink*, Eq. 2 (Olesen and Plauborg, 1995), which in turn is a simplification of the *Penman-Monteith* formula. ET_0 (mm) is calculated from the slope of the vapour pressure curve (Δ, [kPa °C^{-1}]), solar radiation (R_s, [MJ m$^{2-1}$ day^{-1}]), latent heat of vaporization (λ, [2.45 MJ kg^{-1}]), and a psychrometric constant (γ, [0.667 hPa °C^{-1}]. The months January and February were taken out of the datasets, meaning that the simulations always started March 1.

$$ET_0 \text{ (mm day}^{-1}\text{)} = 0.7 * \Delta * R_g / (\lambda * (\Delta + \gamma)) \qquad \text{Eq. 2}$$

Table 2.2 *Stations and sources used for the extraction of climatic data*

Station	*Data source*
Årslev (1)	DMI Database
Askov (2)	DMI Database
Borris (3)	DMI Database
Flakkebjerg (4)	DMI Database
Foulum (5)	DMI Database
Jyndevad (6)	DMI Database
Ribe (7)	DMI Square grid for Nitrate Investigations
Skjern (8)	DMI Square grid for Nitrate Investigations
Silstrup (9)	DMI Database
Tylstrup (10)	DMI Database

Table 2.3 *Correction factors for precipitation from gauge to field level (Allerup, Madsen and Vejen, 1998).*

Month	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Correction factor	1.41	1.42	1.35	1.24	1.13	1.11	1.10	1.10	1.11	1.14	1.23	1.37

4.2.2 The soils

A specification of RZC was preferred over topsoil-soil classification, as the RZC represents the amount of soil water which can be utilised by a plant before wilting (Madsen and Platou, 1983). The RZC selected are similar to the ones used by Gregersen and Knudsen (1981), and are representative for Danish soils. In *Vandregnskab*, the RZC were connected to the Danish soil classification system (JB's) and maximum rooting depth (irrespectively of crop) (Table 2.4).

Table 2.4 *Soil specifications for the root zone capacities simulated in the present study.*

JB topsoil	*JB subsoil*	*Max rooting depth (cm)*	*Max RZC (mm)*
JB 1	JB 1	50	60
JB 1	JB 1	60	80
JB 3	JB 3	70	100
JB 4	JB 4	75	120
JB 4	JB 4	75	140
JB 6	JB 6	90	160

4.2.3 The crops

The crops used in the analyses required specification of both date of emergence and date of harvest (Table 2.5). For the spring crops a specified date of emergence indicated the start of growth, whereas for winter crops this was indicated by the temperature sum calculated from March 1st. Grass-clover does not have a date of emergence either, as it is established in the previous year; *Vandregnskab* treats grass-clover as a winter crop. The dates of emergence of spring barley and beetroot vary from year to year, and were derived from average sowing dates of spring barley in field trials (27 years between 1992-2016) plus 7 and 12 days respectively. The dates of emergence of potatoes was difficult to correlate to the day of planting, yet the emergence varies to a much lesser extent than planting and was therefore set to a fixed date every year. Starch potato was simulated with two different dates of emergence (May 12 and May 25), representing two management strategies. The harvest dates of the different crops were fixed between years and programmed in *Vandregnskab* (Table 2.5), except for the crops which are harvested after the last day of the simulation, September 30. The harvest date of grass-clover was fixed for all 26 years, to let the annual results depend on the climatic data only.

Table 2.5 *Crop specification as simulated in the present study. The date of emergence is specified for the spring crops only. The date of harvest is specified for the crops harvested before the last day of the simulations (September 30).*

Crop	*Date of emergence*	*Date of harvest*
Spring barley	Average sowing date + 7 days	August 20
Potato (consumption)	May 12	September 1
Starch potato	May 12	-
Starch potato	May 25	-
Maize	May 7	-
Grass-clover for silage	-	4 cuts: June, July, August, and September 1
Winter barley	-	July 20
Winter wheat	-	August 20
Winter rapeseed	-	July 20
Winter rye	-	August 10
Beetroot	Date of spring barley + 12 days	-

4.3 Data Analyses

The output files were truncated to the date of harvest for the crops harvested before September 30, in accordance with Table 2.5. Starch potato with the emergence on May 25 has been left out of further analyses, as the results on irrigation were nearly similar to those on starch potato with emergence on May 12. *Vandregnskab* generates a variety of data, but the focus in the present study was on the GIWR and the increase in drainage due to irrigation (ΔD), the latter calculated from simulations of drainage with and without irrigation: Di and Dni, respectively (Eq. 3). The NIWR was subsequently calculated as the difference between GIWR and ΔD (Eq. 4).

$$D = Di - Dni \qquad \text{Eq. 3}$$

$$NIWR = GIWR - \Delta D \qquad \text{Eq. 4}$$

At crop-level, the long-term averages of yearly GIWR, ΔD, and NIWR were calculated for each combination of crop and RZC using the 26 years of climatic data from each of the 10 locations. The 80^{th} percentile GIWR (i.e. the GIWR of the year ranked sixth with respect to highest irrigation water requirement) was derived for the same combinations, to define a more realistic irrigation requirement. Because the permits for water extraction are issued at farm level, it is critical to gain information of the irrigation requirement and its effects on drainage at farm-level. Therefore, three model-farms were designed with specified crop rotations: a dairy farm (1.7 livestock units (LU)), an arable/pig farm, and a potato farm (Table 2.6). For these model-farms the values of the average, median, and 80^{th} percentile GIWR were calculated, as were the average ΔD and average NIWR.

We also developed a method to address the limitations of the irrigation capacity: the practical irrigation capacity (PIC). The PIC is a measure of the technical irrigation capacity of a farm assuming an irrigation capacity of either 3 or 4 mm $ha^{-1}day^{-1}$. The PIC assumes that a farm's irrigation capacity can build up to a maximum of five days since irrigation can be commenced earlier and end later as the optimum time, thus suggesting a five-day window of opportunity to irrigate. A farmer thus has an irrigation capacity-buffer (IC_B) of 15 mm with 3 mm $ha^{-1}day^{-1}$ capacity and an IC_B of 20 mm with 4 mm $ha^{-1}day^{-1}$ capacity. When the day to day accumulated irrigation water requirement exceeds the IC_B, an irrigation deficit is registered, which is subtracted from the annual GIWR for unlimited conditions. The PIC was calculated as the summation of such daily deficits over the growing season according to Eq. 5, in which I_{WR} represents the irrigation water requirement, and where the integral denotes the summation of irrigation water requirements for consecutive five days periods throughout the season, which are only taken into account when exceeding IC_B.

$$PIC = GIWR - \Sigma \left(\int_1^5 I_{WR} - IC_B\right) \mid \left(\int_1^5 I_{WR} - IC_B\right) > 0 \qquad \text{Eq. 5}$$

Table 2.6 *The designed model-farms with specific crop rotations*

Dairy farm		*Arable/pig farm*		*Potato farm*	
Grass-clover for silage	35 %	Winter rapeseed	20 %	Potato (consumption)	25 %
Maize	25 %	Winter wheat	20 %	Winter barley	25 %
Spring barley (mature)	20 %	Winter barley	20 %	Spring barley	50 %
Spring barley (whole crop) + grass	20 %	Spring barley	40 %		

5 Validation of the simulations

A validation of the simulated GIWR was performed on data from irrigation experiments from Jyndevad experimental station as described earlier. In Fig. 3.1 the GIWR as calculated by *Vandregnskab* is plotted against the observed amounts of actual applied irrigation in independent field trials. The simulated values of *Vandregnskab* were generally close to the observed amount applied in the fully irrigated treatments (at or near the 1:1-line). The model prediction error (RMSE 34.4 mm) is close to the maximum irrigation event in *Vandregnskab* (30 mm), meaning that on average, the model predictions was one irrigation event off. Although we found over- and underestimations, the validation test supported the simulated GIWR with a significant r^2 of 0.67. The slope of the trend line of 0.7 indicated a tendency to irrigate more in the experiments than the model suggested in dry years, whereas in wet years actual irrigation was less than simulated. This could be explained by the considerations that are made in actual irrigation management. That is, the precipitation forecast of today and tomorrow were taken into account in the wet years, when there would often have been rain predicted, whereas in *Vandregnskab* this is only accounted for with the 10-mm buffer. Oppositely, in dry years, the practical experiments employed a fixed allowable SWD as irrigation criterion (e.g. Jensen (1987)) disregarding the crop-specific A_F used in Vandregnskab. The model thus does not necessarily underestimate the GIWR in dry years, but rather underestimates the amount applied in experiments.

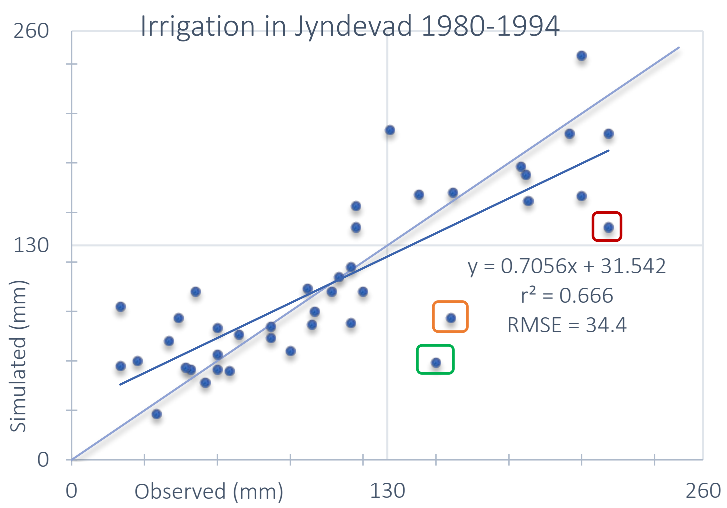


Fig. 3.1. The validation test of the data derived from independent field trials on irrigation (based on either neutron-probe, tensiometers, or a combination of both) and the gross irrigation water requirement as simulated by Vandregnskab. Data with coloured boxes are underestimations discussed in the text.

The underestimations were most pronounced in beetroot 1991 (orange) and winter rapeseed 1983 (green) and 1992 (red), of which 1983 was a possible outlier of the trial data: this year there was a lot of rainfall up to early June, leaving little of the growing season to irrigate (harvest around mid-July). The other deviations are more difficult to reconcile, but the explanation may be found in the crop development versus water balance. For example, the deviation in 1992 seemed the result of the strictness of the phenological model in *Vandregnskab*: the last growing stage of winter rapeseed was reached at June 16, after which no more irrigation was simulated based on the A_F (Table 2.1), while in the corresponding experiment, 60 mm was applied after that date. Further deviation could be explained by the standardised, fixed, sowing dates of spring crops in *Vandregnskab*. When the actual date of sowing deviates, the relation between crop development and weather will deviate as well. In some years, actual conditions for sowing may have been too wet, which could have caused some deviation requiring different irrigation scheduling than simulated.

6 Irrigation at crop-level

6.1 The gross irrigation water requirement at crop-level

The average annual GIWR for each combination of crop and RZC at each location is presented in Table 4.1. The average was taken over all 26 years simulated and thus include extremes in case of extraordinary high and low requirements. The annual GIWR at crop-level are presented in Appendix I.

The GIWR depends on both soil- and crop specifications which can be read from the results. The average GIWR decreased nearly linearly with increasing RZC. From RZC 60 to RZC 160, the decrease was about 50 mm for potatoes and maize, 60 mm for winter wheat, winter rapeseed, winter barley, and spring barley, and 70 mm for beetroot, grass-clover for silage and winter rye. The variation between crops was related to (i) the length of the growing season and (ii) the amount of precipitation within their different growing seasons. Even though the simulated GIWR of the individual crops varied, some may be grouped in order to decrease the size of a dataset. For example, starch potato and potato for consumption could be represented just as potatoes without much loss of detail. Winter wheat and winter rye had largely the same GIWR even though winter rye is usually regarded as more drought tolerant than wheat. Spring barley, winter barley, and winter rapeseed formed another group with a somewhat lower GIWR. These differences and similarities may be taken into account during strategic irrigation planning in order to lower peak demands. The highest average GIWR was always noted with the climatic dataset of Flakkebjerg, and the lowest average GIWR with the climatic dataset of Jyndevad. This indicated spatial trends of GIWR, which is related to the differences in precipitation patterns and ET_0.

From an agricultural point of view is the average GIWR of limited interest since an annual irrigation permit corresponding such values would allow a farmer to irrigate sufficiently only every other year, while in the other 50 % of the years the permit it is not sufficient to meet the requirement, thus causing yield loss. The 80th percentile GIWR is the amount of irrigation water that is sufficient to meet the requirement in 80 % of the years, thus the level at which the limited irrigation permit causes yield loss in two out of ten years. These values were generally 20-30 mm higher than average GIWR (Table 4.2). The consequences of such an increase can be considerable for crop production and farm management. For example, the dry matter grain yield of spring barley increases with 20 kg ha^{-1} per mm PAW (Aslyng, 1978; Andersen, Jensen and Lösch, 1992). In another study, to the socio-economic effects of irrigation, data from experiments in Jyndevad were used which showed that the yield increased with 42 % for spring barley with 77 mm of irrigation, 24 % for rye with 65 mm, 54 % for wheat with 85 mm, 24 % for winter barley with 77 mm, and 23 % and 21 % for potatoes (consumption and starch respectively) with 68 mm (Sønderjyllands amtskommune, 1986). Sufficient irrigation facilities and possibilities can moreover encourage farmers to change their crop rotation and include high value crops that respond more to irrigation, for example winter wheat and potatoes instead of spring barley (Sønderjyllands amtskommune, 1986).

Table 4.1 Average gross irrigation water requirement (mm) for the crops at the different root zone capacities according to the different climatic conditions 1990-2015. The way in which the locations are ordered is defined by the high-to-low ranking of the average gross irrigation water requirement of all crops all years, and is continued in the following tables and figures

Spring barley	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	142	130	117	110	92	78
Årslev	132	119	103	93	81	61
Silstrup	140	125	112	97	88	70
Tylstrup	120	107	90	84	68	52
Foulum	125	111	97	87	76	58
Skjern	122	110	96	88	75	60
Ribe	115	103	91	76	65	51
Borris	112	98	87	74	65	53
Askov	108	99	78	67	52	42
Jyndevad	104	89	70	65	46	39

Potato (consumption)	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	181	168	156	152	140	119
Årslev	169	156	143	128	122	106
Silstrup	170	154	138	127	118	102
Tylstrup	157	139	133	121	104	96
Foulum	153	140	128	119	106	89
Skjern	148	136	125	115	100	89
Ribe	141	130	117	107	97	82
Borris	141	128	112	102	91	78
Askov	142	120	107	97	87	69
Jyndevad	134	116	104	93	80	68

Starch potato	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	180	173	160	159	144	129
Årslev	169	159	150	133	123	110
Silstrup	168	156	140	129	120	103
Tylstrup	160	143	132	126	106	97
Foulum	154	144	131	123	111	92
Skjern	149	141	126	118	104	91
Ribe	143	129	120	107	102	84
Borris	144	132	112	105	95	80
Askov	142	126	110	98	88	72
Jyndevad	134	119	105	93	81	70

Maize	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	137	121	112	106	93	78
Årslev	125	107	96	88	76	61
Silstrup	111	95	81	74	66	53
Tylstrup	109	92	83	73	65	46
Foulum	105	96	78	72	59	45
Skjern	103	87	75	69	57	44
Ribe	99	83	72	63	53	44
Borris	93	82	68	63	52	40
Askov	90	78	63	55	46	36
Jyndevad	89	74	62	54	42	33

Grass-clover	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	270	249	233	213	202	182
Årslev	243	227	200	187	168	151
Silstrup	227	209	180	172	151	134
Tylstrup	212	192	173	151	140	115
Foulum	211	196	174	158	148	126
Skjern	206	190	170	155	142	123
Ribe	204	188	165	151	138	118
Borris	193	178	153	138	126	107
Askov	191	173	148	129	117	98
Jyndevad	187	172	144	127	108	90

Winter barley	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	138	120	107	98	84	67
Årslev	121	108	92	77	67	52
Silstrup	137	115	97	90	74	59
Tylstrup	112	100	82	73	57	45
Foulum	119	106	91	81	68	52
Skjern	113	100	85	77	62	48
Ribe	110	95	81	73	58	44
Borris	104	91	78	65	55	39
Askov	105	89	76	61	50	39
Jyndevad	98	81	69	54	43	31

Winter wheat	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	187	170	155	147	133	115
Årslev	173	155	140	127	114	98
Silstrup	177	158	142	130	119	105
Tylstrup	159	140	123	113	96	80
Foulum	161	146	132	120	105	88
Skjern	156	141	128	117	105	89
Ribe	151	136	125	110	99	81
Borris	143	129	115	105	91	76
Askov	142	124	112	93	83	70
Jyndevad	135	125	99	91	75	61

Winter rapeseed	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	135	115	103	90	77	60
Årslev	121	103	88	75	65	45
Silstrup	125	111	95	83	66	53
Tylstrup	113	91	80	66	54	36
Foulum	115	99	83	76	59	46
Skjern	113	98	81	72	58	42
Ribe	108	92	75	67	53	40
Borris	100	85	73	65	53	33
Askov	103	85	72	52	48	37
Jyndevad	95	78	63	51	42	27

Winter rye	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	183	163	144	130	115	92
Årslev	165	148	127	114	96	78
Silstrup	165	147	121	115	100	80
Tylstrup	154	122	110	93	82	61
Foulum	155	130	119	102	92	70
Skjern	153	133	113	103	89	69
Ribe	144	127	110	93	78	62
Borris	136	117	103	89	78	62
Askov	136	114	91	83	67	50
Jyndevad	132	106	91	75	63	45

Beetroot	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	192	177	151	145	133	114
Årslev	173	150	132	122	108	92
Silstrup	156	138	115	110	89	80
Tylstrup	150	132	108	97	88	73
Foulum	148	129	111	102	80	73
Skjern	147	123	107	96	83	70
Ribe	138	120	97	91	74	62
Borris	132	115	97	90	74	60
Askov	130	110	91	82	63	52
Jyndevad	123	109	90	77	60	50

Table 4.2 The *80th percentile gross irrigation water requirement(mm) for the crops at the different root zone capacities according to the different climatic conditions 1990-2015*

Spring barley	*60*	*80*	*100*	*120*	*140*	*160*	*Potato (consumption)*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	171	150	150	150	120	120	Flakkebjerg	227	216	202	210	180	180
Årslev	159	150	120	120	120	90	Årslev	199	198	178	150	150	150
Silstrup	184	150	150	120	120	90	Silstrup	218	203	175	180	180	150
Tylstrup	163	150	120	120	120	90	Tylstrup	209	200	202	180	180	150
Foulum	148	150	120	120	120	90	Foulum	192	175	175	150	150	120
Skjern	157	150	120	120	120	90	Skjern	190	175	174	150	150	120
Ribe	143	120	120	90	90	60	Ribe	184	176	146	150	150	120
Borris	143	150	120	120	90	90	Borris	196	175	172	150	150	120
Askov	145	120	120	90	90	60	Askov	183	177	150	150	150	120
Jyndevad	126	120	90	90	60	60	Jyndevad	171	159	147	150	120	120

Starch potato	*60*	*80*	*100*	*120*	*140*	*160*	*Maize*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	224	215	202	210	180	180	Flakkebjerg	173	150	150	150	120	120
Årslev	203	203	200	180	150	150	Årslev	173	150	150	120	120	90
Silstrup	204	203	200	180	180	150	Silstrup	151	150	120	120	90	90
Tylstrup	214	200	199	180	180	150	Tylstrup	149	150	120	120	120	90
Foulum	190	173	175	150	150	120	Foulum	120	120	120	90	90	60
Skjern	190	191	174	180	150	150	Skjern	143	120	120	120	90	90
Ribe	185	176	146	150	150	120	Ribe	134	120	120	90	90	90
Borris	190	175	172	150	150	120	Borris	126	120	120	90	90	90
Askov	185	194	173	150	150	120	Askov	141	120	120	90	90	60
Jyndevad	171	167	147	150	120	120	Jyndevad	124	120	120	90	90	60

Grass-clover	*60*	*80*	*100*	*120*	*140*	*160*	*Winter barley*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	308	300	270	270	240	240	Flakkebjerg	151	150	120	120	90	90
Årslev	294	270	240	240	210	180	Årslev	143	150	120	120	90	90
Silstrup	270	240	240	210	210	180	Silstrup	169	150	120	120	90	90
Tylstrup	283	270	240	210	210	180	Tylstrup	143	150	120	120	90	90
Foulum	253	240	210	210	210	180	Foulum	148	150	120	120	90	90
Skjern	256	240	210	210	180	180	Skjern	142	120	120	120	90	90
Ribe	235	240	210	210	180	150	Ribe	126	120	120	90	90	60
Borris	228	210	210	180	180	150	Borris	130	120	120	90	90	60
Askov	229	210	180	180	150	120	Askov	126	120	90	90	60	60
Jyndevad	215	210	180	180	150	150	Jyndevad	119	90	90	60	60	30

Winter wheat	*60*	*80*	*100*	*120*	*140*	*160*	*Winter rapeseed*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	230	203	210	180	180	150	Flakkebjerg	158	150	120	120	90	60
Årslev	209	198	180	150	150	120	Årslev	160	150	120	90	90	60
Silstrup	220	203	180	180	150	150	Silstrup	151	120	120	120	90	60
Tylstrup	201	198	180	180	150	120	Tylstrup	145	120	120	90	90	60
Foulum	200	177	180	180	180	150	Foulum	151	120	120	120	90	60
Skjern	202	176	180	150	150	120	Skjern	153	120	120	120	90	60
Ribe	193	172	150	150	120	120	Ribe	132	120	90	90	60	60
Borris	180	167	150	150	150	120	Borris	134	120	90	90	90	90
Askov	186	168	150	120	120	90	Askov	122	120	90	60	60	60
Jyndevad	165	148	120	120	90	90	Jyndevad	114	90	90	60	60	30

Winter rye	*60*	*80*	*100*	*120*	*140*	*160*	*Beetroot*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	218	210	180	180	150	120	Flakkebjerg	236	227	180	180	180	150
Årslev	205	180	150	150	120	90	Årslev	213	198	150	150	120	120
Silstrup	203	180	150	150	120	120	Silstrup	186	172	150	150	120	120
Tylstrup	207	180	150	150	150	120	Tylstrup	191	172	150	150	150	120
Foulum	189	180	180	150	150	120	Foulum	185	171	150	150	120	120
Skjern	203	180	150	150	120	120	Skjern	180	144	120	120	120	90
Ribe	180	150	150	120	90	90	Ribe	181	168	120	120	90	90
Borris	185	150	150	120	120	90	Borris	173	148	120	120	90	90
Askov	167	150	120	120	90	60	Askov	176	146	120	120	90	90
Jyndevad	164	150	120	90	90	60	Jyndevad	159	142	120	120	90	90

6.2 The effect of the GIWR on drainage at crop-level

Supplemental irrigation increases the water content in the root zone and thereby increases drainage (Table 4.3) as situations with precipitation events exceeding the soil water deficit arises more frequently (Fig. 4.1). There was however no significant correlation between ΔD and the GIWR (slopes ranging from 0.120 to 0.179 and r^2 from 0.176 to 0.101 for different RZC). This may be because the GIWR is high in dry years, when fewer precipitation events result in the SWC exceeding FC. In addition, the 10-mm buffer set in the simulations further reduced the risks of irrigation triggering drainage after rain. The effect of the GIWR on drainage was predominantly positive, meaning that the simulated GIWR tended to increase drainage. At 60 mm RZC the ΔD of the different crops and locations ranged from 20 % to 43 %, but was typically in the order of 25-30 % of the average GIWR. This return flow relates well to general expectation that about 30 % of the water abstracted for agriculture returns to natural water bodies (European Environment Agency, 2009, p. 5). The effect of GIWR on drainage became lesser with increasing RZC, because the combination of maximum irrigation (set to 30 mm per event) and precipitation became increasingly unlikely to reach FC. The smaller the extra losses via ΔD are, the closer the GIWR and the NIWR are together. The NIWR is presented in Table 4.4.

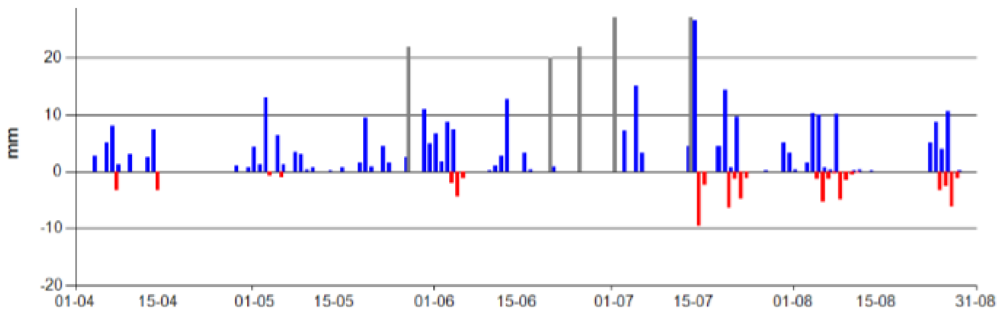


Fig 4.1 Graphic presentation of the output of Vandregnskab for spring barley at root zone capacity 60, Foulum 2005. Blue: precipitation; red: drainage; grey: irrigation.

Table 4.3 *The increase of drainage (mm) due to the simulated average gross irrigation water requirement (Table 4.1) for the crops at the different root zone capacities according to the different climatic conditions 1990-2015*

Spring barley	*60*	*80*	*100*	*120*	*140*	*160*	*Potato (consumption)*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	24	20	15	11	7	4	Flakkebjerg	28	24	18	13	9	6
Årslev	31	27	16	11	9	4	Årslev	33	29	20	10	8	3
Silstrup	31	25	17	7	4	3	Silstrup	37	36	25	16	11	8
Tylstrup	30	24	14	12	9	2	Tylstrup	38	27	23	19	11	7
Foulum	26	18	13	9	5	5	Foulum	26	24	18	13	10	6
Skjern	31	27	22	14	11	6	Skjern	39	38	32	25	18	13
Ribe	34	31	29	19	14	10	Ribe	37	35	32	25	24	15
Borris	30	26	23	15	15	6	Borris	39	32	25	22	21	12
Askov	40	44	29	22	12	9	Askov	45	35	30	24	18	9
Jyndevad	42	37	30	24	13	10	Jyndevad	46	40	34	27	19	14
Starch potato	*60*	*80*	*100*	*120*	*140*	*160*	*Maize*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	38	37	31	27	22	18	Flakkebjerg	25	21	16	14	11	9
Årslev	44	43	36	25	21	15	Årslev	29	24	18	14	8	6
Silstrup	55	54	44	37	31	27	Silstrup	37	32	24	20	19	12
Tylstrup	56	47	43	36	23	20	Tylstrup	38	32	29	19	14	8
Foulum	43	42	35	28	21	15	Foulum	29	28	20	14	10	7
Skjern	53	59	54	50	44	37	Skjern	38	35	32	31	24	17
Ribe	49	49	49	42	42	33	Ribe	33	30	27	23	20	18
Borris	55	51	44	39	39	28	Borris	38	35	30	20	23	17
Askov	58	54	48	43	37	27	Askov	32	32	25	21	18	13
Jyndevad	56	54	47	39	32	27	Jyndevad	34	30	24	21	14	12
Grass-clover	*60*	*80*	*100*	*120*	*140*	*160*	*Winter barley*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	43	35	32	21	15	15	Flakkebjerg	17	9	5	5	2	2
Årslev	51	48	33	27	19	17	Årslev	22	16	10	5	5	2
Silstrup	56	54	38	37	29	24	Silstrup	26	16	10	4	3	2
Tylstrup	61	52	45	29	23	12	Tylstrup	24	17	13	9	4	1
Foulum	48	44	31	20	18	13	Foulum	19	12	9	4	2	1
Skjern	56	55	51	47	44	37	Skjern	19	13	8	7	4	4
Ribe	54	54	49	46	42	39	Ribe	20	14	10	7	5	3
Borris	60	56	50	35	34	18	Borris	17	15	15	9	6	4
Askov	64	63	55	45	41	35	Askov	30	27	21	11	8	6
Jyndevad	64	66	52	45	37	29	Jyndevad	32	22	16	6	4	3
Winter wheat	*60*	*80*	*100*	*120*	*140*	*160*	*Winter rapeseed*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	26	19	14	11	8	5	Flakkebjerg	15	7	4	2	1	0
Årslev	35	26	18	10	10	7	Årslev	19	15	9	4	4	2
Silstrup	36	26	16	7	6	4	Silstrup	17	14	10	2	1	4
Tylstrup	37	25	20	17	12	6	Tylstrup	20	11	9	5	4	-1
Foulum	27	21	15	11	7	5	Foulum	14	8	5	3	1	1
Skjern	34	28	23	15	13	9	Skjern	14	11	6	5	4	1
Ribe	38	33	27	20	16	12	Ribe	17	11	7	5	3	3
Borris	31	23	26	21	14	7	Borris	15	8	9	9	10	3
Askov	46	41	35	24	19	16	Askov	29	25	16	6	6	5
Jyndevad	49	50	33	24	16	9	Jyndevad	26	19	11	6	4	2
Winter rye	*60*	*80*	*100*	*120*	*140*	*160*	*Beetroot*	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	18	13	6	4	3	1	Flakkebjerg	35	33	22	17	18	12
Årslev	23	18	9	7	5	4	Årslev	42	34	24	21	15	10
Silstrup	21	15	4	3	1	1	Silstrup	46	45	35	29	24	20
Tylstrup	30	12	14	8	5	2	Tylstrup	46	44	29	19	18	11
Foulum	20	12	10	4	3	1	Foulum	41	36	27	18	11	12
Skjern	25	18	8	7	5	3	Skjern	50	45	43	37	34	29
Ribe	24	18	13	8	5	3	Ribe	44	43	36	33	29	23
Borris	22	11	16	11	10	7	Borris	55	44	30	31	21	22
Askov	35	27	18	15	10	7	Askov	47	45	40	34	24	19
Jyndevad	35	26	17	9	6	4	Jyndevad	44	46	39	31	21	18

Table 4.4 *Average net irrigation water requirement(mm) for the crops at the different root zone capacities according to the different climatic conditions 1990-2015*

Spring barley	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	119	111	102	99	85	74
Årslev	101	93	87	82	73	59
Silstrup	109	100	94	90	83	68
Tylstrup	91	83	76	72	60	50
Foulum	99	93	84	78	71	53
Skjern	92	83	74	74	64	54
Ribe	82	72	62	57	50	41
Borris	83	72	64	59	50	48
Askov	69	56	49	45	40	33
Jyndevad	62	51	41	40	33	29

Potato (consumption)	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	154	143	139	139	131	113
Årslev	135	128	123	119	115	104
Silstrup	133	119	114	111	107	94
Tylstrup	119	112	109	102	93	88
Foulum	127	116	110	106	97	83
Skjern	109	97	92	90	82	76
Ribe	104	95	85	83	73	66
Borris	103	97	88	80	72	67
Askov	97	85	77	73	68	60
Jyndevad	88	76	70	67	61	54

Starch potato	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	142	136	130	132	123	111
Årslev	124	116	114	109	104	96
Silstrup	113	102	97	92	89	76
Tylstrup	105	96	89	90	83	77
Foulum	110	102	97	95	89	77
Skjern	95	82	72	68	60	55
Ribe	94	80	71	66	60	51
Borris	90	81	69	66	57	52
Askov	84	72	62	56	50	45
Jyndevad	78	65	58	54	49	43

Maize	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	112	101	96	92	82	70
Årslev	97	85	78	75	68	55
Silstrup	74	63	57	54	47	41
Tylstrup	71	61	54	54	50	38
Foulum	76	67	59	58	49	38
Skjern	65	52	43	38	33	27
Ribe	66	53	44	40	33	26
Borris	55	47	38	44	29	24
Askov	58	46	39	34	28	23
Jyndevad	55	44	38	34	28	21

Grass-clover	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	227	214	201	193	187	168
Årslev	195	182	169	165	153	137
Silstrup	170	155	142	134	122	110
Tylstrup	151	140	128	122	116	103
Foulum	163	152	143	138	130	112
Skjern	151	136	119	107	98	86
Ribe	150	134	116	105	96	79
Borris	134	122	104	105	92	90
Askov	127	110	93	84	76	63
Jyndevad	123	106	93	82	72	61

Winter barley	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	120	111	102	94	82	65
Årslev	102	95	84	74	64	51
Silstrup	110	99	87	86	71	57
Tylstrup	88	84	69	64	52	44
Foulum	101	95	82	76	66	51
Skjern	94	88	77	71	59	45
Ribe	90	81	71	66	53	41
Borris	87	76	64	55	50	36
Askov	75	62	55	50	42	34
Jyndevad	66	59	54	48	39	28

Winter wheat	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	161	151	140	135	125	111
Årslev	139	130	123	118	107	93
Silstrup	141	132	126	123	113	101
Tylstrup	123	115	104	97	84	74
Foulum	133	125	117	109	98	83
Skjern	123	113	105	101	92	80
Ribe	113	102	97	89	84	69
Borris	113	106	89	85	78	70
Askov	96	83	77	70	64	54
Jyndevad	86	75	66	67	59	52

Winter rapeseed	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	120	108	98	88	76	60
Årslev	104	90	80	72	63	44
Silstrup	108	96	84	82	65	49
Tylstrup	92	80	70	60	50	36
Foulum	101	91	78	73	58	45
Skjern	99	87	75	67	54	41
Ribe	92	81	68	62	50	38
Borris	86	79	64	56	44	31
Askov	74	61	55	46	42	32
Jyndevad	70	59	52	45	38	25

Winter rye	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	165	150	139	126	113	91
Årslev	142	131	119	110	92	77
Silstrup	144	132	117	112	99	79
Tylstrup	124	110	96	86	77	59
Foulum	135	119	108	98	89	69
Skjern	128	114	105	96	84	66
Ribe	119	109	97	85	73	59
Borris	114	105	88	79	69	57
Askov	100	88	74	68	57	42
Jyndevad	97	80	74	66	58	41

Beetroot	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	158	144	129	128	115	102
Årslev	131	118	107	103	93	84
Silstrup	109	93	81	80	65	60
Tylstrup	104	88	79	78	70	61
Foulum	107	92	84	83	68	61
Skjern	98	78	64	59	49	41
Ribe	94	77	61	58	45	39
Borris	77	71	67	61	53	40
Askov	83	66	51	48	40	33
Jyndevad	79	63	51	46	39	32

7 Irrigation at the model farms-level

Sønderjyllands amtskommune (1986)investigated the socio-economic consequences of irrigation in order to evaluate the importance of allocation of water for irrigation versus other uses (for example industry or environment). Irrigation can namely stabilise a farms production by decreasing the difference between the best and the worst years of production (Sønderjyllands amtskommune, 1986). This aspect of creating resilience to drought has an innate value on dairy farms due to the stabilisation of roughage yields and thereby milk production. The values of irrigation and yield increase were based on results from the research station in Jyndevad (coarse sand). This study concluded that irrigation increased the value of production with between 500 kr and 2,000 kr ha^{-1}, or 8 kr to 25 kr per mm ha^{-1} irrigation water, and the socio-economic value of agricultural production with 1.18 kr per mm ha^{-1} irrigation water. These values are likely different nowadays, because the prices of most products have become less since the publication.

7.1 Gross irrigation water requirement at farm level

The GIWR at farm level reflects the crop rotations of the three model-farms, with the dairy farm having more grass with high GIWR. At farm-level, there thus was great variety between locations and a decrease with increased RZC. Annually, the GIWR varied tremendously from year to year even when calculated at farm level, highlighting the influence of climatic variation between years. An example is shown in Fig. 5.1, in which the annual GIWR for the model dairy farm given the climatic conditions of Jyndevad (generally the lowest demand) and Flakkebjerg (generally the highest demand) at RZC 60 are presented. Additional figures (for the other farms, RZC, and climatic conditions) can be found in Appendix II. The median generally varied little from the average (data not shown). The annual variation of GIWR in Jyndevad was almost 300 % (from 82 mm ha^{-1} in 2007 up to 244 mm ha^{-1} in 1992), and almost 230 % in Flakkebjerg (from 128 mm ha^{-1} up to 295 mm ha^{-1} in 2007). The median in the figures represents the amount of irrigation water that has been sufficient to reach ET_P in 50 % of the years: 141 mm ha^{-1} in Jyndevad and 192 mm ha^{-1} in Flakkebjerg. The 80th percentile GIWR in Jyndevad was near the median, at 150 mm ha^{-1}, due to a high number of years close to this requirement. Generally, the difference between the median and the 80th percentile was clearer, as for example in Flakkebjerg, where the 80th percentile GIWR was 230 mm ha^{-1}, while the median was 192 mm ha^{-1}.

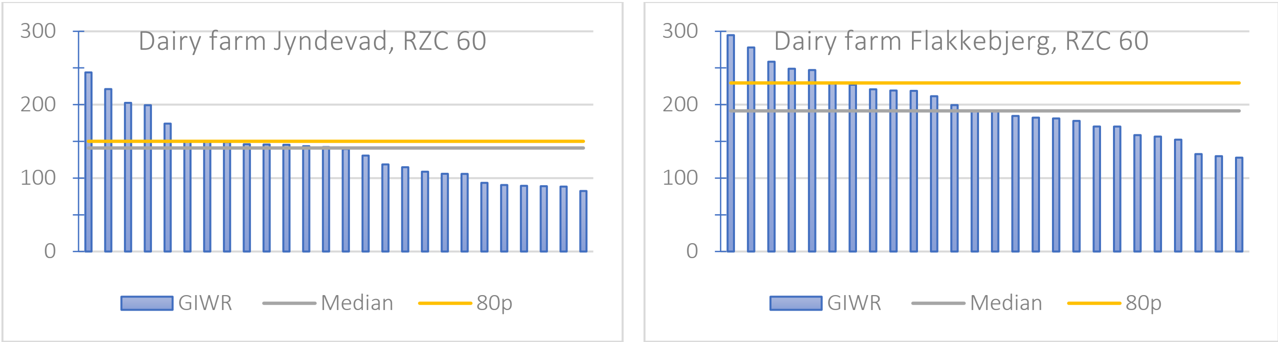


Fig. 5.1 *Annual gross irrigation water requirement (mm) for the model-dairy farm at root zone capacity 60 given the climatic conditions of Jyndevad and Flakkebjerg. Each bar represents the simulated gross irrigation water requirement of one year (1990-2015); the median the level of irrigation sufficient to meet the gross irrigation water requirement in five out of ten years, and; 80p the 80th percentile (i.e. the level of irrigation sufficient to meet the gross requirement in 80 % of the years).*

If farmers were given irrigation permissions up to the 80th percentile GIWR it would reduce the number of years their crops suffer from SWD (in comparison with the average GIWR) supposing no other conditions are limiting. For example, for the model-dairy farm at RZC 60, given the climatic conditions of Jyndevad, the average GIWR in Jyndevad was sufficient to irrigate the GIWR in 14 out of 26 years, while the 80th percentile was sufficient in 21 out of 26 years. A permission based on the average GIWR would have resulted in an excess-GIWR (the GIWR that could not be fulfilled) of 430 mm, whereas the excess-GIWR would have been 291 mm when the permit was based on the 80th percentile GIWR. For the model dairy farm at RZC 60 in Flakkebjerg, the excess GIWR would have been 472 mm when the permit was based on the average GIWR, while 179 mm when it would have been based on the 80th percentile GIWR. Assuming that barley has a water use efficiency of 20-25 kg grain mm^{-1} ha^{-1} (Aslyng, 1978; Andersen, Jensen and Lösch, 1992) the extra loss in transpiration over the 26 years would equal a loss in production of about 3000 kg grain ha^{-1} in Jyndevad, and of about 6000 kg grain ha^{-1}, or approximately the yield for one year, in Flakkebjerg.

***Table 5.1** The average gross irrigation water requirement (mm) of the three model farms for each root zone capacity given the climatic conditions of the various locations*

Dairy farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	206	187	173	161	146	129
Årslev	188	173	150	139	125	105
Silstrup	179	161	140	130	114	98
Tylstrup	165	147	129	115	102	80
Foulum	166	151	131	119	108	87
Skjern	161	145	127	116	103	85
Ribe	156	141	123	108	97	80
Borris	149	135	116	104	92	76
Askov	145	132	108	94	81	66
Jyndevad	143	125	104	92	73	61

Arable/pig farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	149	133	120	111	96	80
Årslev	137	122	106	94	83	65
Silstrup	144	127	111	99	87	72
Tylstrup	125	109	93	84	69	53
Foulum	129	115	100	90	77	60
Skjern	126	112	97	88	75	60
Ribe	120	106	93	80	68	53
Borris	114	100	88	76	66	51
Askov	113	99	83	68	57	46
Jyndevad	107	92	75	65	50	39

Potato farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	151	137	124	117	102	86
Årslev	139	127	111	99	89	71
Silstrup	147	130	115	103	92	75
Tylstrup	128	114	99	91	74	61
Foulum	131	117	103	93	82	64
Skjern	127	114	100	92	78	64
Ribe	120	107	95	83	71	57
Borris	117	104	91	78	69	56
Askov	116	102	85	73	60	48
Jyndevad	110	94	78	69	54	44

Table 5.2 *The 80th percentile gross irrigation water requirement (mm) of the three model farms for each root zone capacity given the climatic conditions of the various locations*

Dairy farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	230	216	210	191	180	162
Årslev	214	204	170	167	149	122
Silstrup	224	186	176	158	156	128
Tylstrup	199	198	174	152	141	122
Foulum	192	171	161	144	137	114
Skjern	190	173	158	144	137	114
Ribe	178	174	150	138	128	105
Borris	180	614	144	134	123	104
Askov	180	164	147	128	111	87
Jyndevad	150	146	135	134	99	104

Arable/pig farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	163	150	138	132	108	102
Årslev	158	144	120	114	108	84
Silstrup	168	150	138	120	108	90
Tylstrup	149	132	126	120	114	90
Foulum	149	138	108	108	102	90
Skjern	154	138	120	120	108	90
Ribe	139	120	108	90	90	60
Borris	132	138	108	108	90	78
Askov	129	114	96	90	66	60
Jyndevad	122	108	78	78	54	48

Potato farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	157	146	134	132	126	108
Årslev	143	128	122	108	108	84
Silstrup	151	132	124	114	108	90
Tylstrup	146	128	120	120	96	84
Foulum	139	130	112	108	98	84
Skjern	130	127	112	114	96	84
Ribe	124	113	100	96	84	66
Borris	129	119	103	96	90	78
Askov	126	106	96	90	84	66
Jyndevad	114	97	90	84	66	60

Table 5.3 *The difference between the average gross irrigation water requirement and the 80th percentile gross irrigation water requirement (mm) of the three model farms for each root zone capacity given the climatic conditions of the various locations*

Dairy farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	24	29	37	30	34	33
Årslev	26	31	20	28	24	17
Silstrup	45	25	36	28	42	30
Tylstrup	34	51	45	37	39	42
Foulum	26	20	30	25	29	27
Skjern	29	28	31	28	34	29
Ribe	22	33	27	30	31	25
Borris	31	479	28	30	31	28
Askov	35	32	39	34	30	21
Jyndevad	7	21	31	42	26	43

Arable/pig farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	14	17	18	21	12	22
Årslev	21	22	14	20	25	19
Silstrup	24	23	27	21	21	18
Tylstrup	24	23	33	36	45	37
Foulum	20	23	8	18	25	30
Skjern	28	26	23	32	33	30
Ribe	19	14	15	10	22	7
Borris	18	38	20	32	24	27
Askov	16	15	13	22	9	14
Jyndevad	15	16	3	13	4	9

Potato farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	6	9	10	15	24	22
Årslev	4	1	11	9	19	13
Silstrup	4	2	9	11	16	15
Tylstrup	18	14	21	29	22	23
Foulum	8	13	9	15	16	20
Skjern	3	13	12	22	18	20
Ribe	4	6	5	13	13	9
Borris	12	15	12	18	21	22
Askov	10	4	11	17	24	18
Jyndevad	4	3	12	15	12	16

The results presented in Table 5.1 and in Table 5.2 assume optimal irrigation situations, i.e. all fields of a farm are irrigated the moment SWD exceeds the A_F of a given crop at a given growth stage. This neglects the fact that a farmer is restricted by (i) the irrigation capacity of his irrigation system, (ii) the limited area around a well that can be irrigated from the well, and (iii) the time it takes to move the irrigation equipment around to irrigate all fields. Taking such restrictions into consideration lowers the GIWR of a farm, yet it is impractical to account for all such management specific circumstances in a general study as the one presented here. The practical irrigation capacity (PIC) accounts for some of these technical limitations. Analyses using Eq. 5 at RZC 60 given the climactic conditions of Jyndevad showed that an irrigation capacity of 4 mm $ha^{-1}day^{-1}$ (IC_4) only limited the GIWR to a negligible extent in a few years. For a farmer with an irrigation capacity of 3 mm $ha^{-1}day^{-1}$ (IC_3) however, the application of irrigation water would have encountered limitations due to irrigation capacity in most years; an IC_3 would have kept actual irrigation from meeting the GIWR in

15 out of 26 years on the dairy farm, and in 17 out of the 26 on both the arable/pig and potato farm (Table 5.4). When we assume that the annual irrigation permission was based on the average GIWR, the model farms would not have been able to meet their PIC in multiple years, whether with an IC of 3 or 4 mm $ha^{-1}day^{-1}$. An IC_3 of course resulted in more, and higher, incapacities: five years at the model dairy farm with an average excess PIC of 46 mm; nine years at the model arable/pig farm with an average excess PIC of 32 mm, and; nine years at the model potato farm with an average excess PIC of 29 mm. Assuming that the annual irrigation permission was based on the 80th percentile, the model farms would have been able to make more use of their PIC. Such a permission would have meant that the model dairy farm could not use its PIC in five years with an average excess PIC of 39 mm; the model arable/pig farm not in six years with an average excess PIC of 30 mm, and; the model potato farm not in eight years with an average excess PIC of 29 mm.

The GIWR at Jyndevad is the lowest of all climatic conditions simulated. The irrigation capacity is therefore expected to be more limiting at the other locations in this study, even though small deviations may exist. Such deviations may occur because the PIC is calculated on a daily basis, and is thus stronger related to the occurrence of individual periods with high SWD than to the total magnitude of SWD over a season. It is expected that the irrigation capacity is more limiting in practice than the PIC calculated. Many farms are expected to have an irrigation capacity of less than 3 mm and thus to have bigger limitations. Moreover, the calculations were limited by the irrigation capacity, but not limited by management. The PIC assumed that the crop requiring irrigation was provided with irrigation if technically feasible. The total capacity of the farm was freely and evenly usable on all crops, meaning that for instance the capacity 'reserved' for one crop, which did not require irrigation, could be used on all other crops that did. In practice, a farmer is often much more limited with respect to performing such spatial shifts of irrigation capacity. For instance, the fields which need to be irrigated may belong to another well already in use or may require long distance movement of irrigation machines, which doesn't fit with the overall farm logistics. Such conditions in practise contribute to reduced possibilities of applying irrigation water to the requiring crops at the right time. The PIC attempted to account for this with the 5-day buffer, however, being able to compensate for 15 mm or 20 mm could be too optimistic.

Table 5.4 *Annual gross irrigation water requirement, excess gross irrigation water requirement at IC_3 and IC_4 (>IC_3 and >IC_4), and annual PIC for the three model farms at Jyndevad, RZC 60, in mm.*

	Dairy					Arable/pig					Potato				
Year	*GIWR*	*>IC_3*	*>IC_4*	*PIC_3*	*PIC_4*	*GIWR*	*>IC_3*	*>IC_4*	*PIC_3*	*PIC_4*	*GIWR*	*>IC_3*	*>IC_4*	*PIC_3*	*PIC_4*
1990	105	0	0	105	105	78	0	0	78	78	76	1	0	75	76
1991	114	0	0	114	114	83	1	0	82	83	76	1	0	75	76
1992	240	25	3	215	237	191	25	5	166	186	208	41	12	167	196
1993	131	3	0	128	131	154	7	0	147	154	160	11	1	149	159
1994	142	5	0	137	142	102	0	0	102	102	110	0	0	110	110
1995	204	13	0	191	204	136	6	0	130	136	150	8	0	142	150
1996	166	0	0	166	166	114	2	0	112	114	127	0	0	127	127
1997	137	7	0	130	137	96	13	0	83	96	117	11	0	106	117
1998	78	0	0	78	78	94	1	0	93	94	91	16	3	75	88
1999	142	0	0	142	142	77	0	0	77	77	79	0	0	79	79
2000	140	0	0	140	140	107	5	0	102	107	99	0	0	99	99
2001	146	3	0	143	146	128	0	0	128	128	120	0	0	120	120
2002	85	0	0	85	85	45	2	0	43	45	62	1	0	61	62
2003	133	0	0	133	133	66	0	0	66	66	8	0	0	8	8
2004	80	2	0	78	80	80	0	0	80	80	81	0	0	81	81
2005	140	11	0	129	140	97	2	0	95	97	100	5	0	95	100
2006	199	22	0	177	199	156	7	0	149	156	163	11	0	152	163
2007	86	5	0	81	86	99	4	0	95	99	87	6	0	81	87
2008	203	6	0	197	203	202	12	0	190	202	185	19	2	166	183
2009	115	3	0	112	115	107	2	0	105	107	100	1	0	99	100
2010	106	6	0	100	106	116	2	0	114	116	117	8	0	109	117
2011	86	0	0	86	86	86	0	0	86	86	79	3	0	76	79
2012	80	0	0	80	80	78	0	0	78	78	75	0	0	75	75
2013	145	21	1	124	144	103	7	0	96	103	116	4	0	112	116
2014	102	0	0	102	102	76	1	0	75	76	88	0	0	88	88
2015	138	14	2	124	136	112	0	0	112	112	118	1	0	117	118

Red values: irrigation limited by the IC; blue values: maximum (by capacity limited) GIWR.

7.2 The effect of the GIWR on drainage

The effect of the GIWR on drainage at farm-level showed, logically as at crop-level, the tendency to decrease with increasing RZC (Table 5.5). However, the decrease is not equivalent due to the shares of crops in the rotation. The NIWR at farm-level is presented in Table 5.6.

Table 5.5 *The increase of drainage (mm) of the irrigation simulations for the three model farms for each root zone capacity given the climatic conditions of the various locations.*

			Dairy farm			
Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	37	30	26	19	14	12
Årslev	44	40	27	21	16	12
Silstrup	49	45	33	28	22	17
Tylstrup	51	43	35	24	19	9
Foulum	41	36	26	17	14	11
Skjern	49	47	43	39	34	27
Ribe	48	47	44	38	34	30
Borris	50	48	42	29	30	16
Askov	54	56	45	37	30	25
Jyndevad	56	54	44	38	28	22
			Arable/pig farm			
Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	21	15	11	8	5	3
Årslev	28	22	14	8	7	4
Silstrup	28	21	14	5	4	3
Tylstrup	28	20	14	11	7	2
Foulum	22	15	11	7	4	3
Skjern	26	21	16	11	8	5
Ribe	28	24	21	14	11	8
Borris	25	20	20	14	12	5
Askov	37	36	26	17	12	9
Jyndevad	38	33	24	17	10	7
			Potato farm			
Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	23	18	13	10	6	4
Årslev	29	25	15	9	8	3
Silstrup	31	25	18	8	6	4
Tylstrup	31	23	16	13	8	3
Foulum	24	18	13	9	6	4
Skjern	30	26	21	15	11	7
Ribe	31	28	25	17	14	10
Borris	29	25	22	15	14	7
Askov	39	37	28	20	13	8
Jyndevad	41	34	27	20	12	9

Table 5.6 *The average net irrigation water requirement (mm) for the three model farms for each root zone capacity given the climatic conditions of the various locations.*

Dairy farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Jyndevad	169	157	147	142	132	117
Askov	144	133	123	118	109	93
Tylstrup	130	116	107	102	92	81
Borris	114	104	94	91	83	71
Skjern	125	115	105	102	94	76
Silstrup	112	98	84	77	69	58
Ribe	108	94	79	70	63	50
Årslev	99	87	74	75	62	60
Foulum	91	76	63	57	51	41
Flakkebjerg	87	71	60	54	45	39

Arable/pig farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	128	118	109	103	91	77
Årslev	109	100	92	86	76	61
Silstrup	115	105	97	94	83	68
Tylstrup	97	89	79	73	61	51
Foulum	107	99	89	83	73	57
Skjern	100	91	81	77	67	55
Ribe	92	82	72	66	57	46
Borris	90	81	69	63	54	47
Askov	76	63	57	51	45	37
Jyndevad	69	59	51	48	40	33

Potato farm

Station \ RZC	*60*	*80*	*100*	*120*	*140*	*160*
Flakkebjerg	128	119	111	107	96	82
Årslev	110	102	95	89	81	68
Silstrup	115	104	97	94	86	71
Tylstrup	97	91	83	77	66	58
Foulum	106	99	90	85	76	60
Skjern	97	88	79	77	67	57
Ribe	89	80	70	66	57	47
Borris	89	79	70	63	55	50
Askov	77	64	58	53	47	40
Jyndevad	69	59	51	49	41	35

8 A comparison with previous studies

8.1 A comparison with the study by Gregersen and Knudsen (1981)

In comparison with Gregersen and Knudsen (1981) we generally found higher to much higher values for the average GIWR (Table 6.1). When comparing the average effect of the GIWR on drainage, the results tended also to be slightly higher in the simulations of *Vandregnskab* (Table 6.2). At higher RZC, these trends were similar. Even though the way the results are calculated and presented differs between the current study and the study by Gregersen and Knudsen (1981), we believe a comparison is relevant. That is, Gregersen and Knudsen (1981) resented their results averaged over an aggregated area (county), while in the present study the results are related to the climatic conditions of individual locations. Moreover, the authors calculated the results for six groups of crops based on one or more out of four crop models (grass, spring cereal, potato for consumption, and starch potato), whereas we assessed the crops individually. Still, we were able to compare the crops spring barley, grass-clover, potatoes (both starch and consumption), and maize for several locations. For example, Borris and Skjern are compared to Ringkøbing, which in Gregersen and Knudsen (1981) was comprised by station-data from Studsgård, Borris, and Stauning.

Table 6.1 *Comparison of long-term average gross irrigation water requirement (mm) for crops at root zone capacity 60 as simulated by Vandregnskab and modelled by Gregersen and Knudsen (1981).*

Vandregnskab 1990-2015 GIWR		Gregersen and Knudsen 1957-1976 GIWR	
Crop	*Borris*	*Crop*	*Ringkøbing*
Spring barley	112	Spring cereals	85
Potatoes (consumption)	142	Potatoes (consumption)	89
Starch potatoes	130	Starch potatoes	99
Grass	193	Grass	181
Maize	144	Maize	92

Table 6.2 *Comparison of long-term average effect of gross irrigation water requirement on drainage (ΔD, in mm) for crops at root zone capacity 60 as simulated by Vandregnskab and modelled by Gregersen and Knudsen (1981).*

Vandregnskab 1990-2015 ΔD		Gregersen and Knudsen 1957-1976 ΔD	
Crop	*Borris*	*Crop*	*Ringkøbing*
Spring barley	30	Spring cereals	29
Potatoes (consumption)	39	Pooatoes (consumption)	36
Starch potatoes	55	Starch potatoes	36
Grass	60	Grass	40
Maize	38	Maize	31

Several reasons may underlie the increase of GIWR. First of all, the way ET_0 is calculated has changed: Gregersen and Knudsen (1981) used the pan-evapotranspiration measurements, whereas in *Vandregnskab* the *Makkink* equation is used. The *Makkink* equation is preferred over pan-evapotranspiration measurements as the latter has several difficulties affecting the accuracy such as the shelter and oasis effect, the heat capacity of the water volume in the pan, and the screen placed over the pan (Mikkelsen and Olesen, 1991). Mikkelsen and Olesen (1991) concluded that the shelter and oasis effect may result in a 10 % error on the average evapotranspiration. One way to assess the effect of these different methods, is to calculate ET_0 for 1957-1976 according to the *Makkink* equation. However, the required data on solar radiation was not measured at the time of the study by Gregersen and Knudsen (1981), when the use of sun-hours still was common practice. Part of the increase could also be caused by differences in the model applied such as leaf area development and duration over the season, as well as a change of the evapotranspiration factors in the crop models to calculate ET_A. In the study of Gregersen and Knudsen (1981), crop coefficients were expected to be maximum of 1.0, whereas the crop coefficients in *Vandregnskab* now reach 1.20 for potatoes and 1.10 for all other crops. Another reason for the increased GIWR may be climate change, yet such an analysis would need to be very detailed to be conclusive and did not fit the scope of the current study.

8.2 A comparison with Madsen and Holst (1990)

Madsen and Holst (1990) calculated the NIWR of grass and spring barley in four climatic regions over the period 1956-1985 for calculated RZC (based on the Danish Geological Surveys map at scale 1:25.000). The average NIWR for spring barley in Tørring-Uldum was presented by Breuning-Madsen, Hedegaard and Balstrøm (1999). Two locations of the present study are clearly located in the climatic region of Madsen and Holst (1990) in which Tørring-Uldum is located: Årslev and Flakkebjerg. Possibly, Tylstrup is part of the same climatic region. In a comparison, we found higher average NIWR (Table 6.3). As in the comparison with Gregersen and Knudsen (1981), the difference may be explained by the improvement of models over time or possibly in climate change. Yet, part of the difference in the comparison of the present study with Tørring-Uldum may be explained by the way the climatic data has been used: for Tørring-Uldum the data of 15 stations was used to calculate weekly values of precipitation and ET_P from April until the end of October, after which the weekly data has been evenly distributed to obtain daily values (Madsen and Holst, 1990). The differences concerning the months used in the two analyses are not expected to have caused an increase, as spring barley would not have been irrigated in March and was harvested in August. Yet, given the variation of the requirements between the different stations in the current study, it seems unreliable to calculate the location-specific climatic data based on such an aggregated area.

Table 6.3 *Comparison of the long-term average net irrigation water requirement (mm) for spring barley as simulated by Vandregnskab and modelled by Madsen and Holst (1990) (figures taken from Breuning-Madsen, Hedegaard and Balstrøm (1999)).*

	Vandregnskab 1990-2015 NIWR			Madsen and Holst 1956-1985 NIWR	
RZC	Årslev	Flakkebjerg	Tylstrup	RZC	Tørring-Uldum
80	93	111	83	75	68
100	87	102	76	112	51
120	82	99	72	122	46
140	73	85	60	147	36
160	59	74	50	162	31

9 Perspectives

During the study several side-projects developed out of the interest to support the discussion of issuing irrigation permission in Denmark. One of these projects focusses on the correlation between climatic conditions and the GIWR, while another focusses on the influence of irrigation on crop yield.

Given the spatial differences of the GIWR it is desirable to calculate the requirement based on location-specific set of climatic data. Yet, current methods are devious, and a method which enables to calculate the GIWR for any given location based on its climatic dataset is required. The GIWR is however not well correlated to individual parameters of the climatic datasets as precipitation. We still aim to develop a method to correlate the GIWR, yet the project is ongoing. Currently, the results are most positive when seasonal GIWR is calculated from precipitation deficit data, and when it is calculated from data on drought periods. The method needs however to be tested and developed further, and on bigger scale.

Vandregnskab not only calculated the daily GIWR and drainage, but also provided data on crop yield development. Such information will be valuable in irrigation planning, however requires further analyses of the data generated in the present study. With such a study, we expect to become able to compare the difference between full-irrigated and non-irrigated yield for each combination of RZC and crop, i.e. the effect of the annual GIWR on yield. The effect of the 80^{th} percentile GIWR might also be extracted. Such analysis would be an important contribution for further evaluation of the size of irrigation permits.

10 Conclusion

The simulated GIWR of the present study were supported by a good correlation with actual irrigation amounts used in fully irrigated experiments carried out in Jyndevad, with a significant r^2 of 0.67. The slope of the trend line (0.7) indicated a tendency to irrigate more in the experiments than the model suggested in dry years, whereas in wet years actual irrigation was less than simulated.

The GIWR depends on both soil- and crop specifications. The average GIWR decreased nearly linearly with increasing RZC. The variation between crops was related to (i) the length of the growing season and (ii) the amount of precipitation within their different growing seasons. Some crops may however be grouped in order to decrease the size of the dataset. These characteristics may be taken into account during strategic irrigation planning in order to lower peak demands.

The GIWR showed big spatial variation, which is a response to the differences in precipitation patterns and ET_0 between the ten locations analysed. Jyndevad tended to be the location with the lowest GIWR, while Flakkebjerg often had the highest GIWR, corresponding to the difference in precipitation between the two locations. At a given location, the GIWR decreased nearly linearly with increasing RZC. At farm level, the differences between the three model farms (dairy, arable/pig, and potato) resulted from their different crop rotations, with the dairy farm having more grass with higher GIWR. The GIWR also showed a big temporal variation: for example, for the model dairy farm at RZC 60, the annual variation in Jyndevad was up to almost 300 % (from 82 mm ha^{-1} in 2007 up to 244 mm ha^{-1} in 1992), and up to nearly 230 % in Flakkebjerg (from 128 mm ha^{-1} up to 295 mm ha^{-1} in 2007). No correlation was found between the GIWR and drainage (the slopes ranged from 0.120 to 0.179 and r^2 from 0.176 to 0.101 for the different RZC). The return flow related well to general expectations (typically 25-30 % at RZC 60, compared to a reference of 30 %).

The use of an average GIWR is not suitable as a basis for issuing annual irrigation permission due to the yearly variation of the GIWR. Such an average – as has commonly been used by the Danish countries – is only sufficient to meet the GIWR in 50 % of the years. It is however a challenge to issue irrigation permits in such a way that it is acceptable for farming, environment, and society. From an agricultural point of view, a permit covering the maximum demand could be desirable: irrigation is most valuable in the dry years when the demands are high, and irrigation allows the farmer to reach potential yield and avoid loss of both quantity and quality due to drought. Yet, this could result in very high water extraction in some years which can be incompatible with environmental goals for stream flows. Moreover, it neglects the fact that a farmer is restricted, by amongst others the irrigation capacity of his irrigation system (it is generally assumed that many farms have a capacity of 3 mm $ha^{-1}day^{-1}$ or less, while 4 mm $ha^{-1}day^{-1}$ is used when dimensioning an optimal irrigation system). A more realistic optimum of water extraction permissioned for irrigation may thus be found between the average and maximum GIWR, e.g. at the 80th percentile GIWR: the level sufficient to meet the GIWR in 80 % of the years.

For the assessed period (1990-2015), the 80th percentile GIWR for the model farms at Jyndevad RZC 60, were 150 mm for the dairy farm, 122 mm for the arable/pig farm, and 114 mm for the potato farm. These values are respectively 7 mm, 15 mm, and 4 mm per year higher than the average GIWR. At Jyndevad with an RZC of 60 mm, an irrigation capacity of 4 mm would have limited the annual GIWR with a negligible extent and in only a few years. However, an irrigation capacity of 3 mm would have limited the GIWR in 15 out of 26 years on the dairy farm, and in 17 out of the 26 on both the arable/pig and potato farm. Nevertheless, when we considered the 80th percentile GIWR (as a basis for permission), the PIC was in some years larger than the limits of such permission. Based on the average GIWR and an irrigation capacity of 3 mm $ha^{-1}day^{-1}$, the model dairy farm could not have irrigated sufficiently to reach its PIC in five years out of 26 (with an average excess PIC of 46 mm). Similarly, the model arable/pig farm and model potato farms could not reach their PIC in nine years (with an average excess PIC of 32 mm and 29 mm respectively). Based on the 80th percentile GIWR, the model dairy farm could not reach its PIC in five years (yet with an average excess PIC of 39 mm), the model arable/pig farm not in six years (with an average excess of 30 mm), and the model potato farm not in eight years (with an average excess PIC of 29 mm). Compared to the average GIWR, the 80th percentile GIWR accordingly fits better to a farm's needs. The GIWR of the other locations were higher, thus the limitations as well would be expected to be bigger.

In comparison with the earlier studies of Gregersen and Knudsen (1981) and Madsen and Holst (1990) we found higher values of the GIWR. The increases may partly result from the improved methods of calculating evapotranspiration: instead of using pan-measurements, global radiation is now measured. Furthermore, crop coefficients have been given higher values from a maximum of 1.0 to now 1.20 for potatoes and 1.10 for other crops. Climate change may also have affected the GIWR. To verify this assumption more detailed studies are needed to better compare the different periods.

11 References

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. (1998) 'Introduction to evapotranspiration', in *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. FAO, Rome, pp. 1–13. doi: 10.1016/j.eja.2010.12.001.

Allerup, P. and Madsen, H. (1979) 'Accuracy of Point Precipitation Measurements', *Danmarks Meteorologiske Institut. Klimatologiske Meddelelser No. 5.*

Allerup, P., Madsen, H. and Vejen, F. (1998) 'Standardværdier (1961-90) af Nedbørkorrektioner - Technical report'. Danish Meteorological Institute, Copenhagen, 98–10, p. 1–18 (in Danish).

Andersen, M. N., Asch, F., Wu, Y., Jensen, C. R., Næsted, H., Mogensen, V. O. and Koch, K. E. (2002) 'Soluble invertase expression is an early target of drought stress during the critical, abortion-sensitive phase of young ovary development in maize', *Plant physiology*, 130, pp. 591–604. doi: 10.1104/pp.005637.

Andersen, M. N., Jensen, C. R. and Lösch, R. (1992) 'The interaction effects of potassium and drought in field-grown barley. I. Yield, water-use efficiency and growth', *Acta Agriculturae Scandinavica*, Sect. B.(42), pp. 34–44.

Aslyng, H. C. (1978) *Vanding i jordbruget, DSR Forlag, Den kgl. Veterinær- og Landbohøjskole*.

Breuning-Madsen, H., Hedegaard, M. B. and Balstrøm, T. (1999) 'Land assessment maps of Denmark based on the Danish Soil Classification's databases and former trial land assessments', *Geografisk Tidsskrift, Danish Journal of Geography*, (si01), pp. 33–45.

Danmarks Statistik (2010) *Landbrug 2010 Statistik om landbrug, gartneri og skovbrug*. (in Danish).

Denmead, O. T. and Shaw, R. H. (1962) 'Availability of Soil Water to Plants as Affected by Soil Moisture Content and Meteorological Conditions', *Agronomy Journal*, 54, pp. 385–390. doi: 10.2134/agronj1962.00021962005400050005x.

Doll, P. and Siebert, S. (2002) 'Global modeling of irrigation water requirements', *Water Resources Research*, 38(4), pp. 1–10. doi: 10.1029/2001WR000355.

European Environment Agency (2009) 'Water resources across Europe — confronting water scarcity and drought', *EEA Report*. Copenhagen, (No 2), pp. 1–58.

Fischer, G., Tubiello, F. N., van Velthuizen, H. and Wiberg, D. A. (2007) 'Climate change impacts on irrigation water requirements: effects of mitigation, 1990-2080', *Technological Forecasting and Social Change*, 74(7), pp. 1083–1107. doi: 10.1016/j.techfore.2006.05.021.

Foster, S. S. D. and Perry, C. J. (2010) 'Improving groundwater resource accounting in irrigated areas: a prerequisite for promoting sustainable use', *Hydrogeology Journal*, 18(2), pp. 291–294. doi: 10.1007/s10040-009-0560-x.

Gregersen, A. K. and Knudsen, H. (1981) 'Normalværdier for vandingsbehov, afstrømning og nettovandbehov ved forskellig rodzonekapacitet', *Tidsskrift for Planteavls Secialserie*, nr. S 1537, p. 1–21 (in Danish with English summary).

Hansen, G. K. (1975) 'A dynamic continuous simulation model of water-state and transportation in the soil-plant-atmosphere system', *Acta Agriculturae Scandinavica*, (24), pp. 83–92.

Hansen, G. K. (1987) 'A summary of a simulation model, Heimdal, for water use and growth of crops', in Feyen, J. (ed.) *Simulation Models for Cropping Systems in Relation to Water Management, Proc. Symp. in the Community Programme for Coordination of Agricultural Research, 26-28 November 1986, Louvain. Rep. EUR 10869 EN, Luxembourg, Commission of the European Communities*, pp. 73–

90.

Jensen, F. (1987) 'Vandingsbehov i forskellige vækstfaser hos ærter', *Tidsskrift for Planteavls*, 91, p. 113–119 (in Danish).

Jensen, O. E., Jensen, P. N., Nilsson, I. K., Kruse, A. S., Vansgaard, C., Hvid, S. K., Rohde, M. J., Thygesen, L. B., Pedersen, J., Voss, J., Roelsgaard, J. S., Nielsen, H., Skriver, M., Guldager, H., Kjærstrup, M. and Larsen, G. (2013) 'Balance mellem vandforekomster og vandindvinding til markvanding', *Arbejdsnotat*, p. 1–82 (in Danish).

Kolind Hvid, S. (2017) 'Landskonsulent at Seges, Planter & Miljø', p. April.

Legg, B. J., Day, W., Lawlor, D. W. and Parkinson, K. J. (1979) 'The effects of drought on barley growth: models and measurements showing the relative importance of leaf area and photosynthetic rate', *The Journal of Agricultural Science*, 92, pp. 703–716. doi: 10.1017/S0021859600053958.

Madsen, H. B. and Holst, K. A. (1990) 'Mapping of irrigation need based on computerized soil and climatic data', *Agricultural Water Management*, 17, pp. 391–407.

Madsen, H. B. and Platou, S. W. (1983) 'Land-Use planning in Denmark: the use of soil physical data in irrigation planning', *Nordic Hydrology*, pp. 267–276.

Mikkelsen, H. E. and Olesen, J. E. (1991) 'Sammenligning af metoder til bestemmelse af potentiel vandfordampning', *Tidsskrift for Planteavls Secialserie*, nr. S 2157, p. 72 (in Danish with English summary).

Mogensen, V. O. and Hansen, B. S. (1978) 'Drought periods in Denmark 1956-1976 - Calculations for field irrigation', *Den Kongelige Veterinær- og Landbohøjskole*, 1979, pp. 25–42.

Olesen, J. E. and Plauborg, F. (1995) 'MVTOOL version 1.10 for developing MARKVAND', SP report(No 27), p. 64.

Perry, C., Steduto, P., Allen, R. G. and Burt, C. M. (2009) 'Increasing productivity in irrigated agriculture: agronomic constraints and hydrological realities', *Agricultural Water Management*, 96(11), pp. 1517–1524. doi: 10.1016/j.agwat.2009.05.005.

Plauborg, F. and Olesen, J. E. (1991) 'Udvikling og validering af modellen MARKVAND til vandingsstyring i landbruget', *Tidsskrift for Planteavls Secialserie*, nr S 2113, p. 1–103 (in Danish with English summary).

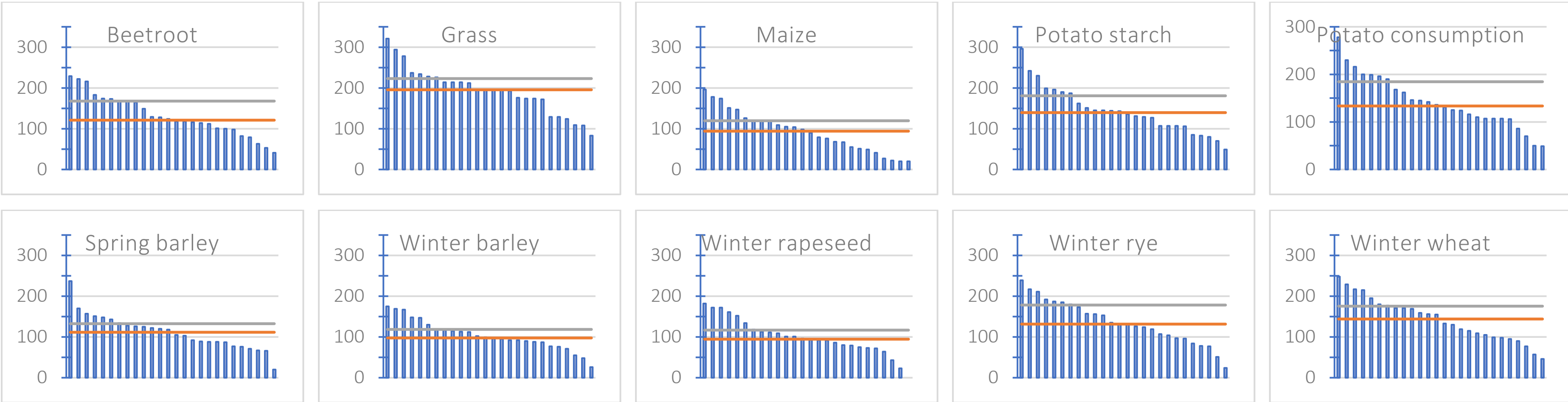
Sønderjyllands amtskommune (1986) 'Markvanding i Sønderjylland - Produktionsøkonomiske bereninger (in Danish)'.

Thysen, I., Andersen, M. N. and Plauborg, F. (2006) 'Vandregnskab i PlantenInfo', *Grøn Viden, Markbrug*, 319, p. 2–8 (in Danish).

Thysen, I. and Detlefsen, N. K. (2006) 'Online decision support for irrigation for farmers', *Agricultural Water Management*, 86(3), pp. 269–276. doi: 10.1016/j.agwat.2006.05.016.

Tuller, M. and Or, D. (2004) 'Retention of water in soil and the soil water characteristic curve', *Encyclopedia of soils in the environment*, 4, pp. 278–289.

12 Appendix I - A. Annual GIWR at crop-level at RZC 60



NB. All graphs from Borris RZC 60

Beetroot

Year	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Flakkebjerg	182	122	303	165	223	270	236	242	163	147	223	155	203	201	120	210	173	96	195	256	181	101	197	223	236	176
Årslev	147	163	273	142	157	269	212	244	104	149	90	166	174	226	146	170	175	64	189	213	204	80	119	185	288	156
Silstrup	155	186	255	142	183	242	228	202	54	118	134	75	166	182	180	161	177	104	158	178	163	85	96	197	151	71
Tylstrup	160	203	258	148	173	241	257	180	36	133	104	55	175	173	159	122	159	78	164	76	191	42	87	182	205	139
Foulum	186	139	240	185	170	244	209	202	55	145	97	125	148	170	139	128	178	97	156	159	141	80	77	130	158	79
Skjern	117	145	245	131	151	242	187	180	72	101	116	97	150	155	136	141	174	78	143	168	177	116	76	198	219	117
Ribe	82	141	241	94	157	223	156	165	58	79	134	112	128	154	122	158	196	49	182	165	154	77	73	182	181	130
Borris	112	118	229	128	114	222	174	167	53	129	118	116	168	149	124	165	173	79	101	216	82	41	98	183	100	63
Askov	98	107	233	93	145	222	115	183	77	129	98	100	69	127	137	122	197	63	129	118	120	55	93	176	204	159
Jyndevad	82	86	242	96	131	222	158	146	35	136	107	115	132	172	76	164	183	60	159	99	125	34	79	134	107	115

Grass-clover (for silage)

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	281	195	363	258	299	360	316	331	210	257	295	233	270	253	189	278	277	212	308	361	191	186	277	294	296	234
Årslev	259	257	345	238	233	304	276	281	166	230	171	231	236	294	187	274	256	173	303	296	212	173	168	254	368	214
Silstrup	256	289	322	249	298	308	279	259	128	190	218	129	213	213	252	232	250	190	260	262	170	171	151	270	235	107
Tylstrup	237	298	347	213	285	323	315	216	104	170	171	149	232	156	209	167	214	155	260	107	194	127	152	258	283	166
Foulum	256	198	318	252	274	297	290	235	124	206	167	192	211	196	192	194	211	170	253	234	169	168	127	199	235	127
Skjern	188	232	296	211	215	282	250	211	126	173	171	170	170	171	212	191	258	171	260	252	170	194	107	256	282	147
Ribe	199	214	320	174	212	280	247	216	103	165	191	170	149	190	189	212	274	168	283	232	171	170	109	232	235	191
Borris	214	214	294	196	172	278	234	193	109	226	195	174	212	196	174	195	228	176	214	321	108	124	129	237	129	83
Askov	189	191	328	170	229	278	214	190	125	190	170	130	89	168	207	149	281	150	232	213	129	150	153	220	261	151
Jyndevad	169	170	312	190	210	280	228	196	107	215	209	191	141	213	127	173	254	150	277	168	128	124	106	190	169	175

Maize

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	93	131	207	102	196	244	197	176	122	142	173	147	101	123	44	158	147	42	124	153	107	48	121	168	167	128
Årslev	118	166	209	78	123	247	176	150	70	143	56	121	105	173	66	133	125	22	122	124	102	48	66	176	222	127
Silstrup	121	176	206	56	149	218	177	178	20	123	103	49	96	151	98	141	128	45	99	104	29	50	46	142	125	49
Tylstrup	114	198	228	77	146	216	217	157	20	91	70	50	102	121	107	99	96	23	100	55	81	22	70	149	144	93
Foulum	119	105	203	79	150	219	201	154	26	115	71	104	94	120	88	106	116	21	97	100	68	47	40	98	116	73
Skjern	93	125	189	52	143	224	143	125	26	87	96	97	46	118	89	79	145	22	117	81	48	79	43	154	150	95
Ribe	90	123	210	28	126	197	145	124	28	89	98	76	28	124	65	134	147	43	102	102	53	47	23	133	137	101
Borris	76	104	178	55	109	196	174	118	27	118	98	79	68	120	90	105	147	22	51	151	20	20	41	126	49	67
Askov	95	75	180	26	148	200	98	125	0	141	72	76	26	99	73	73	147	22	69	53	52	26	44	156	138	120
Jyndevad	72	75	184	28	122	194	141	95	20	124	76	98	48	146	43	107	145	20	104	53	55	48	47	100	67	106

Potato starch

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	146	139	289	149	249	244	263	223	157	134	224	187	109	171	102	168	194	109	184	208	183	85	153	205	231	181
Årslev	150	163	287	141	190	248	233	217	122	133	99	143	107	203	113	152	182	95	195	196	188	78	126	190	263	173
Silstrup	154	190	298	151	230	266	261	219	73	123	165	123	117	184	174	180	194	106	172	140	160	75	124	204	184	103
Tylstrup	178	203	286	164	214	251	275	215	48	107	125	123	101	161	156	144	177	91	174	90	138	61	106	186	238	160
Foulum	176	124	280	160	192	248	236	202	101	126	109	151	97	152	140	114	182	84	170	146	156	80	93	170	190	115
Skjern	131	150	286	111	190	245	191	181	70	77	129	117	68	146	146	131	190	83	177	148	139	95	108	180	225	153
Ribe	95	126	295	83	185	226	188	167	62	83	144	125	82	138	134	141	207	71	182	147	153	77	90	164	194	163

Potato starch (continuation)

Borris	151	145	296	129	162	242	196	187	80	127	143	144	107	145	136	131	190	85	107	230	83	49	106	199	107	70
Askov	110	128	287	104	190	230	155	174	102	120	114	128	51	113	137	115	226	73	129	124	134	81	93	183	216	185
Jyndevad	96	101	280	84	174	227	179	165	56	111	127	135	89	164	105	109	195	91	171	107	120	67	79	154	142	144

Potato consumption

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	149	121	283	270	248	227	242	205	139	134	207	186	108	171	102	167	201	108	184	212	188	91	153	205	236	180
Årslev	150	162	286	242	190	227	236	199	98	133	102	143	87	184	113	132	182	94	195	195	190	78	125	190	262	182
Silstrup	154	189	297	245	229	236	261	218	76	123	148	130	100	166	174	179	194	106	172	140	185	75	124	204	188	108
Tylstrup	181	184	290	231	214	209	275	198	31	90	125	104	83	160	156	135	177	91	174	90	164	61	87	189	227	165
Foulum	159	132	279	247	192	210	235	201	82	126	109	151	79	151	140	114	182	84	170	145	138	80	93	170	190	124
Skjern	103	118	269	227	193	202	190	180	53	77	129	117	71	127	149	130	190	83	177	151	174	100	108	180	214	141
Ribe	95	115	272	202	184	194	174	166	34	83	126	108	73	138	137	132	207	76	182	132	155	77	90	164	194	163
Borris	124	125	278	216	162	200	196	168	50	110	142	146	107	145	136	131	190	86	107	230	116	49	106	199	107	70
Askov	110	97	287	179	190	210	147	174	85	119	113	130	53	112	137	114	207	73	129	124	155	81	93	183	216	181
Jyndevad	96	83	263	207	163	190	179	164	56	111	109	117	88	146	105	123	195	90	171	107	135	67	78	154	142	144

Spring barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	119	98	260	191	169	164	165	162	106	71	171	166	84	73	107	146	144	87	195	182	147	122	107	144	185	138
Årslev	141	128	239	174	126	141	159	142	94	71	118	143	83	93	83	140	145	92	193	167	148	99	86	126	166	146
Silstrup	140	171	240	184	187	151	206	189	104	73	129	119	86	69	156	119	173	91	168	191	158	79	93	174	140	44
Tylstrup	113	150	237	186	173	163	189	146	61	48	97	91	84	74	126	70	146	69	191	99	140	45	42	146	150	96
Foulum	141	101	238	214	187	147	193	147	84	114	92	142	64	71	108	118	123	105	164	146	109	78	62	148	115	49
Ribe	92	95	211	134	126	143	114	112	65	68	119	116	65	51	85	119	164	74	193	122	143	97	82	148	137	126
Skjern	87	129	237	168	120	142	163	118	109	43	117	93	86	50	105	119	140	92	165	157	141	128	64	147	164	95
Borris	88	128	237	157	126	125	151	89	105	67	120	122	103	77	87	118	148	92	134	170	71	76	66	143	88	20
Askov	93	75	239	143	147	145	119	93	80	51	95	88	41	69	107	95	147	65	139	119	110	98	63	147	148	99
Jyndevad	69	69	211	143	94	144	117	112	90	67	98	126	40	44	63	100	165	70	189	97	118	77	89	123	65	125

Winter barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	147	112	196	197	146	127	151	123	120	91	137	166	97	102	119	127	130	147	189	177	111	142	138	118	143	131
Årslev	136	110	172	169	125	120	153	120	68	65	117	138	124	103	97	140	125	143	174	143	98	117	117	94	143	105
Silstrup	139	161	194	219	169	132	185	145	94	69	118	118	124	47	121	133	154	145	169	176	152	124	93	137	156	82

Winter barley (continuation)

Tylstrup	143	133	166	172	138	125	147	73	90	66	94	96	124	49	128	67	128	102	190	81	168	98	70	68	126	79
Foulum	118	120	172	193	143	126	167	70	95	90	95	144	96	49	91	117	122	142	165	148	124	119	71	123	150	54
Skjern	97	114	142	169	69	102	150	76	121	89	93	118	92	56	123	73	125	148	170	154	140	125	69	135	124	74
Ribe	90	112	149	148	97	122	126	96	70	88	93	120	101	53	95	77	124	118	171	131	150	119	97	112	95	98
Borris	92	112	169	175	88	102	130	77	115	87	119	96	95	55	92	76	117	147	167	148	90	71	48	113	99	26
Askov	94	116	173	143	95	126	108	78	91	62	90	121	49	55	121	75	133	122	184	130	98	114	68	118	100	78
Jyndevad	71	83	146	146	89	123	94	80	95	69	91	111	80	81	93	76	125	119	192	98	96	96	67	65	78	79

Winter rapeseed

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	154	99	198	186	131	134	131	131	127	71	154	153	99	100	114	130	130	158	203	161	81	149	124	102	158	130
Årslev	123	121	176	160	104	130	160	120	71	73	123	132	93	101	97	151	102	152	183	160	81	127	97	97	162	111
Silstrup	121	144	202	214	151	145	185	121	96	51	110	106	92	21	119	134	135	150	168	146	133	111	65	116	160	54
Tylstrup	133	145	175	184	142	133	152	73	63	72	102	102	102	51	123	81	134	104	205	78	152	83	44	95	118	88
Foulum	102	120	174	213	153	110	150	67	101	75	101	135	78	53	86	111	103	151	172	157	111	107	68	127	110	49
Skjern	94	117	172	154	74	110	150	75	123	73	96	99	72	52	117	80	113	153	178	164	151	138	71	120	154	50
Ribe	100	115	146	144	82	130	132	72	73	71	96	130	84	53	95	80	131	123	172	135	132	99	98	123	102	100
Borris	92	113	172	182	64	111	134	73	93	72	96	109	92	23	86	80	101	152	172	161	101	75	43	118	79	0
Askov	117	88	175	157	101	101	102	72	94	73	94	109	52	51	113	81	132	122	173	133	74	96	96	87	103	70
Jyndevad	68	83	141	160	80	101	79	74	101	71	114	119	29	81	92	82	108	121	202	102	99	79	61	65	80	89

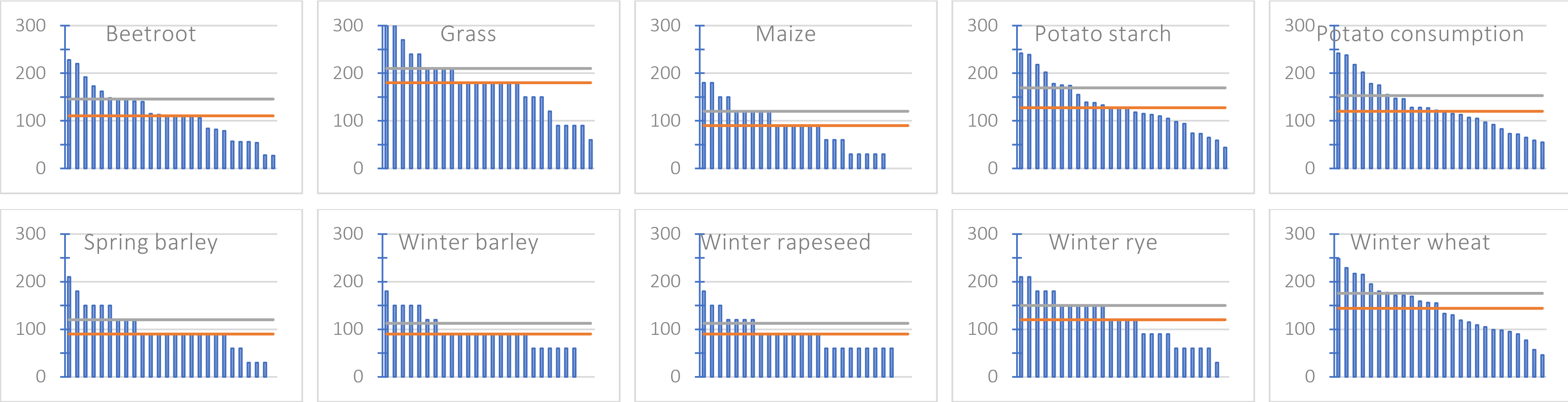
Winter rye

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	180	134	266	239	218	218	209	189	149	107	210	214	97	133	124	178	195	158	235	215	159	163	151	199	235	186
Årslev	156	164	235	209	200	192	211	161	102	109	149	182	97	136	96	184	166	133	205	217	162	162	105	196	214	160
Silstrup	186	184	272	203	244	217	199	172	96	113	162	127	98	79	181	190	191	148	205	206	178	132	72	184	179	78
Tylstrup	161	195	265	207	242	218	241	132	74	85	133	120	123	79	121	131	189	130	227	104	207	80	51	165	186	128
Foulum	156	134	238	238	245	190	212	158	95	138	134	189	103	79	127	126	187	150	188	187	159	138	74	154	159	73
Skjern	126	152	243	209	190	192	181	106	124	78	153	134	74	55	150	122	183	151	206	216	183	159	71	219	203	103
Ribe	133	125	232	187	163	166	156	126	72	109	152	153	74	107	96	127	187	125	210	159	180	138	97	186	127	154
Borris	131	156	239	180	157	192	185	107	119	77	135	132	97	78	126	124	187	153	173	211	104	84	51	217	96	24
Askov	133	123	235	167	192	165	156	104	96	84	126	158	49	55	148	95	195	130	179	192	128	135	76	159	152	102
Jyndevad	108	103	242	188	170	164	160	103	93	84	127	156	48	111	72	107	194	129	229	160	129	107	72	154	75	140

	Winter wheat																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	172	138	264	243	243	230	235	207	154	110	228	221	93	101	116	181	218	134	233	219	159	160	168	222	219	183
Årslev	179	181	272	207	194	209	221	179	100	109	163	205	89	155	120	182	187	131	215	217	154	141	120	200	245	150
Silstrup	203	199	276	224	245	203	233	199	104	146	175	152	98	89	178	178	205	156	207	227	175	121	98	220	206	74
Tylstrup	199	195	271	189	261	198	255	156	66	63	132	139	106	106	173	112	212	121	225	114	201	74	79	185	185	125
Foulum	186	154	242	218	240	213	223	159	125	139	130	175	113	94	139	130	185	147	200	172	150	122	98	188	158	82
Skjern	158	152	245	195	149	185	202	125	128	111	160	133	95	88	135	106	215	132	202	215	174	169	60	214	205	109
Ribe	129	133	254	172	195	193	175	122	75	98	143	158	73	67	109	151	216	124	233	172	193	141	90	197	157	155
Borris	156	171	248	180	195	169	177	99	109	95	159	155	98	90	115	130	215	133	171	229	77	119	57	217	105	46
Askov	160	131	256	159	193	195	157	129	113	112	132	127	55	67	142	92	212	116	169	157	133	126	75	187	186	107
Jyndevad	112	110	244	177	155	170	165	103	92	112	134	158	35	81	87	127	216	113	238	142	150	103	107	140	91	140

NB. the years 90-15 represent the years 1990-2015.

13 Appendix I – B. Annual GIWR (mm) at crop-level at RZC 80



NB. All graphs from Borris RZC 80

Beetroot

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	140	116	254	165	195	256	227	231	139	146	227	140	178	202	82	205	188	84	199	252	135	82	170	193	224	164
Årslev	135	174	259	134	142	256	166	230	85	114	80	138	174	203	87	144	167	59	134	198	138	29	83	192	284	140
Silstrup	139	171	254	135	171	231	191	198	26	111	139	82	145	172	140	174	172	59	137	108	107	57	86	170	142	59
Tylstrup	139	198	256	139	172	225	246	162	0	88	83	79	144	143	140	110	142	60	142	54	107	30	86	167	200	113
Foulum	170	110	221	161	171	222	217	174	55	115	84	111	112	144	110	116	130	86	135	111	108	57	56	113	173	85
Skjern	114	144	222	107	144	227	134	141	53	90	82	81	90	113	140	117	165	60	139	137	80	85	58	163	199	115
Ribe	85	113	221	80	143	198	168	142	27	55	113	87	115	144	84	170	197	59	162	114	109	30	53	168	145	144
Borris	111	113	220	110	109	228	173	141	54	115	84	106	146	148	110	145	140	56	79	192	27	28	56	162	82	57
Askov	86	86	223	80	146	196	86	138	29	142	85	80	60	113	138	87	193	60	82	112	82	29	53	168	200	114
Jyndevad	86	84	219	80	142	201	141	114	26	116	84	114	87	174	56	144	193	58	135	53	111	28	84	85	85	136

Grass-clover (for silage)																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	240	180	330	240	300	330	300	300	210	240	300	240	240	240	150	270	240	180	300	300	150	150	270	270	300	210
Årslev	240	270	330	210	240	300	270	270	150	210	150	210	210	270	150	240	240	180	270	300	180	180	150	240	360	180
Silstrup	240	300	330	210	270	300	240	240	90	180	210	120	180	180	210	240	240	210	240	240	180	150	120	210	210	90
Tylstrup	240	270	330	210	300	300	330	210	60	120	150	120	180	180	180	120	210	120	240	90	210	90	120	210	270	120
Foulum	240	180	300	240	270	300	270	210	120	180	150	180	180	180	180	180	210	180	240	180	180	150	90	180	210	120
Skjern	180	240	270	180	180	270	210	180	120	150	180	150	150	150	210	150	240	180	240	240	210	150	90	240	270	120
Ribe	180	210	300	180	210	270	240	180	60	120	180	150	120	150	150	210	270	150	270	240	180	120	90	240	240	180
Borris	210	210	300	180	180	270	240	180	120	180	180	150	180	150	180	150	240	180	210	300	90	90	90	210	90	60
Askov	180	210	300	150	210	270	150	180	90	180	150	150	120	120	210	150	270	120	180	150	120	120	120	210	240	150
Jyndevad	150	150	300	180	210	270	210	150	90	180	150	180	90	210	120	180	240	150	270	150	150	120	90	150	150	180

Maize																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	120	210	90	180	240	180	150	90	120	150	120	90	120	30	150	120	30	120	150	60	0	120	150	150	120
Årslev	120	150	180	60	120	210	150	150	60	120	30	90	90	150	60	120	120	30	120	90	90	30	30	150	210	90
Silstrup	120	150	210	60	150	210	180	120	0	90	90	60	60	120	90	120	120	30	60	60	30	30	30	150	90	30
Tylstrup	120	180	180	60	150	210	180	120	0	90	60	30	60	120	60	90	90	30	60	30	30	30	60	150	150	60
Foulum	120	90	180	60	150	210	180	150	30	120	60	90	60	120	90	90	120	30	90	60	60	30	30	90	90	90
Skjern	90	90	150	30	150	210	120	120	0	90	60	60	30	120	90	90	120	30	90	60	60	30	30	120	120	90
Ribe	60	90	180	30	120	180	120	90	0	60	90	60	30	120	60	90	150	30	90	90	60	30	0	120	120	90
Borris	90	90	180	30	120	180	150	90	0	120	60	90	60	120	90	90	120	30	60	150	0	0	30	120	30	30
Askov	90	60	180	30	150	180	60	120	0	120	60	60	0	90	90	60	150	30	30	30	30	30	30	120	150	90
Jyndevad	60	60	150	30	120	180	120	90	0	90	60	60	30	120	30	120	150	30	90	30	60	0	0	90	60	90

Potato starch																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	141	164	275	123	178	267	237	195	121	129	70	155	89	203	117	149	166	65	186	169	178	51	67	206	271	178
Årslev	82	102	248	82	197	240	138	194	66	108	102	97	47	133	120	72	194	50	84	136	118	44	74	175	196	178
Silstrup	128	133	242	105	155	239	202	174	59	110	139	118	94	128	127	138	178	65	113	218	74	44	98	175	115	73
Tylstrup	129	111	287	154	227	265	247	215	145	132	214	165	121	174	95	149	171	94	187	197	173	90	172	205	216	167
Foulum	173	118	262	151	202	258	213	221	66	129	115	146	78	128	121	124	157	64	143	144	152	75	73	149	170	101
Skjern	81	80	248	66	169	232	167	147	46	105	125	130	91	177	72	95	198	47	159	64	122	55	56	129	119	124
Ribe	82	105	271	64	180	230	176	169	49	80	147	93	66	130	101	102	201	47	155	147	143	75	47	173	178	149

Potato starch (continiuation)

Borris	159	195	295	124	223	259	244	222	37	110	161	93	121	157	169	168	190	97	132	143	135	66	101	203	169	92
Askov	107	130	262	104	160	264	191	185	55	81	123	104	92	156	125	99	197	68	168	142	144	92	70	203	211	145
Jyndevad	174	185	270	116	197	259	244	200	46	81	102	90	92	131	135	119	171	72	136	71	135	48	81	202	214	149

Potato consumption

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	129	114	261	154	227	240	247	198	118	132	216	165	120	145	95	149	171	94	187	197	163	90	146	205	216	177
Årslev	141	138	278	123	178	266	219	198	101	128	70	155	92	206	117	152	180	65	170	169	188	51	67	179	271	177
Silstrup	158	179	294	132	222	258	253	221	37	110	135	93	93	156	169	170	190	97	132	123	152	75	101	203	171	92
Tylstrup	148	167	270	116	197	231	247	200	46	81	102	90	95	131	135	126	171	72	136	71	148	26	53	201	214	149
Foulum	175	103	267	130	202	257	216	194	66	129	114	146	51	127	121	124	157	64	143	146	127	75	73	149	170	107
Skjern	107	112	235	104	160	237	191	157	55	81	123	104	65	128	125	99	197	68	167	142	168	92	70	175	219	149
Ribe	82	108	270	64	180	229	176	168	48	80	146	93	65	130	101	102	201	52	155	147	154	75	47	173	178	149
Borris	128	107	242	105	155	238	202	146	59	83	122	118	97	128	127	147	178	65	113	218	92	55	72	175	115	73
Askov	82	84	248	65	183	242	138	168	39	108	102	97	27	107	121	72	194	50	84	109	130	44	74	175	196	177
Jyndevad	81	53	251	66	168	231	176	147	46	105	125	104	70	150	72	101	198	51	159	64	110	55	56	129	119	128

Spring barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	90	240	180	150	150	150	150	90	90	150	150	60	60	90	120	150	90	180	150	120	120	90	120	180	150
Årslev	120	90	240	180	120	120	150	150	60	60	120	120	90	60	90	120	120	90	180	150	120	90	90	120	150	120
Silstrup	120	150	240	180	180	120	180	150	90	90	120	90	60	30	150	120	150	90	150	150	150	90	60	150	120	60
Tylstrup	120	120	240	180	180	120	180	120	60	30	60	60	90	30	120	60	120	60	180	90	120	30	30	150	150	90
Foulum	120	90	210	180	180	150	180	120	90	60	60	150	60	30	90	90	120	90	150	120	90	90	60	120	120	60
Ribe	90	120	210	150	120	90	150	90	90	30	90	90	90	30	90	90	150	90	150	150	120	120	60	150	150	90
Skjern	60	90	210	120	120	120	120	120	60	30	90	90	60	30	90	120	150	60	180	120	120	90	60	120	120	120
Borris	90	120	210	150	120	90	150	90	90	30	90	90	90	0	90	90	150	90	120	180	60	30	60	150	90	30
Askov	90	90	240	120	120	120	120	90	90	30	60	90	60	60	90	90	150	30	120	120	120	90	60	120	120	90
Jyndevad	60	60	210	120	90	90	120	90	60	60	90	90	30	60	60	60	150	60	180	90	120	60	60	90	60	90

Winter barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	90	180	180	120	120	120	120	90	60	150	150	90	60	120	120	90	120	180	150	90	120	120	90	150	120
Årslev	120	120	180	150	90	90	150	90	60	60	90	150	90	60	90	150	90	120	150	150	60	120	90	90	150	120
Silstrup	120	150	180	210	150	150	120	120	90	60	90	90	90	0	120	120	120	120	150	150	150	120	60	90	120	60

Winter barley (continuation)

Tylstrup	120	90	180	180	150	120	150	60	60	60	60	60	90	30	120	60	120	120	180	60	150	60	30	90	120	90
Foulum	120	120	180	210	150	120	150	60	90	60	60	120	90	30	90	90	90	150	150	120	90	120	60	90	120	30
Skjern	90	90	150	150	60	120	120	60	120	60	90	90	60	0	90	90	120	120	150	150	150	120	60	120	120	60
Ribe	90	60	150	150	60	90	120	60	60	60	90	120	60	30	90	90	120	120	180	120	120	90	90	90	90	60
Borris	90	90	150	150	60	90	120	60	90	60	90	90	90	0	90	60	90	150	180	150	90	90	60	120	60	0
Askov	90	90	150	150	60	90	90	60	90	60	60	120	30	30	120	90	90	120	150	120	60	90	60	60	120	60
Jyndevad	60	60	150	150	60	90	90	60	60	60	90	90	30	30	60	60	90	120	180	90	90	90	60	60	60	60

Winter rapeseed

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	60	180	180	120	120	120	120	90	60	150	150	60	60	120	120	90	120	180	120	60	120	120	90	150	120
Årslev	120	90	180	150	90	90	120	90	60	60	90	120	90	60	90	150	90	120	150	150	60	90	90	90	150	90
Silstrup	120	120	180	180	150	120	120	120	90	60	90	90	90	30	120	120	120	120	150	150	120	90	60	90	120	60
Tylstrup	120	90	180	150	120	120	120	60	60	30	60	60	90	30	120	60	90	120	180	30	150	60	30	90	90	60
Foulum	120	90	180	210	120	90	150	60	60	60	60	120	60	30	90	90	90	120	150	120	90	120	60	90	120	30
Skjern	90	90	150	150	60	90	120	60	120	60	90	90	60	30	90	60	120	120	150	150	120	120	60	120	120	60
Ribe	90	90	150	120	60	90	120	60	60	60	90	120	60	30	90	90	90	120	180	120	120	90	60	90	90	60
Borris	90	90	150	150	60	90	120	60	90	60	90	90	90	0	60	60	90	120	180	120	60	60	60	120	60	0
Askov	90	90	150	150	60	90	90	60	60	60	60	90	30	0	120	90	90	120	150	120	60	90	60	90	90	60
Jyndevad	60	90	150	150	60	90	90	60	60	60	60	90	30	30	60	60	90	120	180	60	90	60	60	60	60	60

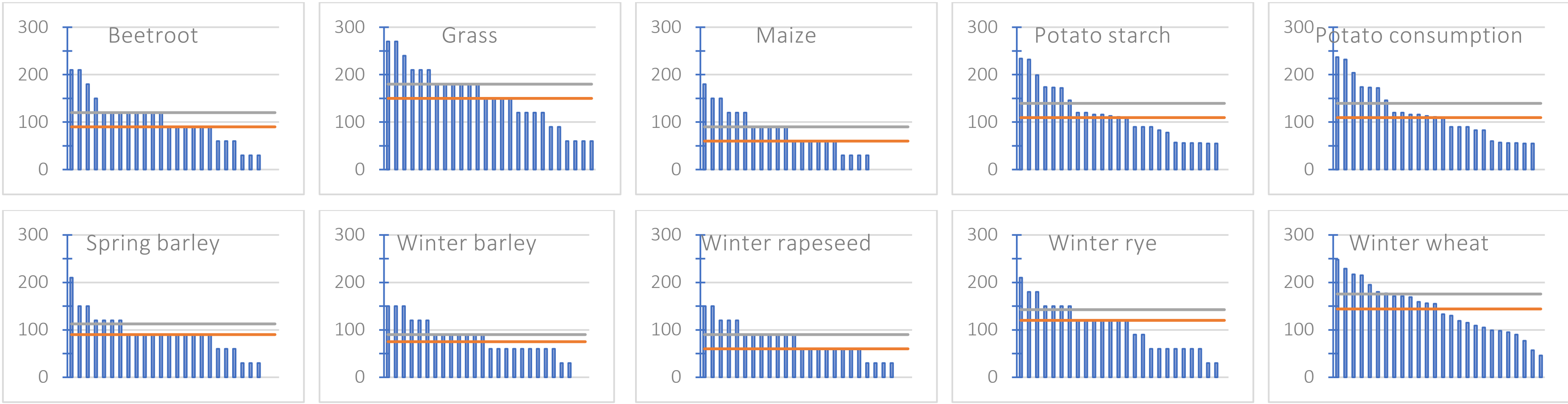
Winter rye

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	150	90	240	210	210	210	210	180	120	90	210	210	90	60	120	150	180	150	210	180	150	150	150	150	210	150
Årslev	150	150	240	210	180	180	210	150	60	90	120	180	90	90	90	150	150	150	210	180	120	120	120	150	180	150
Silstrup	180	180	240	210	210	180	180	180	90	90	150	90	90	30	150	150	180	150	180	180	150	120	60	180	150	60
Tylstrup	120	180	240	180	210	180	180	120	60	60	90	60	90	60	120	90	120	120	180	60	180	60	30	150	150	90
Foulum	150	120	210	210	210	180	180	120	90	120	90	150	90	60	90	90	120	150	180	150	120	120	60	150	120	60
Skjern	120	150	210	180	120	150	180	90	120	60	120	120	60	30	120	90	180	150	180	210	150	150	60	180	180	90
Ribe	120	90	210	150	150	180	150	120	60	60	120	120	60	60	90	120	180	120	210	150	150	120	90	180	120	120
Borris	120	150	210	180	150	150	150	90	90	60	120	120	90	30	120	90	150	150	180	210	60	60	60	180	60	0
Askov	120	90	240	150	150	180	120	90	90	60	90	90	30	60	120	90	180	90	150	150	90	90	60	150	150	90
Jyndevad	90	60	210	150	120	150	150	90	60	60	90	120	30	30	60	60	180	120	210	120	120	90	60	120	90	120

	Winter wheat																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	166	119	252	231	230	203	199	169	140	111	200	199	82	82	108	172	169	143	226	205	145	149	167	177	202	172
Årslev	173	175	257	203	177	175	205	142	84	86	143	170	87	110	83	142	143	145	224	198	143	147	111	173	231	141
Silstrup	198	201	281	194	228	206	222	174	82	118	144	112	81	84	175	147	175	144	206	201	143	118	55	203	174	53
Tylstrup	168	172	258	198	230	206	220	140	84	57	116	86	113	85	136	87	146	113	202	113	168	84	28	177	171	85
Foulum	170	143	257	227	233	177	201	140	83	118	115	141	86	84	137	118	140	147	199	170	142	119	81	175	144	59
Skjern	112	146	226	170	146	176	172	117	107	79	116	114	82	56	140	115	173	142	200	203	168	146	52	200	202	110
Ribe	114	114	249	144	176	172	171	115	85	112	119	111	56	57	109	111	173	112	225	141	170	146	82	175	145	145
Borris	143	142	227	167	146	147	170	110	110	110	146	143	112	60	117	87	173	142	166	225	85	60	57	202	82	28
Askov	142	82	256	139	146	175	114	88	109	86	114	84	53	56	139	83	168	86	172	141	114	119	82	175	174	117
Jyndevad	112	114	225	175	148	175	113	114	82	86	145	143	30	86	81	116	172	113	228	145	142	86	81	144	82	118

NB. the years 90-15 represent the years 1990-2015.

14 Appendix I – C. Annual GIWR (mm) at crop-level at RZC 100



NB. All graphs from Borris RZC 100

Beetroot

Year	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Flakkebjerg	120	120	240	150	180	240	150	180	120	90	210	120	180	180	60	180	150	60	150	210	120	60	150	180	180	150
Årslev	90	150	240	120	120	240	120	180	90	120	60	120	150	210	60	150	120	30	150	150	120	30	60	150	270	120
Silstrup	120	180	240	120	180	210	150	150	30	90	120	30	90	120	150	150	120	60	90	120	90	30	30	150	150	30
Tylstrup	120	180	240	120	150	210	180	150	0	90	90	30	90	90	120	90	120	30	120	60	90	0	30	150	180	90
Foulum	150	90	210	150	150	210	150	150	60	120	60	120	90	120	90	90	120	60	120	90	90	60	30	90	150	60
Skjern	90	90	210	120	120	210	90	150	60	60	90	90	90	120	90	120	150	30	120	120	90	60	30	120	180	90
Ribe	60	90	210	90	120	180	120	120	0	30	90	90	60	120	90	120	150	30	120	120	90	30	30	120	150	90
Borris	90	120	210	120	90	210	120	120	60	90	90	90	120	120	90	120	150	30	60	180	30	0	0	120	60	30
Askov	60	60	210	60	120	180	60	150	30	120	60	90	30	60	90	90	150	30	60	90	90	30	30	120	180	120
Jyndevad	60	60	210	90	120	180	90	90	30	90	90	60	90	150	60	120	150	30	120	60	90	30	0	90	90	90

Grass-clover (for silage)																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	240	180	330	240	270	330	270	270	180	180	300	210	210	210	150	240	240	150	300	300	150	150	240	240	270	210
Årslev	210	210	330	210	210	270	240	210	120	180	150	180	210	240	150	210	180	120	240	240	150	120	120	240	330	180
Silstrup	240	270	300	210	270	270	240	210	90	120	150	90	150	120	210	210	180	150	210	180	150	120	60	210	210	60
Tylstrup	210	270	330	180	270	300	240	210	60	120	150	90	180	120	180	120	150	120	240	90	180	60	60	210	240	120
Foulum	240	180	300	210	240	270	270	210	90	180	120	150	150	150	150	150	150	150	210	150	150	120	90	150	210	90
Skjern	150	180	270	180	180	240	210	180	120	150	150	120	120	120	150	120	210	120	240	210	180	150	90	210	240	120
Ribe	150	180	300	150	180	240	210	180	60	120	150	120	120	150	150	150	210	120	240	180	180	120	60	210	210	150
Borris	180	210	270	180	150	240	210	150	90	180	150	120	180	120	150	120	180	120	180	270	60	60	60	210	90	60
Askov	150	120	270	120	210	240	150	180	90	180	150	90	60	90	180	90	210	90	180	150	120	120	60	180	240	120
Jyndevad	120	120	270	150	180	240	210	120	60	150	150	150	90	150	90	150	240	90	240	120	120	90	60	150	120	120

Maize																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	90	180	60	150	210	180	150	90	90	150	120	90	120	30	120	120	30	120	120	90	0	120	150	150	90
Årslev	90	150	180	60	120	210	120	120	60	90	30	90	60	150	60	90	90	0	90	90	120	0	0	150	180	90
Silstrup	90	150	180	30	150	180	150	120	0	90	90	0	60	120	90	90	90	30	60	60	60	0	0	120	90	0
Tylstrup	90	150	180	60	150	210	180	120	0	90	60	30	60	90	60	30	90	30	60	30	60	0	30	120	120	60
Foulum	120	60	150	60	120	180	150	90	0	120	60	90	60	90	60	60	90	0	90	30	60	30	30	90	90	60
Skjern	60	90	150	30	120	180	120	120	0	60	60	60	30	90	60	30	120	0	90	60	60	30	30	120	120	60
Ribe	60	90	150	0	120	180	120	90	0	60	60	30	30	90	60	90	120	30	90	60	60	0	0	90	120	60
Borris	60	90	150	30	90	180	120	90	0	90	60	60	60	90	60	60	120	0	0	150	0	0	30	120	30	30
Askov	60	60	150	0	120	180	60	90	0	120	60	30	0	60	60	30	120	0	30	30	60	0	0	120	120	90
Jyndevad	60	60	150	30	120	180	120	30	0	90	60	30	0	120	30	60	120	0	60	30	60	0	0	90	60	60

Potato starch																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	150	262	111	176	268	205	200	118	120	80	146	86	201	87	145	174	55	168	174	174	57	56	177	262	140
Årslev	90	90	234	53	145	236	110	173	30	90	115	88	30	90	116	53	204	57	82	83	117	28	30	177	201	147
Silstrup	90	116	232	108	120	234	173	174	55	90	113	116	57	120	90	111	172	56	78	199	56	0	55	146	83	56
Tylstrup	147	120	257	138	231	261	232	202	143	116	205	174	87	147	55	142	173	56	168	201	170	55	145	176	198	171
Foulum	175	120	259	110	175	237	229	176	81	90	88	147	55	149	115	113	173	84	144	87	117	58	30	145	169	90
Skjern	90	60	229	56	150	235	174	118	30	90	115	85	57	147	85	86	174	59	139	59	117	30	0	117	116	117
Ribe	90	120	260	50	145	239	173	146	55	60	113	87	57	115	86	115	202	56	137	145	118	26	56	146	171	145

Potato starch (continuation)

Borris	146	175	291	107	200	262	226	204	29	90	143	85	85	146	143	145	175	87	139	114	111	58	85	205	142	55
Askov	116	120	234	107	177	236	174	173	53	60	116	87	55	120	116	81	174	56	144	114	143	81	55	176	199	118
Jyndevad	172	180	260	114	203	238	260	202	0	60	116	87	55	145	111	116	172	58	136	60	112	30	60	176	199	115

Potato consumption

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	147	90	260	138	231	236	232	202	113	116	205	174	87	147	55	145	173	56	168	201	170	55	120	176	198	171
Årslev	120	150	262	111	176	238	205	200	88	120	80	149	56	171	87	90	174	55	172	174	178	57	56	177	235	145
Silstrup	146	175	291	107	200	262	226	204	26	90	143	85	89	120	143	145	175	87	139	114	115	58	85	175	144	55
Tylstrup	172	180	260	114	203	238	260	202	0	60	116	87	55	150	111	116	172	58	136	60	112	30	60	176	203	117
Foulum	175	90	259	110	176	237	202	176	85	90	88	147	59	149	115	87	173	58	144	87	117	58	30	145	172	90
Skjern	90	120	234	107	180	236	174	173	53	60	116	87	55	120	116	81	174	56	144	114	143	55	55	176	204	118
Ribe	90	90	260	50	145	239	173	146	25	60	113	87	57	115	86	115	202	56	137	118	118	30	56	146	171	145
Borris	90	116	232	108	120	237	173	174	55	90	113	116	57	120	90	111	172	56	83	204	56	0	55	146	83	60
Askov	90	60	234	57	150	236	110	173	28	90	115	88	0	90	118	53	204	57	82	83	117	30	30	147	201	147
Jyndevad	90	60	229	56	150	205	174	118	26	90	115	85	59	147	85	86	174	59	139	59	117	30	0	117	116	117

Spring barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	60	210	180	150	150	150	150	90	30	150	150	60	30	90	120	150	60	150	150	120	90	90	90	150	120
Årslev	90	90	210	150	90	90	150	120	60	60	90	120	60	60	60	120	120	60	150	120	90	60	90	90	150	120
Silstrup	120	150	210	180	180	120	180	150	60	30	90	90	60	30	120	90	150	90	150	120	120	60	60	150	120	30
Tylstrup	90	90	210	150	150	120	180	120	30	0	60	30	60	30	120	30	120	60	150	60	120	30	30	120	120	60
Foulum	90	90	210	180	150	120	150	120	60	60	60	120	60	30	90	60	90	90	120	120	90	60	60	120	90	30
Ribe	60	90	210	150	90	90	120	90	90	30	90	90	60	0	90	90	120	60	150	150	90	90	60	120	150	60
Skjern	30	60	210	120	120	90	90	90	60	30	90	90	60	30	90	120	150	60	150	90	120	60	60	120	90	90
Borris	90	90	210	150	90	90	120	90	90	30	90	90	90	0	60	90	120	90	120	150	60	30	30	120	60	0
Askov	60	30	210	120	120	90	90	90	60	0	60	60	0	30	90	60	120	30	120	90	90	30	60	120	120	90
Jyndevad	30	30	210	120	90	90	90	60	60	0	60	60	30	30	60	60	150	30	150	60	90	30	30	90	30	90

Winter barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	60	180	150	120	120	120	90	90	60	120	120	60	30	90	120	90	120	180	120	60	120	120	90	120	120
Årslev	120	60	150	150	90	90	120	90	60	60	90	120	60	60	60	120	90	120	150	120	30	90	90	60	120	90
Silstrup	90	120	150	180	120	120	120	90	60	60	90	90	60	0	90	90	120	120	150	120	120	90	30	90	120	30

Winter barley (continuation)

Tylstrup	90	90	150	150	120	120	120	60	30	30	60	60	90	0	90	30	90	90	180	30	150	60	30	60	90	60
Foulum	90	90	150	180	120	90	150	60	60	60	60	90	60	30	90	90	90	120	150	90	90	90	60	60	120	30
Skjern	60	90	150	150	60	60	120	30	90	60	60	90	60	0	90	60	90	120	150	120	120	120	30	90	120	30
Ribe	60	60	150	120	60	90	120	60	30	60	60	120	60	0	90	60	90	90	150	90	120	90	60	90	60	60
Borris	90	90	150	150	60	60	120	30	90	60	90	90	60	0	60	60	90	120	150	120	60	60	30	90	60	0
Askov	90	90	150	120	60	90	90	60	60	60	60	90	0	0	90	60	90	90	150	90	60	90	60	60	90	30
Jyndevad	60	60	150	120	60	90	60	60	60	30	60	90	30	30	60	30	90	90	180	60	60	60	60	60	30	60

Winter rapeseed

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	60	180	150	90	120	120	90	90	30	120	120	60	30	90	120	90	120	150	120	60	120	120	90	120	90
Årslev	90	90	150	150	60	60	120	60	30	60	90	120	60	60	60	120	90	120	150	120	30	90	90	60	90	90
Silstrup	90	120	150	180	120	120	120	90	60	30	90	90	60	0	90	90	90	120	150	120	90	90	60	90	120	30
Tylstrup	90	90	150	150	120	120	120	60	30	30	60	60	90	0	90	30	60	90	180	30	120	60	30	60	90	60
Foulum	90	90	150	180	120	90	120	60	60	60	60	90	60	0	60	60	60	120	120	90	90	90	60	60	90	30
Skjern	60	90	120	150	30	60	120	30	90	60	60	90	60	0	90	60	60	120	150	120	120	90	30	90	120	30
Ribe	60	60	120	120	60	90	90	60	30	60	60	90	30	0	60	60	90	90	150	90	120	90	60	90	60	60
Borris	90	90	120	150	60	60	90	30	90	60	90	90	60	0	60	30	60	120	150	120	30	60	30	90	60	0
Askov	90	90	150	120	60	90	90	30	60	60	60	60	0	0	90	30	90	60	150	90	60	90	60	60	90	30
Jyndevad	60	60	120	120	60	90	60	30	60	30	60	90	30	0	60	30	90	90	150	60	60	60	30	60	30	60

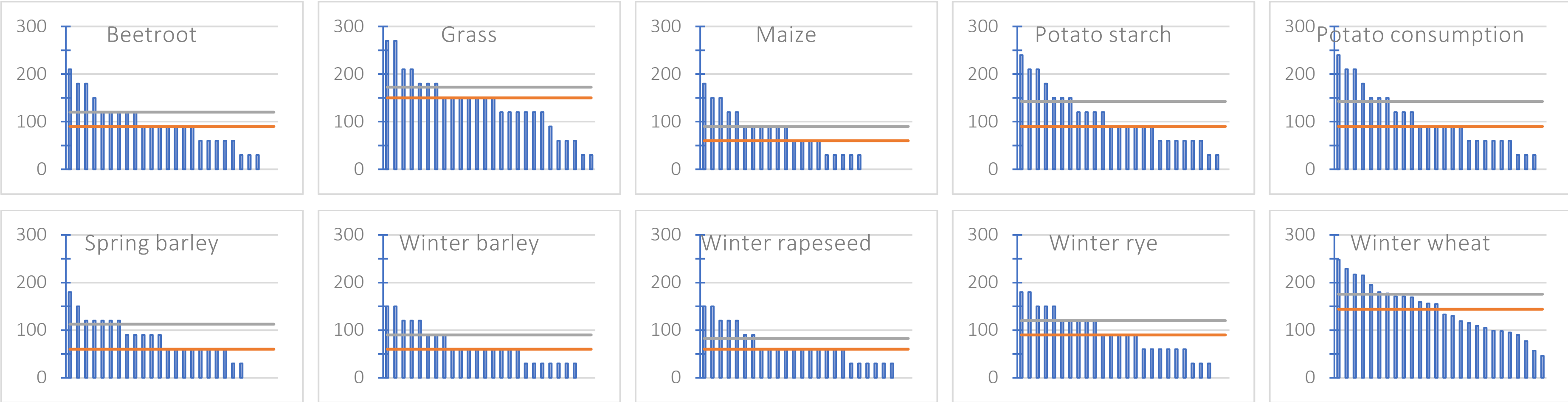
Winter rye

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	150	90	240	210	180	180	180	150	120	60	180	180	60	30	90	150	150	120	210	180	120	120	120	150	180	150
Årslev	150	120	210	180	150	150	180	120	60	90	120	150	90	90	90	120	120	120	180	150	90	90	90	120	180	120
Silstrup	150	150	240	180	180	180	150	120	60	60	90	90	60	30	150	120	150	120	150	150	120	90	30	150	150	30
Tylstrup	120	150	210	150	210	180	150	120	60	30	90	60	90	30	120	60	120	90	180	60	150	60	30	120	150	60
Foulum	150	90	210	210	180	180	180	120	60	90	90	120	60	60	90	90	120	120	180	150	120	90	60	120	120	30
Skjern	90	120	210	150	120	150	150	90	90	60	90	90	60	30	90	60	150	120	180	180	120	120	30	180	150	60
Ribe	90	90	210	150	150	120	150	90	60	60	90	120	60	30	90	90	150	90	180	120	150	90	60	150	90	120
Borris	120	120	210	150	120	120	150	60	90	60	120	120	90	30	60	60	150	120	150	180	60	60	30	180	60	0
Askov	90	60	210	120	120	120	90	60	60	60	60	90	0	30	90	60	120	90	150	120	90	90	60	120	120	90
Jyndevad	60	60	210	150	120	120	120	60	60	30	90	90	30	30	60	60	150	90	210	90	120	60	60	120	30	90

	Winter wheat																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	150	90	240	210	210	210	210	180	120	60	210	180	90	60	120	150	150	120	210	180	120	120	120	150	210	150
Årslev	150	150	240	180	150	150	180	150	90	90	120	150	90	90	90	150	150	120	210	180	120	90	90	150	180	150
Silstrup	180	180	270	180	210	180	210	180	90	90	150	90	90	30	150	150	150	120	180	150	150	90	60	180	150	30
Tylstrup	150	180	240	180	210	180	210	120	60	60	90	60	90	60	120	90	120	90	180	60	180	60	30	150	150	90
Foulum	150	120	240	210	210	180	210	120	90	120	90	150	90	60	90	90	120	120	210	150	120	90	60	150	120	60
Skjern	120	150	210	180	120	150	180	90	120	60	120	120	90	30	120	90	150	120	180	180	150	120	60	180	180	60
Ribe	120	90	210	150	150	150	150	120	60	60	120	120	60	60	90	120	180	90	210	150	150	120	90	180	120	120
Borris	120	150	240	180	150	150	150	90	90	60	120	120	90	30	120	90	150	120	150	210	60	60	60	180	60	0
Askov	120	90	240	150	150	150	120	90	90	90	90	90	30	60	120	90	150	90	150	120	90	90	60	150	150	90
Jyndevad	90	60	210	150	120	120	120	90	60	60	90	120	30	30	60	60	150	90	210	120	120	60	60	120	60	120

NB. the years 90-15 represent the years 1990-2015.

15 Appendix I – D. Annual GIWR (mm) at crop-level at RZC 120



NB. All graphs from Borris RZC 120

Beetroot

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	90	240	150	180	240	210	180	120	90	210	120	150	150	30	180	120	30	150	180	120	60	150	180	180	150
Årslev	90	150	240	120	120	210	150	150	60	90	60	120	120	180	60	150	120	30	120	150	120	30	30	150	270	120
Silstrup	120	180	240	120	150	210	180	150	30	90	90	30	90	120	120	120	120	60	90	90	90	60	0	150	120	30
Tylstrup	120	150	240	120	150	210	180	150	0	30	60	30	90	90	90	60	90	30	90	30	90	0	30	150	180	60
Foulum	150	90	210	150	150	210	180	120	60	60	60	90	60	120	90	90	90	60	120	90	90	30	0	90	120	60
Skjern	60	90	210	120	120	180	120	120	60	60	90	60	60	90	90	60	120	30	120	120	90	60	0	120	180	60
Ribe	60	90	210	90	120	180	120	120	0	30	90	60	60	120	60	120	150	30	120	120	90	30	0	90	120	90
Borris	90	90	210	120	90	180	150	120	60	90	60	90	90	90	60	120	120	30	60	180	30	0	0	120	60	30
Askov	60	60	210	60	120	180	60	120	30	90	60	30	0	60	90	60	150	0	60	90	90	30	0	120	180	120
Jyndevad	60	30	180	90	120	180	120	90	30	90	60	60	30	150	0	90	120	0	120	60	90	30	0	60	60	90

	Grass-clover (for silage)																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	210	150	300	210	270	330	270	240	180	120	270	210	210	180	90	240	180	120	270	270	150	120	240	240	270	210
Årslev	210	210	300	210	180	270	240	210	120	180	120	180	210	210	120	210	150	120	240	240	120	120	90	210	330	180
Silstrup	210	270	300	210	270	270	240	210	60	90	150	90	120	120	180	210	180	150	180	180	120	120	60	210	210	60
Tylstrup	180	270	300	180	270	300	240	180	30	30	120	90	150	120	150	90	120	90	180	60	180	60	60	180	210	90
Foulum	210	150	270	210	240	270	240	150	90	120	120	150	120	150	120	150	150	120	210	150	150	120	60	150	180	60
Skjern	150	180	240	180	180	240	210	150	90	120	150	120	90	90	150	90	150	120	210	180	150	150	60	210	240	120
Ribe	120	150	270	150	180	210	210	150	60	90	150	120	90	120	150	150	210	90	240	180	150	120	60	180	210	120
Borris	150	180	270	180	120	210	210	150	90	150	150	120	150	120	120	120	150	120	150	270	60	60	30	180	60	30
Askov	150	120	270	120	180	210	120	150	60	150	90	90	30	60	150	90	180	90	150	150	90	90	60	180	210	120
Jyndevad	120	120	270	150	180	210	180	120	60	120	120	120	60	150	90	90	180	90	210	90	120	90	60	90	90	120

	Maize																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	90	180	90	150	210	180	120	90	60	150	120	90	90	0	120	120	0	120	120	90	0	120	150	120	90
Årslev	90	120	180	60	120	210	120	90	60	90	30	90	60	120	30	60	90	0	90	90	120	0	0	120	180	90
Silstrup	90	150	180	30	150	180	150	90	0	60	60	0	30	90	90	90	90	30	30	60	60	0	0	120	90	0
Tylstrup	90	150	180	60	150	180	150	120	0	30	60	30	30	60	60	30	90	0	30	0	60	0	30	120	120	60
Foulum	90	60	150	60	120	180	150	90	0	60	30	90	30	90	60	60	90	0	90	30	60	30	0	90	90	60
Skjern	60	60	150	30	120	180	120	90	0	60	60	60	0	90	60	30	120	0	90	60	60	30	0	90	120	60
Ribe	60	90	150	0	90	150	120	90	0	30	60	30	0	90	60	60	120	0	90	60	60	0	0	90	90	60
Borris	60	90	150	30	90	180	120	90	0	90	60	60	30	90	60	30	120	0	0	150	0	0	0	90	30	30
Askov	60	30	150	0	120	150	60	90	0	90	60	0	0	60	60	0	120	0	0	30	60	0	0	90	120	90
Jyndevad	60	30	150	30	120	150	90	30	0	90	60	30	0	90	30	60	120	0	60	0	60	0	0	60	60	30

	Potato starch																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	150	270	120	150	240	210	180	90	90	60	120	60	180	90	90	150	30	150	150	150	30	30	180	270	120
Årslev	60	60	240	60	150	210	120	150	30	90	90	60	0	60	90	60	180	30	90	90	90	30	30	180	180	120
Silstrup	90	120	240	90	120	210	180	150	60	90	120	90	60	120	90	90	150	30	60	210	60	0	30	150	60	60
Tylstrup	120	120	270	150	210	270	240	210	150	90	210	180	90	150	60	150	150	60	180	180	150	60	150	180	210	150
Foulum	150	90	240	120	180	240	210	180	60	90	90	120	60	120	90	90	150	90	150	90	120	60	30	150	150	90
Skjern	60	60	240	60	150	210	150	90	30	90	90	90	60	150	30	90	180	30	120	60	90	30	0	90	90	90
Ribe	60	90	240	60	150	210	150	150	0	60	120	90	60	120	90	90	180	30	150	120	120	30	0	150	150	120

Potato starch (continuation)

Borris	150	180	270	120	210	240	240	180	30	90	120	60	90	120	150	150	150	60	120	90	120	30	30	180	150	30
Askov	90	120	240	90	150	240	180	150	60	60	90	90	30	120	120	90	180	30	150	120	120	60	30	180	180	90
Jyndevad	150	180	270	120	210	240	240	180	0	60	90	60	60	120	120	90	120	60	150	60	120	0	60	180	210	120

Potato consumption

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	90	270	150	210	240	240	180	120	90	210	180	90	120	60	150	150	60	180	180	150	60	120	180	210	150
Årslev	120	120	270	120	150	240	210	150	90	90	60	120	60	180	90	90	150	30	150	150	150	30	30	150	240	120
Silstrup	150	150	270	120	210	240	240	180	30	90	120	60	60	120	150	150	150	60	120	90	120	30	30	180	150	30
Tylstrup	150	150	270	120	210	240	240	180	0	60	90	60	30	90	120	90	120	60	150	60	120	0	30	180	210	120
Foulum	150	60	240	120	180	240	210	150	60	90	90	120	60	120	90	90	150	60	150	90	120	60	30	120	150	90
Skjern	90	90	240	90	150	240	180	150	60	60	90	90	30	120	120	90	180	30	150	120	120	60	30	150	180	90
Ribe	60	90	240	60	150	210	150	150	0	60	120	90	60	120	90	90	180	30	150	120	120	30	0	150	150	120
Borris	90	90	240	90	120	210	180	150	60	60	120	90	60	120	90	90	150	30	60	210	60	0	30	150	60	30
Askov	60	60	240	60	150	210	120	150	30	90	90	60	0	60	90	60	180	30	90	90	90	30	30	150	180	120
Jyndevad	60	60	240	60	150	210	150	90	30	90	90	90	60	150	30	90	180	30	120	60	90	30	0	90	90	90

Spring barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	60	210	180	150	120	150	120	90	30	150	120	60	30	90	120	120	60	150	120	90	90	90	90	150	120
Årslev	60	60	210	150	90	90	120	120	60	30	90	90	60	60	60	90	120	60	150	120	90	60	60	90	150	90
Silstrup	120	120	210	150	150	120	180	120	60	30	60	60	60	0	120	90	120	90	120	120	120	60	30	120	90	0
Tylstrup	90	90	210	150	150	120	180	90	30	0	60	30	60	30	90	30	90	60	150	30	120	30	0	120	120	60
Foulum	90	60	210	180	150	120	150	120	60	30	30	120	60	30	60	60	90	90	120	90	60	60	30	90	90	0
Ribe	60	90	180	120	90	90	120	90	90	30	60	60	60	0	90	60	120	60	120	150	90	90	30	120	150	60
Skjern	30	60	210	120	90	60	90	90	30	30	60	60	30	0	60	90	120	30	150	90	90	60	60	90	90	90
Borris	90	90	180	120	60	60	120	60	90	0	90	90	60	0	60	60	120	60	120	150	30	0	30	120	60	0
Askov	60	30	210	90	90	60	60	60	60	0	60	60	0	0	90	30	120	30	120	90	90	30	60	90	90	60
Jyndevad	30	30	180	120	90	60	90	60	30	0	60	60	30	30	60	60	120	30	150	60	90	30	30	60	30	90

Winter barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	60	150	150	90	90	120	90	90	30	120	120	60	30	90	120	90	120	150	120	60	90	120	60	120	90
Årslev	90	60	150	150	60	60	120	60	30	30	60	120	60	30	60	90	90	90	120	120	30	90	60	60	90	90
Silstrup	90	120	150	180	120	120	120	90	60	0	60	90	60	0	90	90	90	120	120	120	90	90	30	90	120	30

Winter barley (continuation)

Tylstrup	60	90	150	150	120	90	120	60	30	30	60	30	90	0	90	30	90	90	150	30	120	30	0	60	60	60
Foulum	90	90	150	180	120	90	120	60	60	60	60	90	60	0	60	60	60	120	120	90	90	90	30	60	90	0
Skjern	60	90	120	150	30	60	120	30	90	30	60	60	30	0	90	60	90	120	150	120	120	90	30	90	90	30
Ribe	60	60	120	120	60	60	90	60	30	60	60	90	30	0	60	60	90	90	150	90	90	90	60	90	60	60
Borris	60	90	120	150	30	60	90	30	60	30	60	60	60	0	60	30	60	120	150	120	30	60	30	90	30	0
Askov	60	60	150	120	60	60	90	30	60	30	30	60	0	0	90	30	90	60	120	90	30	60	60	60	60	30
Jyndevad	30	60	120	120	30	60	60	30	30	30	30	90	0	0	60	30	60	90	150	60	60	60	30	30	30	60

Winter rapeseed

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	60	150	150	90	90	90	90	90	30	120	120	60	30	90	90	60	90	150	90	60	90	90	60	120	90
Årslev	90	60	150	120	60	60	120	60	30	60	60	90	60	30	60	90	60	90	120	90	30	90	60	60	90	90
Silstrup	90	120	150	180	120	90	120	60	30	0	60	60	60	0	90	90	90	90	120	120	90	90	30	90	120	0
Tylstrup	60	90	150	150	120	90	90	30	30	30	60	30	60	0	90	30	60	60	150	0	120	30	30	60	60	30
Foulum	90	60	150	180	120	90	120	30	60	60	60	60	60	0	60	60	60	120	120	90	60	90	30	60	60	30
Skjern	60	60	120	120	30	60	120	30	90	60	60	60	30	0	90	30	60	120	120	120	90	90	30	90	90	30
Ribe	60	60	120	120	30	30	90	30	30	60	60	90	30	0	60	60	90	90	150	90	90	60	60	90	60	30
Borris	60	60	120	150	30	60	90	30	60	60	60	60	60	0	60	30	60	120	150	120	30	60	30	90	30	0
Askov	60	60	120	120	30	30	60	30	30	30	30	60	0	0	90	30	30	60	120	90	30	60	30	60	60	30
Jyndevad	30	60	120	120	30	30	60	30	30	30	60	60	0	0	30	0	60	90	150	60	60	60	30	60	30	30

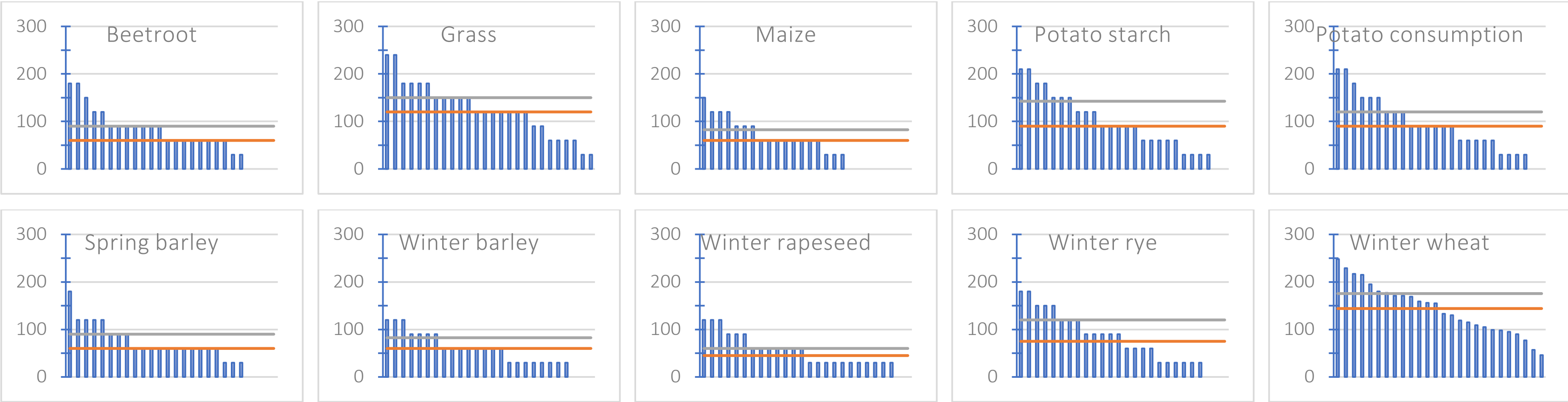
Winter rye

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	60	210	180	180	180	180	150	90	30	180	150	60	30	90	120	150	120	180	150	120	120	120	120	180	120
Årslev	120	90	210	180	120	150	180	120	30	60	90	150	60	60	60	120	120	120	180	150	90	90	90	120	150	120
Silstrup	150	150	210	180	180	180	150	120	60	30	90	90	60	0	120	120	150	120	150	150	120	90	30	150	120	30
Tylstrup	120	150	210	150	180	150	150	90	30	0	60	30	90	0	90	30	90	90	150	30	150	60	30	120	120	60
Foulum	120	90	180	180	180	150	150	90	60	60	60	120	60	30	60	90	120	120	150	120	90	90	30	120	90	30
Skjern	90	120	180	150	120	120	150	60	90	30	90	90	60	0	90	60	120	120	150	150	120	120	30	150	150	60
Ribe	60	60	180	120	120	120	120	60	30	60	60	90	60	30	60	90	150	90	180	120	120	90	60	120	90	90
Borris	90	120	180	150	90	120	120	30	90	30	90	90	60	0	60	60	120	120	150	180	60	60	30	150	60	0
Askov	90	60	210	120	120	120	90	60	60	30	30	90	0	0	90	60	120	60	150	120	60	60	60	120	120	60
Jyndevad	60	60	180	120	120	90	90	30	60	30	60	90	30	0	60	30	120	90	180	90	90	60	30	60	30	90

	Winter wheat																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	150	90	240	210	180	180	210	150	120	60	180	180	60	30	120	150	150	120	210	180	120	120	120	150	180	150
Årslev	150	120	210	180	150	150	180	150	60	90	120	150	90	90	90	120	120	90	180	150	90	90	90	120	180	120
Silstrup	150	180	240	180	210	180	210	150	60	60	90	90	60	30	150	150	150	120	180	150	120	90	30	180	150	30
Tylstrup	120	150	240	180	210	180	180	120	60	30	90	60	90	30	120	60	120	90	180	60	150	60	30	120	150	60
Foulum	150	90	210	180	210	180	180	120	60	90	90	120	90	60	90	90	120	120	180	120	120	90	60	120	120	60
Skjern	90	120	210	150	120	150	150	90	90	60	90	90	60	30	90	90	150	120	180	180	150	120	30	180	180	60
Ribe	90	90	210	120	150	120	150	90	60	60	90	90	60	30	90	90	180	90	180	120	150	90	60	150	120	120
Borris	120	120	210	150	120	120	150	60	90	60	120	120	90	30	90	60	150	120	150	210	60	60	30	180	60	0
Askov	90	60	210	120	120	120	90	90	60	60	60	90	0	30	120	60	150	90	150	120	90	60	60	120	120	90
Jyndevad	60	60	210	150	120	120	120	60	60	30	90	90	30	30	60	60	150	90	210	90	120	60	60	120	30	90

NB. the years 90-15 represent the years 1990-2015.

16 Appendix I – E. Annual GIWR (mm) at crop-level at RZC 140



NB. All graphs from Borris RZC 140

Beetroot

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	90	210	150	180	180	150	150	120	60	180	120	150	150	30	150	120	30	150	180	120	60	150	150	180	120
Årslev	60	120	210	120	120	180	120	120	60	90	60	90	120	180	60	90	120	30	120	120	120	30	0	150	240	90
Silstrup	120	150	210	120	150	150	120	120	0	60	90	30	60	90	90	120	120	30	90	60	60	30	0	120	120	0
Tylstrup	120	150	210	120	150	180	150	120	0	30	60	30	60	60	90	30	90	30	90	30	90	0	30	150	150	60
Foulum	120	60	180	120	120	180	120	120	30	60	30	90	30	90	60	60	90	30	90	60	60	30	0	90	120	30
Skjern	60	60	180	90	120	150	90	120	30	60	60	60	60	90	60	60	120	30	90	120	60	60	0	120	150	60
Ribe	30	60	180	60	90	150	90	90	0	30	60	60	60	90	60	90	120	0	90	90	90	30	0	90	120	90
Borris	60	90	180	90	60	150	90	90	30	90	60	60	90	90	60	60	120	30	60	180	0	0	0	120	60	0
Askov	30	30	180	60	90	150	30	120	0	90	60	30	0	60	60	30	120	0	30	90	60	0	0	90	150	90
Jyndevad	30	30	180	90	90	150	90	30	0	90	60	30	0	120	0	90	120	0	90	30	60	0	0	60	60	60

Grass-clover (for silage)																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	210	120	300	210	240	300	270	240	180	120	270	180	180	180	90	240	150	120	240	240	120	120	240	240	270	180
Årslev	180	180	300	180	180	240	210	180	120	150	120	150	150	210	120	180	150	90	240	210	120	90	60	180	330	150
Silstrup	210	240	270	180	240	240	210	180	60	60	120	60	120	120	180	180	150	120	180	150	120	90	30	210	180	30
Tylstrup	180	240	300	180	240	270	210	180	30	30	120	60	120	90	150	60	120	90	180	60	150	30	60	180	210	90
Foulum	210	150	270	180	240	240	240	150	60	90	90	150	90	120	120	120	150	120	210	150	150	120	30	150	180	60
Skjern	150	150	240	150	150	210	180	150	90	90	120	90	90	90	150	90	150	120	210	180	150	120	30	210	240	90
Ribe	120	150	270	150	180	210	210	150	30	60	150	90	60	120	120	120	180	90	210	180	150	90	60	150	180	120
Borris	150	180	240	150	120	180	180	150	60	120	120	120	120	90	120	90	150	120	150	240	60	60	30	180	60	30
Askov	120	120	270	120	150	210	120	150	60	120	90	60	0	60	120	90	180	60	120	120	90	60	60	180	210	90
Jyndevad	90	60	240	150	150	210	150	90	60	120	120	90	0	120	60	90	150	90	210	90	120	60	30	90	90	90

Maize																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	90	150	60	150	210	150	120	60	60	120	90	60	90	0	120	90	0	90	120	90	0	90	120	120	90
Årslev	60	120	150	30	90	180	120	90	30	60	30	60	60	120	30	60	90	0	90	60	90	0	0	120	180	60
Silstrup	90	120	180	30	150	150	150	90	0	60	60	0	30	90	90	90	90	0	30	30	30	0	0	90	60	0
Tylstrup	90	150	150	60	120	180	150	90	0	30	60	0	30	60	60	30	60	0	30	0	60	0	0	120	120	30
Foulum	90	60	150	30	120	180	120	90	0	60	30	60	0	60	30	30	90	0	60	30	60	0	0	60	90	30
Skjern	30	60	120	30	120	150	90	90	0	30	30	30	0	90	60	30	90	0	60	30	60	0	0	90	120	60
Ribe	30	60	150	0	90	150	90	60	0	30	60	30	0	90	30	30	120	0	60	60	60	0	0	60	90	30
Borris	60	60	120	30	60	150	120	60	0	60	60	60	30	90	60	30	90	0	0	120	0	0	0	90	0	0
Askov	60	30	150	0	90	150	30	90	0	90	30	0	0	30	30	0	120	0	0	0	30	0	0	90	120	60
Jyndevad	30	30	120	0	90	150	90	0	0	60	30	30	0	90	0	30	90	0	60	0	60	0	0	60	30	30

Potato starch																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	120	240	120	150	240	180	150	90	90	60	120	60	180	90	90	150	30	150	150	150	0	0	150	240	120
Årslev	60	60	240	30	150	210	90	150	30	90	90	30	0	60	90	60	180	0	60	60	90	0	0	150	180	120
Silstrup	90	120	210	90	120	210	180	150	30	60	90	90	60	120	60	90	150	30	60	180	30	0	0	150	60	30
Tylstrup	120	90	270	120	210	240	210	180	120	90	210	150	60	120	30	150	150	60	180	180	150	30	120	180	180	150
Foulum	150	90	240	120	180	240	210	120	30	60	60	120	30	120	90	90	120	60	120	90	120	60	30	120	150	60
Skjern	60	60	210	60	120	210	150	90	0	60	90	60	30	150	30	60	150	0	120	30	90	0	0	90	90	90
Ribe	60	90	240	60	150	210	150	120	0	30	120	60	60	120	90	90	180	30	120	120	120	30	0	150	150	90

Potato starch (continuation)

Borris	120	180	240	90	210	240	210	180	30	90	120	30	60	120	120	150	150	60	90	90	120	30	30	180	150	30
Askov	60	90	210	90	150	210	150	150	30	30	90	60	30	120	90	90	150	30	120	120	120	60	30	150	180	90
Jyndevad	120	180	240	90	180	210	240	180	0	30	90	60	30	90	90	60	120	30	90	30	120	0	30	180	180	90

Potato consumption

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	90	240	120	210	240	210	180	90	90	180	150	60	120	30	120	150	60	180	180	150	30	120	180	180	150
Årslev	120	120	240	120	150	240	180	150	60	90	60	120	60	150	90	90	150	30	150	150	150	0	30	150	240	120
Silstrup	120	150	240	90	180	240	210	180	30	90	120	30	60	120	120	150	150	60	90	90	120	30	30	180	150	30
Tylstrup	120	150	240	90	180	210	240	180	0	30	90	60	30	90	90	60	120	30	90	30	120	0	30	150	180	90
Foulum	150	60	240	120	180	240	180	120	30	60	60	120	30	90	90	90	120	60	120	90	120	60	0	120	150	60
Skjern	60	60	210	90	150	210	150	150	30	30	90	60	30	90	90	90	150	30	120	120	120	60	30	120	180	90
Ribe	60	60	240	60	150	210	150	120	0	30	120	60	30	90	90	90	180	30	120	120	120	30	0	120	150	90
Borris	90	90	210	90	120	210	150	120	30	60	90	90	60	120	60	90	150	30	60	180	30	0	0	150	60	30
Askov	60	30	240	30	150	210	90	150	30	90	90	30	0	60	90	60	180	0	60	60	90	0	0	150	180	120
Jyndevad	60	30	210	60	120	210	150	90	30	60	90	60	30	120	30	60	150	0	120	30	90	0	0	90	90	90

Spring barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	30	180	150	120	120	120	120	60	0	120	120	30	0	60	90	120	60	150	90	90	60	90	90	150	90
Årslev	60	60	180	150	90	90	120	90	30	30	60	90	60	30	60	90	90	60	120	120	60	30	60	90	120	90
Silstrup	90	120	180	150	150	120	150	120	60	30	60	60	60	0	90	90	120	60	120	90	90	30	30	120	90	0
Tylstrup	60	90	180	120	120	90	150	90	30	0	30	0	60	0	90	30	90	30	120	30	120	0	0	90	90	60
Foulum	90	60	180	150	150	120	120	90	60	0	30	90	30	30	60	60	90	60	120	90	60	30	30	90	90	0
Ribe	60	90	180	120	60	60	120	60	90	0	60	60	60	0	60	60	90	60	120	120	90	60	30	90	120	30
Skjern	30	30	180	90	90	60	90	60	30	0	60	60	30	0	60	90	120	30	150	60	90	60	30	60	60	60
Borris	60	60	180	120	60	60	90	60	60	0	60	90	60	0	60	60	120	60	90	120	30	0	30	120	30	0
Askov	30	30	180	60	90	60	60	60	60	0	0	30	0	0	60	30	90	0	90	90	60	30	30	60	90	60
Jyndevad	0	0	180	90	60	60	60	60	30	0	30	30	0	0	30	30	120	30	150	30	60	30	30	30	0	60

Winter barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	30	150	150	90	90	90	90	60	30	90	120	30	0	90	90	60	90	150	90	60	90	90	60	120	90
Årslev	90	60	120	150	60	60	90	60	30	30	60	90	60	30	60	90	60	90	120	90	0	60	60	30	90	60
Silstrup	90	90	150	180	120	90	90	60	30	0	30	60	60	0	60	90	90	90	120	90	90	90	0	60	90	0

Winter barley (continuation)

Tylstrup	60	90	150	120	120	90	90	30	30	0	30	0	60	0	60	30	30	60	150	0	120	30	0	30	60	30
Foulum	60	60	120	180	120	90	120	30	30	30	30	60	60	0	60	60	60	90	120	90	60	90	30	60	60	0
Skjern	60	60	120	120	30	30	90	30	60	30	60	60	30	0	60	30	60	90	120	120	90	90	0	90	90	0
Ribe	60	60	120	90	30	30	90	30	30	30	30	90	30	0	60	60	60	90	120	60	90	60	30	60	60	30
Borris	60	60	120	120	30	60	90	30	60	30	60	60	60	0	30	30	30	90	120	90	30	60	0	90	30	0
Askov	60	60	120	90	30	30	60	30	30	30	30	60	0	0	60	30	30	60	120	90	30	60	30	60	60	30
Jyndevad	30	30	120	120	30	30	60	30	30	0	30	60	0	0	30	0	60	60	150	30	60	60	30	30	0	30

Winter rapeseed

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	30	150	120	90	90	90	60	60	30	90	90	30	0	60	90	60	90	120	90	30	90	90	60	120	90
Årslev	90	60	120	120	30	60	90	60	30	30	60	90	30	30	60	90	60	90	120	90	0	60	60	60	90	60
Silstrup	60	90	120	150	120	90	90	60	30	0	30	60	30	0	60	60	60	90	120	90	60	60	30	60	90	0
Tylstrup	60	90	120	120	90	90	90	30	30	0	30	0	60	0	60	30	30	60	150	0	120	30	0	30	60	30
Foulum	60	60	120	150	90	60	120	30	30	30	30	60	30	0	30	60	30	90	120	60	60	60	30	60	60	0
Skjern	60	60	90	120	30	30	90	0	60	30	30	60	30	0	60	30	30	90	120	120	90	90	30	60	90	0
Ribe	60	60	120	90	30	30	90	30	30	30	30	60	30	0	60	30	60	60	120	60	90	60	30	60	30	30
Borris	60	60	120	120	30	30	90	30	60	30	60	60	30	0	30	30	30	90	120	90	30	60	30	60	30	0
Askov	60	60	120	90	30	30	60	30	30	30	30	60	0	0	60	30	30	60	120	60	30	60	30	60	60	30
Jyndevad	30	60	120	90	30	30	30	30	30	30	30	60	0	0	30	0	60	60	150	30	30	60	30	30	0	30

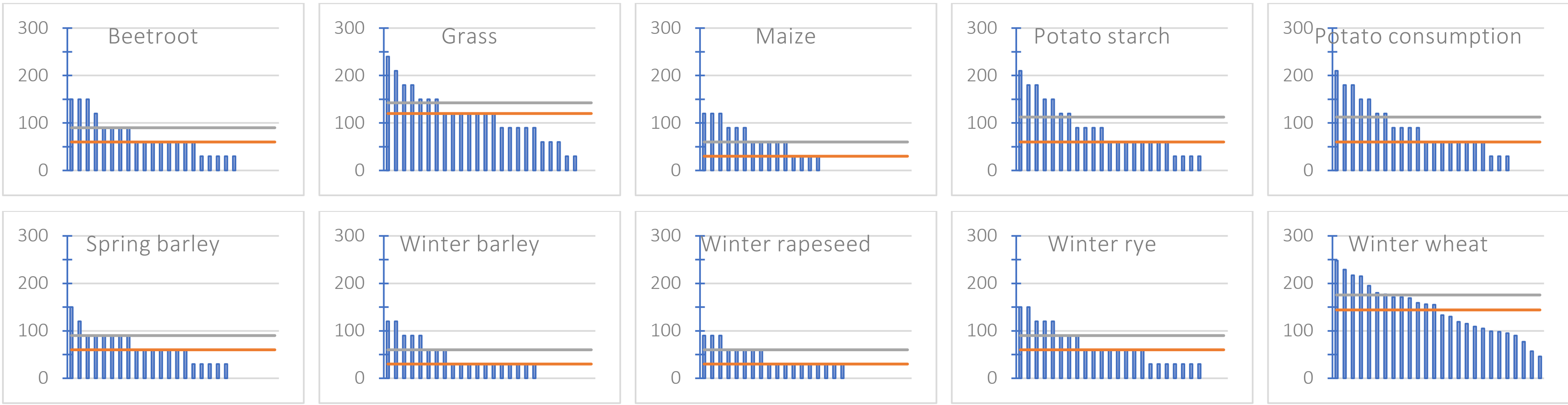
Winter rye

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	30	180	180	150	150	150	120	90	30	150	150	60	30	90	120	120	120	180	120	90	90	90	120	150	120
Årslev	90	90	180	150	120	120	150	90	30	30	90	120	60	60	60	90	90	90	150	120	60	90	60	90	150	90
Silstrup	120	120	210	180	150	150	150	90	60	30	60	60	60	0	120	120	120	90	120	120	90	90	30	120	120	30
Tylstrup	90	120	180	150	180	150	150	90	30	0	60	30	60	0	90	30	90	60	150	30	120	30	0	90	90	60
Foulum	120	60	180	180	180	150	150	90	60	30	30	90	60	30	60	60	90	120	150	120	90	90	30	90	90	0
Skjern	60	90	180	120	90	90	120	60	90	30	60	60	30	0	90	60	120	120	150	150	120	90	30	150	120	30
Ribe	60	30	180	120	120	90	90	60	30	30	60	90	30	0	60	60	150	90	150	90	90	60	60	90	60	90
Borris	90	90	180	150	90	60	120	30	60	30	90	90	60	0	60	30	120	120	150	180	30	30	0	150	30	0
Askov	60	60	180	90	90	90	90	30	60	30	30	60	0	0	90	30	90	60	120	90	60	60	30	90	90	60
Jyndevad	30	30	150	120	90	90	90	30	30	30	30	90	0	0	30	30	120	90	180	60	90	60	30	60	30	60

	Winter wheat																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	150	60	210	180	180	180	180	150	90	60	180	180	60	30	90	120	150	90	180	150	120	90	120	150	180	120
Årslev	120	90	210	180	120	150	180	120	30	60	90	150	60	60	60	120	120	90	180	150	90	90	90	120	180	120
Silstrup	150	150	240	180	180	180	180	120	60	30	90	90	60	0	120	120	150	120	150	150	120	90	30	150	150	30
Tylstrup	120	150	210	150	180	150	180	120	30	0	60	30	90	0	90	60	90	90	180	30	150	30	0	120	120	60
Foulum	120	90	210	180	180	180	180	90	60	60	60	120	60	30	60	90	120	120	180	120	90	60	60	120	90	0
Skjern	90	120	180	150	120	120	150	60	90	60	90	90	60	0	90	60	120	120	150	180	120	120	30	150	150	60
Ribe	60	60	210	120	120	120	150	90	30	60	90	90	60	30	90	90	150	90	180	120	120	90	60	120	90	90
Borris	120	120	210	150	90	90	150	60	90	60	90	90	60	0	60	60	120	120	150	180	30	30	30	150	60	0
Askov	90	60	210	90	120	120	90	60	60	30	60	60	0	0	90	60	120	60	150	120	90	60	60	120	120	60
Jyndevad	60	60	180	120	120	90	90	60	60	30	60	60	30	30	60	30	120	90	180	60	90	60	30	60	30	90

NB. the years 90-15 represent the years 1990-2015.

17 Appendix I – F. Annual GIWR (mm) at crop-level at RZC 160



NB. All graphs from Borris RZC 160

Beetroot

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	60	180	120	150	210	120	150	90	30	180	120	120	120	0	150	120	30	120	150	90	30	120	150	150	120
Årslev	60	120	180	120	90	180	90	120	60	60	60	90	90	150	30	90	90	0	120	120	90	0	0	120	210	90
Silstrup	90	150	180	90	150	180	120	120	0	60	60	30	30	90	90	90	90	30	60	60	60	30	0	120	90	0
Tylstrup	90	120	180	90	120	180	150	120	0	30	30	30	30	60	60	30	90	0	60	30	60	0	0	120	150	60
Foulum	120	60	180	120	120	180	120	60	30	60	30	90	30	90	30	60	60	30	90	60	60	30	0	60	90	30
Skjern	60	60	150	90	90	150	60	90	30	30	60	60	0	60	60	60	120	30	90	90	60	60	0	90	150	30
Ribe	30	60	180	60	90	150	60	90	0	30	60	30	0	90	30	60	120	0	90	90	60	30	0	60	90	60
Borris	60	60	150	90	60	150	90	90	30	60	60	60	30	60	30	60	120	0	30	150	0	0	0	90	30	0
Askov	30	30	150	30	90	150	30	90	0	60	30	30	0	30	30	30	120	0	30	60	60	0	0	90	120	60
Jyndevad	30	30	150	60	90	150	60	30	0	60	30	30	0	90	0	60	120	0	90	30	60	0	0	30	30	60

Grass-clover (for silage)																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	180	120	270	180	240	270	240	210	150	60	240	180	180	150	90	210	150	90	240	240	120	90	210	210	240	180
Årslev	150	180	270	180	150	240	210	150	90	150	90	150	150	180	90	120	120	90	210	180	90	90	60	180	300	150
Silstrup	180	240	270	180	210	240	210	180	30	60	90	60	90	90	150	150	120	90	150	120	90	90	30	180	150	30
Tylstrup	150	210	270	150	210	240	210	150	30	0	90	30	90	60	120	60	90	60	150	30	150	30	30	150	180	60
Foulum	180	120	240	180	210	240	210	120	60	90	90	120	60	120	90	90	120	90	180	120	120	90	30	120	150	30
Skjern	120	120	210	150	150	180	180	120	90	90	120	90	60	90	120	60	120	90	180	150	120	120	30	180	210	60
Ribe	120	120	240	120	150	150	180	120	30	60	120	90	30	90	120	90	180	60	210	150	120	90	30	150	150	90
Borris	120	150	210	150	90	180	180	120	60	120	120	90	120	90	90	60	120	90	120	240	30	30	0	150	60	0
Askov	90	90	240	90	150	180	90	120	30	120	90	60	0	60	90	30	150	60	120	120	90	60	30	120	180	90
Jyndevad	60	60	240	120	150	180	150	60	30	90	90	60	0	120	30	60	150	60	180	60	90	60	30	60	60	90

Maize																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	60	60	120	60	120	180	120	90	60	30	120	90	60	60	0	90	90	0	90	90	60	0	90	120	120	60
Årslev	60	90	120	30	90	150	90	60	30	60	0	60	30	90	30	30	60	0	60	60	90	0	0	90	150	60
Silstrup	60	120	150	0	120	150	120	60	0	60	60	0	0	90	60	60	60	0	0	30	30	0	0	90	60	0
Tylstrup	60	120	120	30	120	150	120	90	0	0	30	0	0	30	30	0	60	0	0	0	30	0	0	90	90	30
Foulum	60	30	120	30	90	150	120	30	0	30	30	60	0	60	30	30	60	0	60	0	30	0	0	60	60	30
Skjern	30	30	120	0	90	150	90	60	0	30	30	30	0	60	30	0	90	0	60	30	30	0	0	60	90	30
Ribe	30	60	120	0	90	120	90	60	0	0	30	30	0	60	30	30	90	0	60	30	30	0	0	60	90	30
Borris	30	60	120	0	60	120	90	60	0	60	30	30	0	60	30	0	90	0	0	120	0	0	0	90	0	0
Askov	30	30	120	0	90	120	30	60	0	60	30	0	0	0	30	0	90	0	0	0	30	0	0	60	90	60
Jyndevad	30	0	120	0	90	120	60	0	0	60	30	0	0	60	0	30	90	0	30	0	30	0	0	60	30	30

Potato starch																										
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	120	240	90	120	240	180	150	60	60	60	120	60	150	60	60	120	0	120	120	150	0	0	150	240	120
Årslev	60	60	210	30	120	180	90	150	0	60	60	30	0	60	60	30	150	0	30	60	60	0	0	120	150	90
Silstrup	60	90	210	60	90	180	150	120	30	60	90	60	30	90	60	60	150	0	60	180	30	0	0	120	60	30
Tylstrup	120	90	240	120	180	240	210	180	120	60	180	150	60	90	0	120	150	30	150	150	120	30	120	150	180	120
Foulum	150	90	210	90	150	210	180	120	30	60	60	120	0	90	60	60	120	30	120	60	90	30	0	90	120	60
Skjern	60	30	210	60	120	180	150	60	0	60	90	30	30	120	30	60	150	0	90	30	90	0	0	60	60	60
Ribe	60	90	210	30	120	180	150	120	0	30	90	60	30	90	60	90	150	0	120	120	90	0	0	90	120	90

Potato starch (continuation)

Borris	120	180	240	90	180	210	210	150	0	60	120	30	30	90	120	120	120	30	60	90	90	30	0	150	120	30
Askov	60	90	210	60	120	210	150	150	30	30	90	60	0	90	60	60	150	30	120	90	90	60	0	120	150	90
Jyndevad	120	150	240	90	150	210	210	150	0	30	60	60	0	90	90	60	120	30	90	30	90	0	30	150	180	90

Potato consumption

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	60	240	120	180	210	210	150	90	60	180	120	30	90	0	120	150	30	150	120	120	30	90	150	180	120
Årslev	90	120	240	90	120	210	180	120	60	60	60	120	60	150	60	60	120	0	120	120	150	0	0	150	210	120
Silstrup	120	150	240	90	180	210	210	150	30	60	90	30	30	90	120	120	120	30	60	90	90	30	0	150	120	30
Tylstrup	120	150	240	90	150	210	210	150	0	30	60	60	0	60	90	60	120	30	90	30	90	0	30	150	180	90
Foulum	120	60	210	90	150	210	180	120	30	60	60	90	0	90	60	60	120	30	120	60	90	30	0	90	120	60
Skjern	60	60	210	60	120	210	150	120	30	30	90	60	0	90	60	60	150	30	120	90	90	60	0	120	150	90
Ribe	60	60	210	30	120	180	150	120	0	30	90	60	30	90	60	90	150	0	120	90	90	0	0	90	120	90
Borris	60	90	210	60	90	180	150	120	30	60	90	60	0	90	60	60	150	0	60	180	30	0	0	120	60	30
Askov	60	30	210	30	120	180	90	120	0	60	60	30	0	60	60	30	150	0	30	60	60	0	0	120	150	90
Jyndevad	60	30	210	60	120	180	120	60	0	60	60	30	30	120	30	60	150	0	90	30	90	0	0	60	60	60

Spring barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	60	0	180	150	90	120	120	120	60	0	120	90	30	0	60	90	90	30	120	90	60	30	60	60	120	90
Årslev	30	30	150	120	60	120	90	90	30	0	60	60	30	30	30	60	60	30	120	90	60	0	60	60	90	60
Silstrup	90	90	180	120	120	120	120	90	30	0	30	30	30	0	90	60	90	60	90	90	90	30	30	90	60	0
Tylstrup	60	60	150	120	120	90	150	60	0	0	0	0	30	0	60	0	60	30	90	0	90	0	0	60	90	30
Foulum	60	30	150	150	120	120	120	60	30	0	0	90	30	0	60	30	60	60	90	60	30	0	30	60	60	0
Ribe	30	60	150	90	60	120	90	60	60	0	30	30	30	0	60	30	90	30	90	90	60	30	30	90	120	30
Skjern	0	0	150	90	60	90	60	60	30	0	30	30	30	0	60	60	90	30	120	60	60	0	30	60	60	60
Borris	60	60	150	90	60	90	90	30	60	0	30	60	60	0	30	30	90	60	90	120	0	0	0	90	30	0
Askov	30	0	150	60	60	90	60	30	30	0	0	30	0	0	60	0	90	0	90	60	60	0	30	60	60	30
Jyndevad	0	0	150	90	60	90	60	30	30	0	0	30	0	0	30	30	90	30	120	30	60	0	30	0	0	60

Winter barley

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	30	120	120	60	60	90	60	60	30	90	90	30	0	60	60	30	90	120	90	30	60	90	30	90	60
Årslev	60	60	120	120	30	30	90	30	0	30	60	90	30	30	30	60	30	60	90	90	0	60	30	30	60	60
Silstrup	60	90	120	150	90	60	90	60	30	0	0	60	30	0	60	60	60	90	90	90	60	60	0	60	60	0

Winter barley (continuation)

Tylstrup	30	60	120	120	90	60	90	30	0	0	30	0	60	0	60	0	30	60	120	0	90	30	0	30	30	30
Foulum	60	60	120	150	90	60	90	30	30	30	30	30	30	0	30	30	30	90	90	60	60	60	0	30	60	0
Skjern	30	60	90	120	0	0	90	0	60	30	30	30	30	0	60	30	30	90	120	90	90	60	0	60	60	0
Ribe	30	30	90	90	30	30	60	30	0	30	30	60	0	0	30	30	60	60	120	60	60	60	30	60	30	30
Borris	30	60	90	120	30	0	60	0	30	30	30	30	30	0	30	0	30	90	120	90	0	30	0	60	30	0
Askov	60	60	120	90	30	30	60	0	30	30	30	30	0	0	60	0	30	30	90	60	30	30	30	30	60	0
Jyndevad	30	30	90	90	0	30	30	0	30	0	30	60	0	0	30	0	30	60	120	30	30	30	0	30	0	30

Winter rapeseed

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	60	30	120	120	60	60	60	60	30	30	60	90	30	0	60	60	30	60	120	60	30	60	60	60	90	60
Årslev	60	60	120	90	30	30	60	30	0	30	30	60	30	0	30	60	30	60	90	60	0	60	30	30	60	60
Silstrup	60	60	120	150	90	60	60	30	30	0	0	30	30	0	30	60	60	60	90	90	60	60	30	60	60	0
Tylstrup	30	60	120	90	90	60	60	0	0	0	30	0	30	0	60	0	0	30	120	0	90	30	0	0	30	0
Foulum	60	30	120	150	90	60	90	0	0	30	30	30	30	0	30	30	30	60	90	60	30	60	30	30	30	0
Skjern	30	60	90	90	0	0	90	0	60	30	30	30	0	0	30	30	30	60	90	90	60	60	0	60	60	0
Ribe	30	30	90	90	30	30	60	0	0	30	30	60	0	0	30	30	30	60	90	60	60	60	30	60	30	30
Borris	30	60	90	90	30	0	60	0	30	30	30	30	30	0	30	0	30	60	90	60	0	30	0	60	0	0
Askov	60	60	90	90	30	30	60	0	30	30	30	30	0	0	60	0	30	30	90	60	0	60	30	30	30	0
Jyndevad	30	30	90	90	0	30	30	0	0	0	30	30	0	0	30	0	30	30	120	30	30	30	0	30	0	0

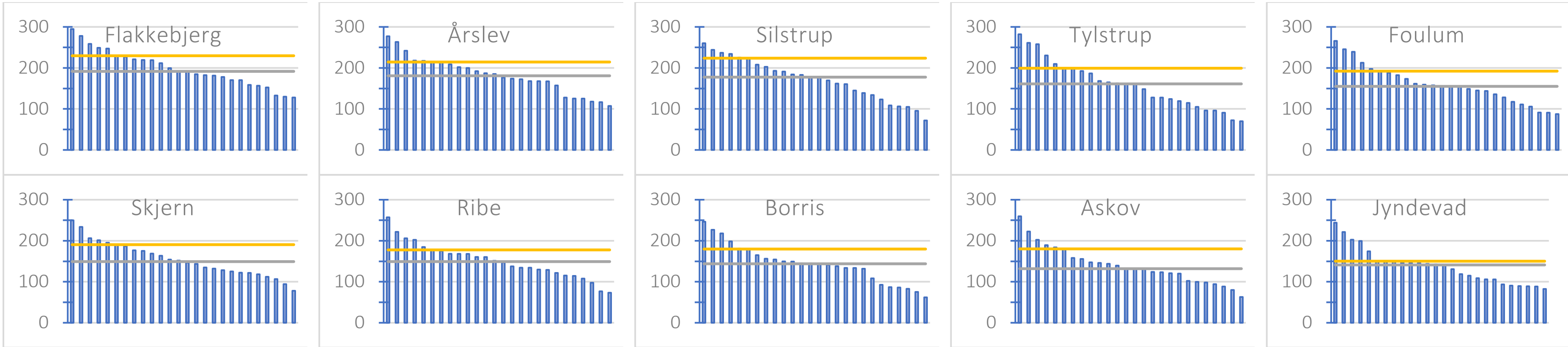
Winter rye

Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	90	30	180	150	120	150	150	90	60	0	120	120	30	0	60	90	90	90	150	90	60	90	90	90	120	90
Årslev	90	60	150	120	90	90	120	90	30	30	60	90	60	30	60	90	90	60	150	90	30	60	60	90	120	90
Silstrup	90	120	180	150	150	120	120	90	30	0	30	60	30	0	90	90	90	90	120	90	60	60	0	120	90	0
Tylstrup	60	90	150	120	150	120	120	60	0	0	30	0	60	0	60	0	60	60	120	0	120	30	0	60	90	30
Foulum	90	60	150	150	150	120	120	60	30	30	30	90	30	0	30	60	60	90	120	90	60	60	30	60	60	0
Skjern	60	60	150	120	60	60	120	30	60	30	60	60	30	0	60	30	90	90	120	120	90	90	0	120	90	0
Ribe	30	30	150	90	90	60	90	30	0	30	30	90	30	0	60	30	120	60	120	90	90	60	30	90	60	60
Borris	60	60	150	120	60	60	90	30	60	30	60	60	60	0	30	30	90	90	120	150	30	30	0	120	30	0
Askov	60	30	150	90	90	60	60	30	30	0	0	60	0	0	60	30	90	30	120	60	30	30	30	60	60	30
Jyndevad	30	30	120	90	60	60	60	30	30	0	30	60	0	0	30	0	90	60	150	30	60	30	30	30	0	60

	Winter wheat																									
Year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*
Flakkebjerg	120	30	210	180	150	150	150	120	90	30	150	150	60	30	90	120	120	90	180	120	90	90	90	120	150	120
Årslev	90	90	180	150	120	120	150	90	30	60	90	120	60	60	60	90	90	90	180	120	60	90	60	90	150	90
Silstrup	120	150	210	150	180	150	180	120	60	30	90	60	60	0	120	90	120	120	120	120	90	60	30	150	120	30
Tylstrup	90	120	180	120	180	150	150	90	30	0	60	30	60	0	90	30	90	60	150	30	120	30	0	90	90	30
Foulum	120	60	180	150	180	150	150	90	60	30	30	90	60	30	60	60	90	120	150	90	60	60	30	90	90	0
Skjern	90	90	180	120	90	90	120	60	90	30	60	60	60	0	90	30	120	90	150	150	120	90	30	150	120	30
Ribe	60	60	180	120	120	90	120	60	30	30	60	90	30	0	60	60	150	60	150	90	90	60	60	90	90	90
Borris	90	90	180	120	90	90	120	30	60	30	90	90	60	0	60	30	120	90	120	150	30	30	30	150	30	0
Askov	60	60	180	90	90	90	90	60	60	30	30	60	0	0	90	30	120	60	120	90	60	60	60	90	90	60
Jyndevad	30	30	180	120	90	90	90	30	30	30	30	60	0	0	60	30	120	60	180	60	90	30	30	60	0	60

NB. the years 90-15 represent the years 1990-2015.

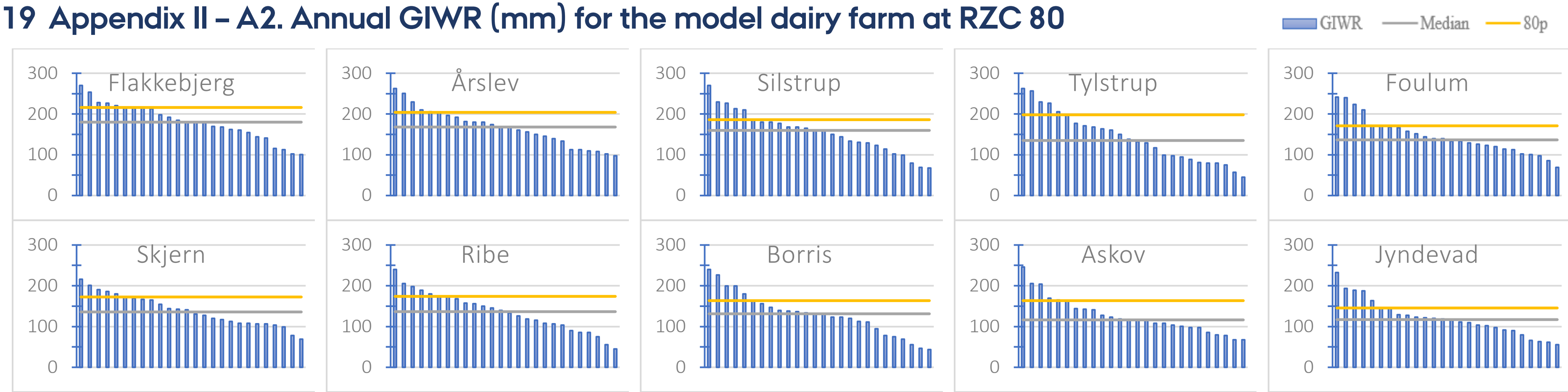
18 Appendix II – A1. Annual GIWR (mm) for the model dairy farm at RZC 60



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	182	152	295	192	230	278	247	249	159	170	227	185	178	170	133
Årslev	185	200	277	172	167	242	217	213	125	157	125	177	168	209	128
Silstrup	184	234	260	179	225	244	237	224	95	139	162	105	145	161	191
Tylstrup	165	230	282	168	210	258	261	187	70	115	124	105	161	128	163
Foulum	188	149	266	198	213	239	246	192	88	159	117	154	136	144	145
Skjern	128	177	250	154	163	234	201	169	94	112	135	125	118	122	152
Ribe	138	160	257	122	160	222	185	168	73	115	147	129	98	134	130
Borris	134	165	246	145	138	218	198	150	87	156	145	134	149	143	132
Askov	131	133	260	123	180	223	156	147	80	139	120	100	63	124	146
Jyndevad	109	119	244	131	146	221	174	150	82	150	144	146	94	145	89

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	212	200	128	221	259	157	130	191	219	219	181	199	37	162
Årslev	202	187	107	218	214	168	117	118	192	263	174	182	44	138
Silstrup	176	193	123	183	203	134	109	106	208	170	72	154	49	105
Tylstrup	119	161	96	192	91	148	72	96	199	199	128	159	51	108
Foulum	154	156	111	182	173	128	106	91	158	161	91	159	41	118
Skjern	147	187	107	190	175	132	143	78	195	206	122	172	49	123
Ribe	168	202	108	206	168	134	114	77	178	175	151	151	48	103
Borris	154	180	108	141	227	75	83	86	181	93	62	143	50	93
Askov	121	202	88	158	144	102	98	94	184	189	131	140	54	86
Jyndevad	140	199	90	203	115	106	91	88	149	106	142	137	56	81

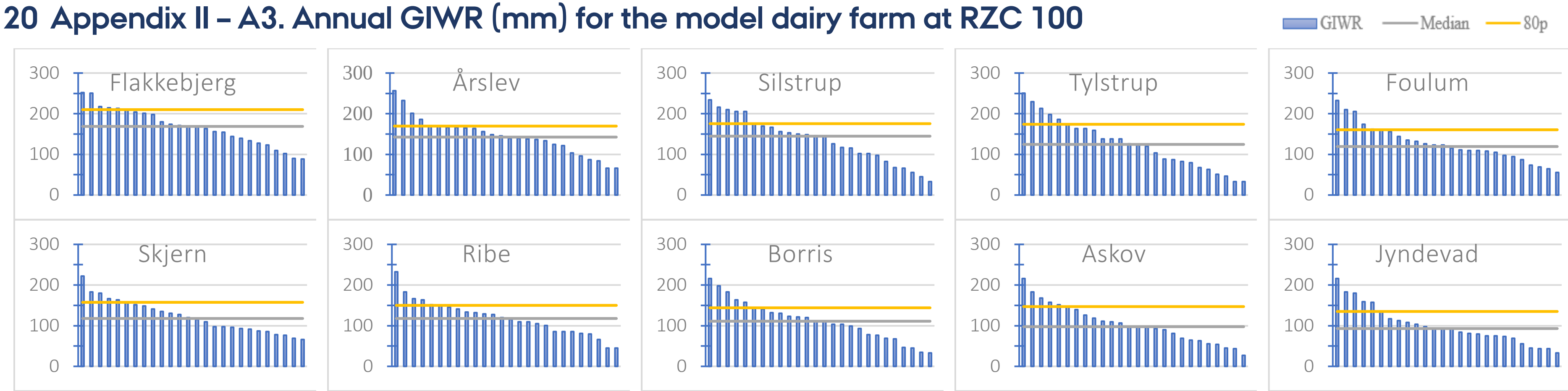
19 Appendix II – A2. Annual GIWR (mm) for the model dairy farm at RZC 80



Station/year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Flakkebjerg	161	141	270	179	216	254	228	227	144	168	215	180	155	162	102
Årslev	174	192	263	161	168	230	204	210	98	146	108	150	156	180	110
Silstrup	168	227	270	161	210	230	213	186	68	134	150	99	114	123	168
Tylstrup	168	206	263	161	227	230	257	164	45	89	98	80	132	117	138
Foulum	168	134	240	171	210	242	224	171	86	129	98	152	114	123	140
Skjern	128	173	216	131	155	201	170	141	78	99	120	104	108	107	144
Ribe	108	150	240	119	158	206	180	146	45	75	134	104	86	107	116
Borris	138	156	240	131	147	200	200	140	78	123	120	111	132	95	134
Askov	128	143	246	108	165	206	116	141	68	123	98	104	78	101	144
Jyndevad	98	104	233	119	146	194	164	123	56	122	110	120	63	146	80

Station/year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	198	180	113	213	221	116	101	185	192	215	170	181	30	151
Årslev	180	168	113	197	206	134	113	102	182	251	140	167	40	127
Silstrup	180	180	129	159	165	131	102	80	177	144	69	155	45	110
Tylstrup	95	150	80	171	75	129	57	81	177	198	99	142	43	99
Foulum	134	158	113	167	126	120	102	69	140	144	101	145	36	109
Skjern	117	180	113	167	165	143	108	69	186	191	107	139	47	92
Ribe	156	198	90	189	173	126	86	56	174	168	140	136	47	89
Borris	123	180	113	137	227	56	44	69	164	75	47	130	48	82
Askov	116	204	68	119	108	98	86	80	164	170	117	127	56	71
Jyndevad	129	188	90	189	102	116	66	62	111	92	128	121	54	67

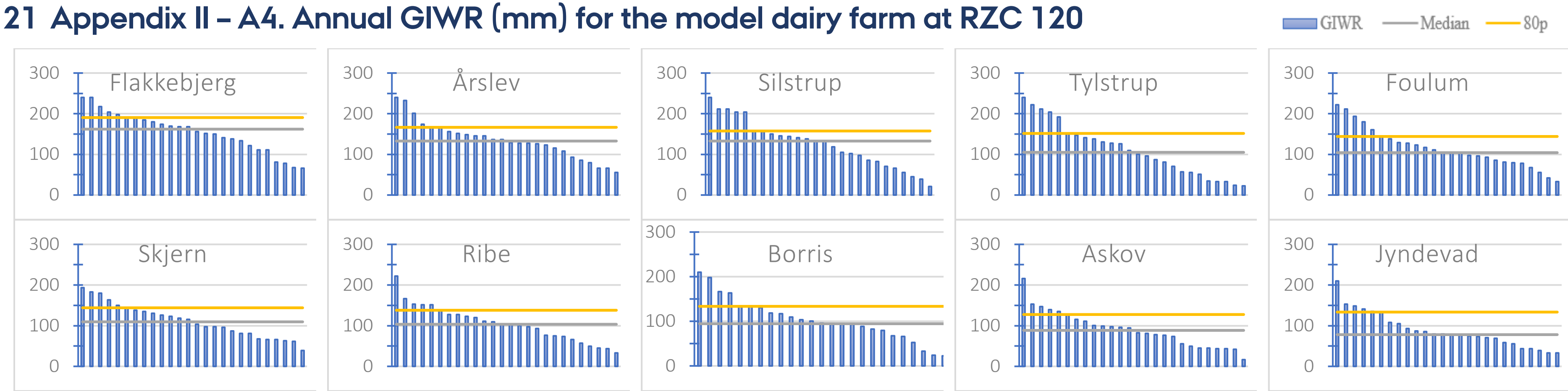
20 Appendix II – A3. Annual GIWR (mm) for the model dairy farm at RZC 100



Station/year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Flakkebjerg	155	128	251	171	198	252	218	210	134	110	215	164	144	140	102
Årslev	138	165	257	149	146	201	186	164	87	122	96	134	137	170	104
Silstrup	167	210	234	153	216	206	206	176	56	83	117	68	98	102	156
Tylstrup	138	186	251	138	198	230	213	164	33	83	104	51	120	89	138
Foulum	162	126	233	161	174	206	210	156	56	135	87	123	110	105	116
Skjern	98	128	222	131	135	183	164	141	78	98	110	93	86	77	116
Ribe	86	128	233	101	141	183	152	134	45	81	110	86	86	105	116
Borris	120	144	216	131	111	183	164	123	68	122	104	93	132	77	104
Askov	98	81	216	90	158	183	110	140	56	111	98	63	27	65	126
Jyndevad	75	81	216	108	135	183	158	80	45	93	98	84	56	113	69

Station/year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	174	180	90	201	213	123	89	168	170	204	156	167	26	141
Årslev	156	140	66	167	167	125	66	84	170	233	140	145	27	118
Silstrup	144	146	102	149	126	116	66	45	170	150	33	134	33	101
Tylstrup	68	123	80	159	63	126	33	47	164	174	87	125	35	90
Foulum	98	111	95	144	108	110	74	69	123	132	65	126	26	100
Skjern	92	152	66	167	149	120	96	69	158	180	87	123	43	80
Ribe	129	164	80	167	120	132	66	45	150	146	110	119	44	75
Borris	99	141	78	111	198	45	33	47	158	69	35	112	42	70
Askov	69	152	44	119	96	93	54	45	147	168	107	104	45	59
Jyndevad	104	180	44	159	74	93	44	33	117	75	93	100	44	56

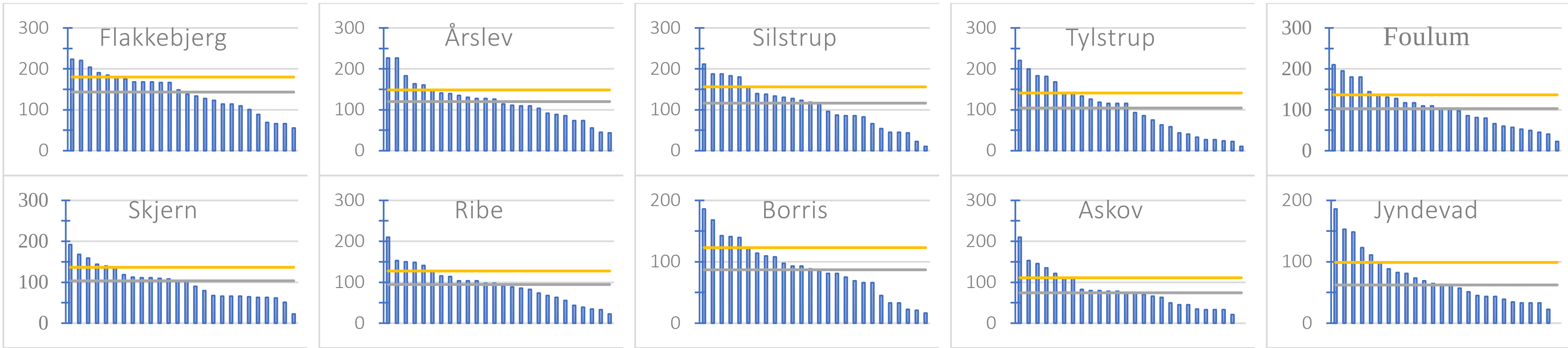
21 Appendix II – A4. Annual GIWR (mm) for the model dairy farm at RZC 120



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	138	111	240	168	198	240	218	174	134	81	204	152	150	122	68
Årslev	126	146	240	149	129	201	174	156	93	116	86	128	137	146	80
Silstrup	150	204	240	141	204	212	212	156	45	71	98	56	86	83	146
Tylstrup	128	192	240	138	204	222	212	141	23	24	87	57	96	81	110
Foulum	138	104	222	161	180	212	194	129	56	81	68	123	86	105	93
Skjern	98	126	194	119	135	183	164	123	68	81	98	81	62	66	116
Ribe	75	111	222	101	128	153	152	123	33	57	98	74	50	77	104
Borris	104	134	210	119	89	167	164	117	68	93	110	93	96	83	93
Askov	98	74	216	78	135	153	81	111	45	99	77	56	17	42	116
Jyndevad	75	74	210	108	135	153	134	80	33	77	87	80	39	105	69

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	180	141	66	191	191	111	78	168	170	185	156	155	19	136
Årslev	137	123	66	167	167	108	66	56	152	233	128	135	21	114
Silstrup	144	134	102	119	132	105	66	39	158	138	21	125	28	97
Tylstrup	51	101	56	131	33	126	33	35	147	152	71	111	24	87
Foulum	104	117	78	144	96	98	80	33	111	128	42	115	17	98
Skjern	63	131	66	144	138	104	96	39	150	180	87	112	39	73
Ribe	110	152	44	167	120	104	66	45	128	138	93	105	38	67
Borris	80	131	66	101	198	33	21	23	134	53	24	100	29	71
Askov	50	147	44	101	96	83	44	45	128	140	95	91	37	54
Jyndevad	77	141	44	149	56	93	44	33	71	59	86	89	38	51

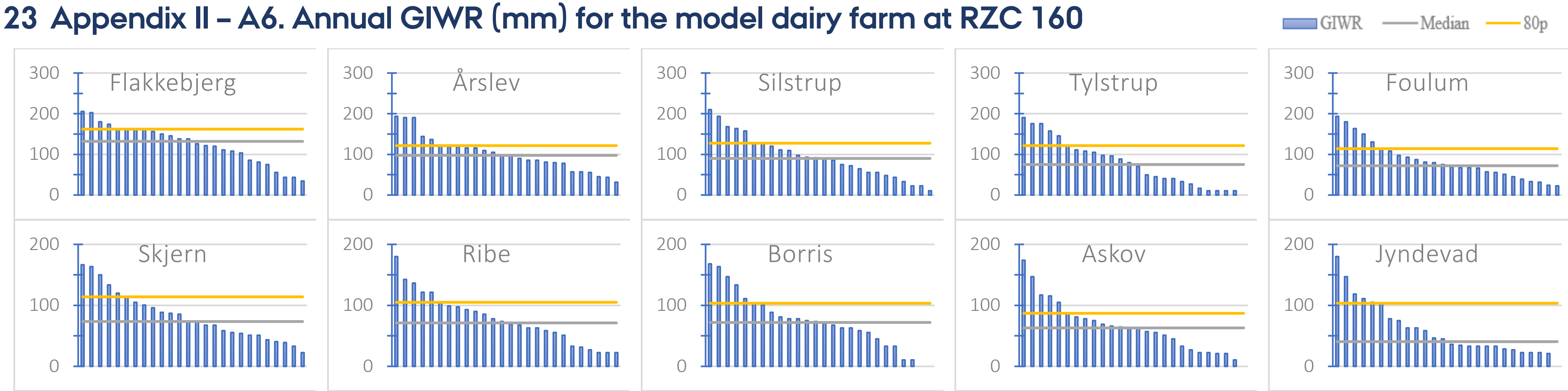
22 Appendix II – A5. Annual GIWR (mm) for the model dairy farm at RZC 140



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	138	89	221	149	176	224	204	180	114	69	185	134	114	110	56
Årslev	114	135	227	131	128	183	164	128	74	92	74	104	110	140	86
Silstrup	138	180	212	131	188	188	183	140	45	54	87	45	86	83	134
Tylstrup	116	182	221	126	168	200	183	134	23	24	75	27	86	59	116
Foulum	144	104	210	131	180	195	180	117	45	53	57	110	50	81	86
Skjern	90	110	192	108	113	159	140	111	68	51	80	63	62	66	104
Ribe	68	98	210	89	128	153	150	104	23	35	104	63	39	83	86
Borris	98	114	186	108	81	143	141	110	45	75	81	93	86	66	93
Askov	75	74	210	66	111	153	80	111	45	83	45	33	0	35	80
Jyndevad	45	35	186	89	99	153	111	62	33	69	74	51	0	83	33

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	168	123	66	167	168	101	66	167	168	191	128	141	14	127
Årslev	126	111	56	161	149	89	44	45	141	227	110	121	16	105
Silstrup	128	123	66	119	96	86	44	23	156	114	11	110	22	88
Tylstrup	41	93	44	119	33	116	11	27	141	140	63	98	19	79
Foulum	80	117	66	137	102	98	60	23	110	128	41	104	14	90
Skjern	63	111	66	137	119	104	66	23	144	168	65	99	34	65
Ribe	92	141	44	149	114	104	56	33	98	116	74	94	34	60
Borris	69	123	66	89	168	33	21	23	140	33	17	88	30	58
Askov	50	135	21	78	78	63	33	33	122	146	71	78	30	48
Jyndevad	57	123	44	149	44	81	33	23	65	39	63	71	28	43

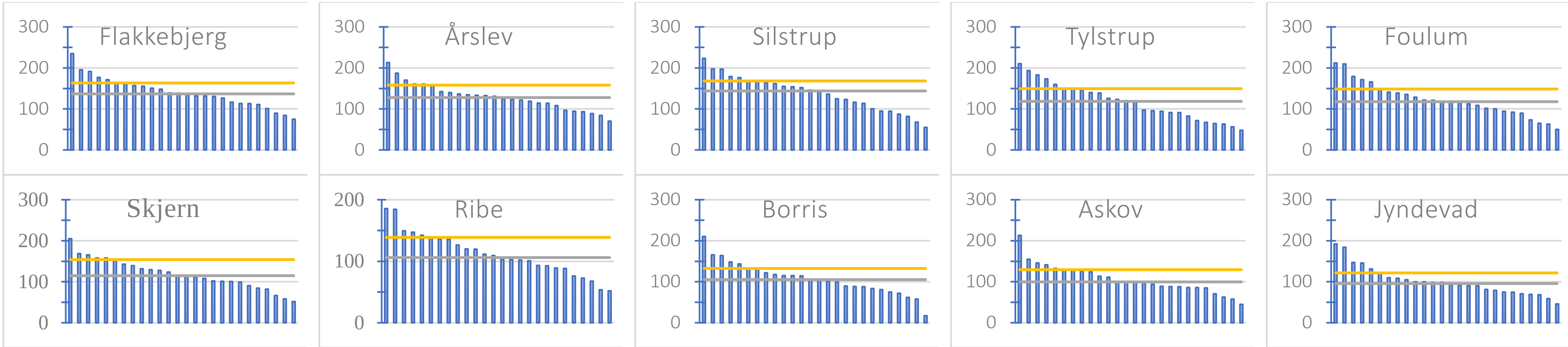
23 Appendix II – A6. Annual GIWR (mm) for the model dairy farm at RZC 160



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	108	75	203	138	162	206	180	156	104	35	174	122	120	86	56
Årslev	86	116	191	119	105	194	144	110	57	86	56	98	90	116	57
Silstrup	120	168	210	111	158	194	164	126	23	48	65	33	56	72	110
Tylstrup	98	146	191	108	158	176	176	111	11	0	45	11	50	41	80
Foulum	108	68	180	131	150	194	164	80	33	51	45	93	39	75	69
Skjern	68	74	164	89	105	167	134	87	56	51	68	51	39	59	86
Ribe	56	69	180	78	105	137	122	93	23	27	68	51	23	59	86
Borris	74	104	164	89	71	147	134	81	45	75	68	63	78	59	63
Askov	57	51	174	56	105	147	63	81	23	75	45	33	0	27	69
Jyndevad	35	27	180	78	105	147	104	33	23	59	45	33	0	75	23

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	150	111	44	161	161	81	44	138	146	162	126	125	12	113
Årslev	80	81	44	137	120	78	32	45	122	191	98	102	12	90
Silstrup	98	93	56	89	86	75	44	23	128	92	11	94	17	77
Tylstrup	27	71	33	89	11	96	11	17	105	122	41	78	9	69
Foulum	57	87	56	114	66	68	32	23	81	98	24	84	11	73
Skjern	33	101	44	114	96	74	54	23	120	150	41	82	27	55
Ribe	63	122	33	143	90	74	32	23	98	99	63	77	30	47
Borris	33	101	56	78	168	11	11	0	111	33	0	74	16	58
Askov	11	117	21	78	66	63	21	23	87	116	65	64	25	39
Jyndevad	47	111	33	119	33	63	21	23	36	29	63	59	22	37

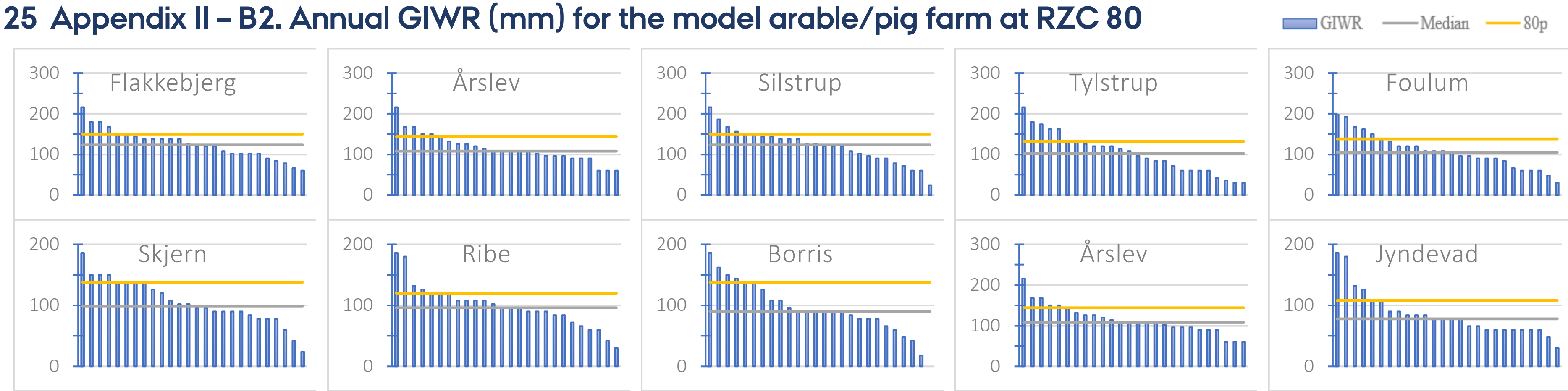
24 Appendix II – B1. Annual GIWR (mm) for the model arable/pig farm at RZC 60



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	132	101	235	191	157	151	155	148	113	75	161	163	90	84	111
Årslev	136	123	213	170	121	135	158	133	84	70	119	140	93	97	89
Silstrup	136	164	223	197	176	146	198	167	100	68	123	116	95	55	142
Tylstrup	123	146	210	183	160	149	173	117	67	56	97	94	96	64	126
Foulum	129	109	212	210	171	135	179	116	90	101	94	141	73	63	100
Skjern	90	124	205	165	101	128	158	101	114	58	108	99	84	52	111
Ribe	93	102	186	139	111	136	120	101	68	73	109	120	76	52	89
Borris	90	122	210	166	106	118	143	83	105	72	115	114	99	62	88
Askov	98	86	213	146	127	132	113	86	85	58	94	99	45	63	111
Jyndevad	69	75	184	147	90	131	105	98	93	68	100	122	46	59	75

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	139	138	113	195	177	127	131	117	130	171	135	140	21	119
Årslev	142	132	114	187	161	125	108	94	114	161	131	129	28	101
Silstrup	125	162	114	168	179	152	94	87	155	147	54	136	28	108
Tylstrup	72	140	83	194	91	148	63	48	120	139	91	117	28	89
Foulum	116	119	122	166	149	112	92	65	139	121	50	122	22	100
Skjern	102	132	115	169	158	143	129	66	139	154	82	119	26	93
Ribe	103	149	93	184	126	142	102	88	136	122	115	113	28	85
Borris	102	132	115	148	164	81	75	58	132	88	17	108	25	83
Askov	88	141	88	155	124	100	101	71	129	129	89	107	37	70
Jyndevad	92	146	90	192	98	110	81	79	100	71	109	101	38	63

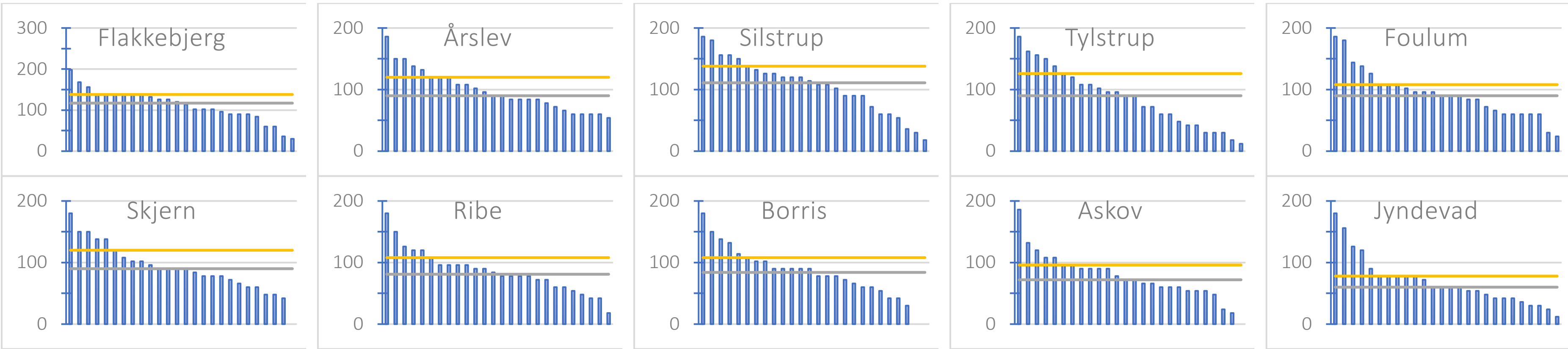
25 Appendix II – B2. Annual GIWR (mm) for the model arable/pig farm at RZC 80



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	120	84	216	180	138	138	138	138	90	78	150	150	66	60	102
Årslev	120	96	216	168	108	108	144	126	60	60	108	126	90	60	90
Silstrup	120	144	216	186	168	126	156	138	90	78	108	90	72	24	138
Tylstrup	120	108	216	174	162	120	162	96	60	36	60	60	90	30	120
Foulum	120	96	198	192	162	132	168	96	84	60	60	138	66	30	90
Skjern	90	108	186	150	96	96	138	78	102	42	90	90	78	24	90
Ribe	72	84	186	126	96	108	120	96	60	42	90	102	60	30	90
Borris	90	108	186	150	96	90	138	78	90	42	90	90	90	0	84
Askov	90	90	204	132	96	108	108	78	84	42	60	96	48	42	102
Jyndevad	60	66	186	132	78	90	108	78	60	60	84	90	30	48	60

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	120	126	102	180	144	102	120	102	108	168	138	125	15	110
Årslev	132	108	102	168	150	96	96	90	108	150	114	115	22	93
Silstrup	120	138	102	150	150	144	96	60	126	120	60	120	21	99
Tylstrup	60	114	84	180	72	132	42	30	126	132	84	103	20	83
Foulum	90	108	108	150	120	90	102	60	108	120	48	108	15	93
Skjern	84	138	102	150	150	126	120	60	138	138	78	105	21	84
Ribe	108	132	84	180	120	120	90	66	108	108	96	99	24	75
Borris	78	126	108	144	162	66	48	60	138	78	18	94	20	74
Askov	90	126	66	132	120	96	90	60	102	114	78	94	36	58
Jyndevad	60	126	84	180	84	108	66	60	78	60	78	85	33	52

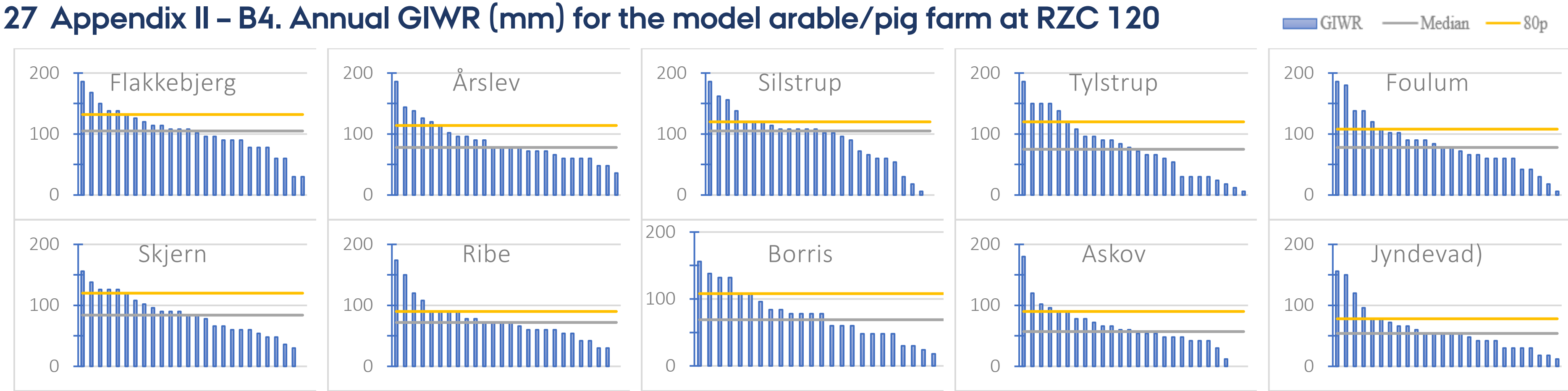
26 Appendix II – B3. Annual GIWR (mm) for the model arable/pig farm at RZC 100



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	102	60	198	168	132	138	138	126	90	36	138	138	60	30	90
Årslev	96	84	186	150	84	84	138	102	54	60	90	120	60	60	60
Silstrup	108	138	186	180	156	120	156	126	60	36	90	90	60	18	108
Tylstrup	90	90	186	150	138	120	156	96	30	12	60	42	72	18	108
Foulum	90	90	186	180	138	108	144	96	60	60	60	108	60	24	84
Skjern	60	90	180	150	72	78	120	66	90	42	78	90	60	0	90
Ribe	42	60	180	120	96	90	96	78	48	42	78	96	54	18	84
Borris	90	90	180	150	78	78	114	66	90	42	90	90	78	0	60
Askov	72	54	186	120	96	90	90	72	60	24	60	66	0	18	90
Jyndevad	42	42	180	120	78	90	78	54	60	12	60	72	30	24	60

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	120	126	84	156	138	96	102	102	90	138	114	112	11	101
Årslev	120	108	84	150	120	66	72	90	78	132	108	98	14	84
Silstrup	90	132	102	150	120	114	72	54	126	120	30	105	14	91
Tylstrup	30	102	72	162	48	126	42	30	96	108	60	86	14	72
Foulum	66	84	102	126	108	90	72	60	96	96	30	93	11	82
Skjern	78	102	84	150	138	102	96	48	108	138	48	91	16	75
Ribe	96	126	72	150	90	120	72	60	108	78	78	86	21	65
Borris	72	102	102	132	138	54	42	30	108	60	0	82	20	62
Askov	54	108	48	132	90	78	54	60	96	108	66	77	26	51
Jyndevad	48	126	54	156	60	78	42	36	78	30	78	69	24	45

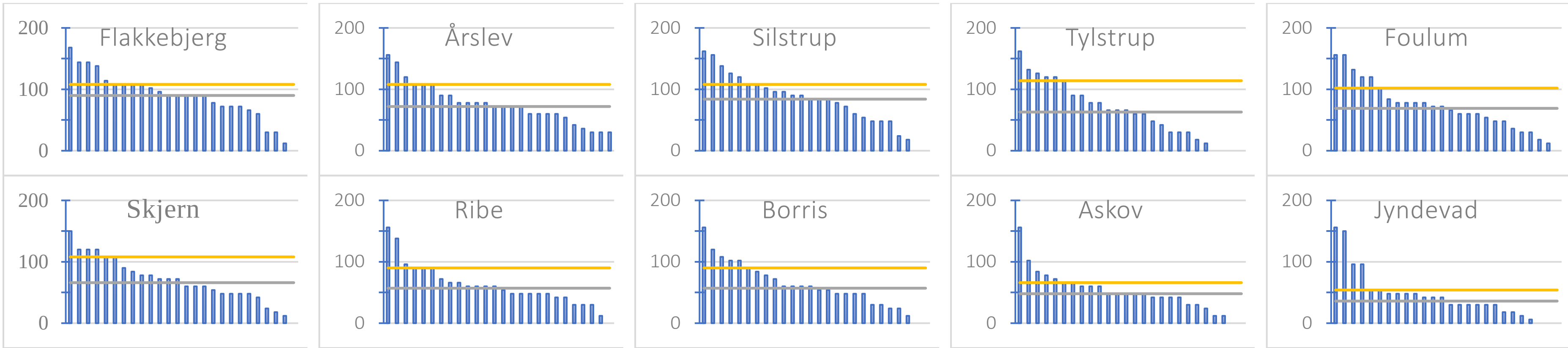
27 Appendix II – B4. Annual GIWR (mm) for the model arable/pig farm at RZC 120



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	96	60	186	168	126	108	132	108	90	30	138	120	60	30	90
Årslev	72	60	186	144	78	78	120	96	48	36	78	96	60	48	60
Silstrup	108	120	186	162	138	114	156	102	54	18	60	66	60	0	108
Tylstrup	78	90	186	150	138	108	150	72	30	12	60	30	66	18	90
Foulum	90	66	186	180	138	108	138	90	60	42	42	102	60	18	60
Skjern	60	84	156	126	66	78	120	66	90	36	60	60	48	0	90
Ribe	42	60	174	120	72	54	90	72	30	42	60	72	30	0	60
Borris	78	84	156	132	48	60	108	48	78	18	78	78	60	0	60
Askov	60	42	180	102	72	54	66	48	54	12	48	60	0	0	90
Jyndevad	30	42	156	120	66	54	78	48	30	12	54	66	18	18	54

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	114	102	78	150	114	78	90	96	78	138	108	103	8	95
Årslev	90	102	72	138	114	66	72	60	78	126	90	87	8	79
Silstrup	90	108	96	120	120	108	72	30	108	102	6	93	5	88
Tylstrup	30	84	66	150	24	120	30	6	96	96	54	78	11	67
Foulum	60	78	102	120	90	66	72	30	78	84	6	83	7	76
Skjern	54	102	84	126	138	96	90	30	108	126	48	82	11	71
Ribe	78	108	54	150	90	90	66	60	90	78	72	74	14	60
Borris	48	96	84	132	138	30	24	30	108	48	0	70	14	56
Askov	30	96	42	120	90	66	42	54	78	78	48	63	17	46
Jyndevad	42	96	54	150	60	78	42	30	54	30	72	60	17	43

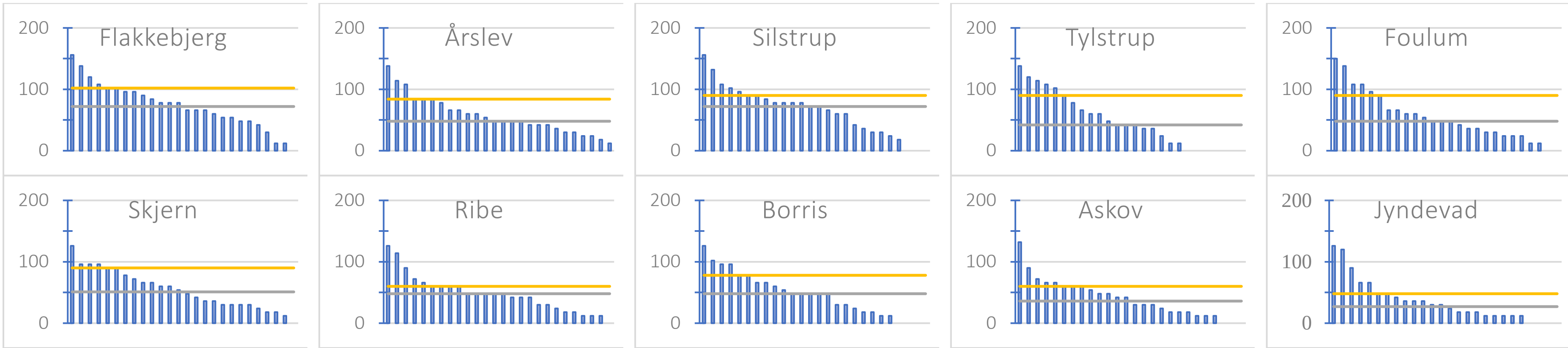
28 Appendix II – B5. Annual GIWR (mm) for the model arable/pig farm at RZC 140



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	90	30	168	144	108	108	108	102	60	12	108	114	30	0	66
Årslev	72	60	156	144	72	78	108	78	30	30	60	90	54	30	60
Silstrup	84	108	162	156	138	108	126	96	48	18	48	60	54	0	78
Tylstrup	60	90	162	120	114	90	126	66	30	0	30	0	60	0	78
Foulum	78	60	156	156	132	102	120	66	48	12	30	78	36	18	54
Skjern	60	78	150	120	48	48	108	42	78	12	54	60	48	0	60
Ribe	42	42	156	90	66	48	90	48	30	12	48	66	30	0	60
Borris	60	60	156	120	48	54	90	48	60	12	60	78	54	0	48
Askov	42	42	156	72	66	48	60	48	48	12	12	42	0	0	60
Jyndevad	12	18	156	96	48	48	54	48	30	6	30	42	0	0	30

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	90	96	72	144	90	72	72	90	78	138	90	88	5	83
Årslev	90	78	72	120	108	36	42	60	72	108	78	76	7	69
Silstrup	84	102	72	120	90	84	48	24	96	90	0	81	4	77
Tylstrup	30	66	42	132	18	120	12	0	66	78	48	63	7	56
Foulum	60	72	72	120	84	60	48	30	78	78	0	71	4	67
Skjern	48	72	72	120	120	90	72	24	84	108	18	69	8	61
Ribe	72	96	48	138	60	90	60	30	60	54	48	61	11	50
Borris	48	84	72	102	108	30	24	24	102	30	0	60	12	48
Askov	30	66	24	102	84	48	42	30	60	78	48	51	12	39
Jyndevad	18	96	42	150	30	54	42	30	30	0	48	45	10	35

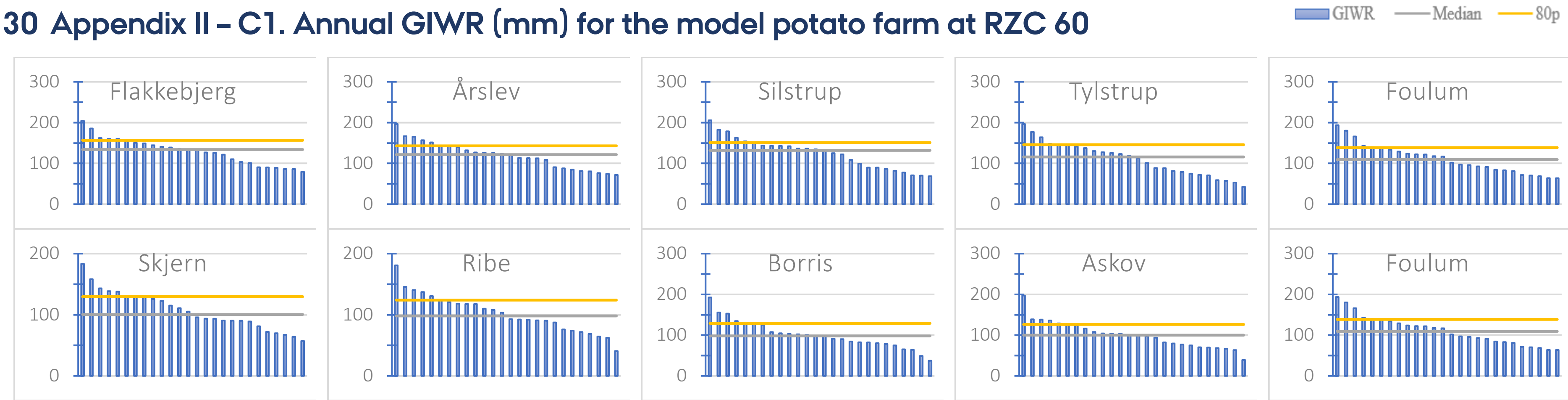
29 Appendix II – B6. Annual GIWR (mm) for the model arable/pig farm at RZC 160



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	66	12	156	138	78	96	102	96	54	12	102	90	30	0	60
Årslev	42	42	138	114	48	84	84	66	18	12	54	66	30	24	30
Silstrup	78	84	156	132	108	96	102	72	30	0	18	36	30	0	72
Tylstrup	48	60	138	114	108	78	120	42	0	0	12	0	36	0	60
Foulum	60	36	138	150	108	96	108	42	24	12	12	66	30	0	48
Skjern	30	60	126	96	36	72	90	36	60	12	30	30	24	0	54
Ribe	12	12	126	90	48	66	60	42	18	12	30	42	18	0	48
Borris	48	60	126	96	48	54	78	18	48	12	30	48	48	0	30
Askov	42	24	132	72	48	66	60	18	30	12	12	30	0	0	60
Jyndevad	12	12	126	90	36	66	48	18	24	0	12	36	0	0	30

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	78	66	48	120	84	48	42	66	54	108	78	72	3	69
Årslev	60	48	42	108	84	36	24	48	48	78	60	57	4	53
Silstrup	60	78	66	90	90	78	42	24	78	60	0	65	3	62
Tylstrup	0	42	36	102	0	90	12	0	42	66	24	47	2	45
Foulum	30	48	66	90	60	36	24	24	48	54	0	54	3	51
Skjern	30	66	48	96	90	66	42	18	78	96	18	54	5	49
Ribe	48	72	42	114	60	60	24	30	60	48	48	47	8	39
Borris	18	66	66	96	102	0	12	0	78	24	0	46	5	41
Askov	0	66	12	90	60	42	18	30	48	54	18	40	9	31
Jyndevad	18	66	36	120	30	48	12	18	12	0	42	35	7	28

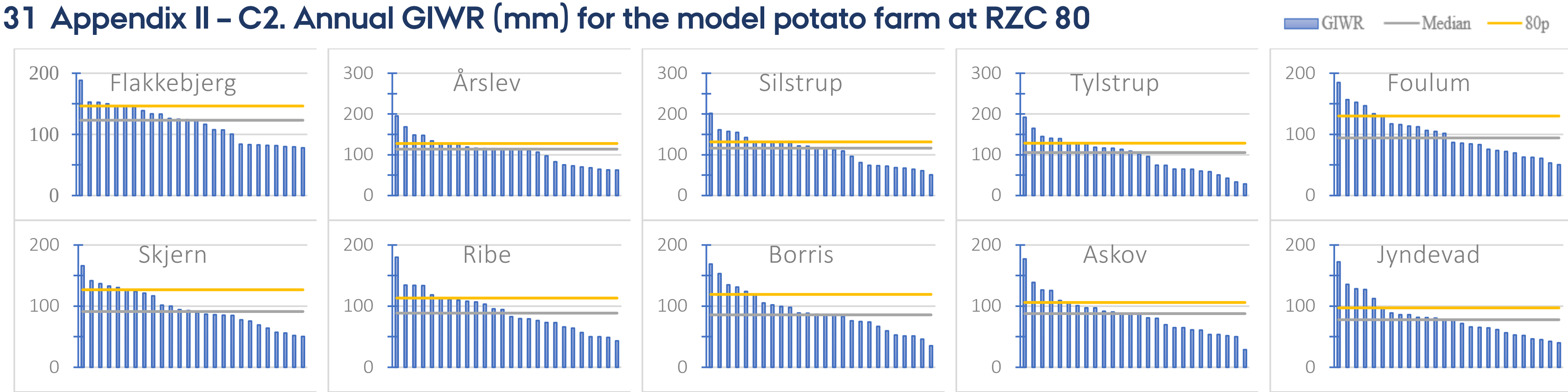
30 Appendix II – C1. Annual GIWR (mm) for the model potato farm at RZC 60



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	134	90	204	186	162	149	160	139	101	86	144	141	79	103	86
Årslev	142	112	197	165	126	143	157	132	72	80	88	113	76	113	81
Silstrup	143	142	206	179	163	151	183	154	70	78	109	99	82	90	125
Tylstrup	138	130	197	164	148	141	177	123	43	59	88	79	75	89	113
Foulum	140	97	194	180	143	139	166	124	69	91	81	118	64	84	96
Skjern	94	96	183	158	115	130	139	111	67	57	94	89	64	72	105
Ribe	92	87	181	137	118	131	118	108	41	64	93	90	62	76	91
Borris	98	98	192	153	108	125	135	100	64	75	105	102	82	84	90
Askov	98	77	197	129	124	138	104	104	68	70	82	94	39	70	100
Jyndevad	76	64	177	141	102	129	114	104	59	72	81	94	59	83	73

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	121	135	90	150	157	127	89	110	134	160	126	129	23	106
Årslev	109	127	85	151	140	125	74	91	120	167	123	120	29	91
Silstrup	122	143	90	136	129	136	71	87	144	134	68	124	31	93
Tylstrup	81	126	71	146	72	127	53	57	118	146	101	110	31	79
Foulum	93	122	83	134	117	102	71	64	122	129	70	111	24	87
Skjern	90	129	81	138	123	126	91	70	128	143	90	107	30	77
Ribe	92	140	69	146	103	121	74	72	118	124	110	102	31	71
Borris	91	129	82	103	156	79	49	65	131	80	37	101	29	72
Askov	80	139	67	116	99	104	75	63	126	136	108	100	39	61
Jyndevad	84	136	74	145	82	97	61	62	99	85	98	94	41	53

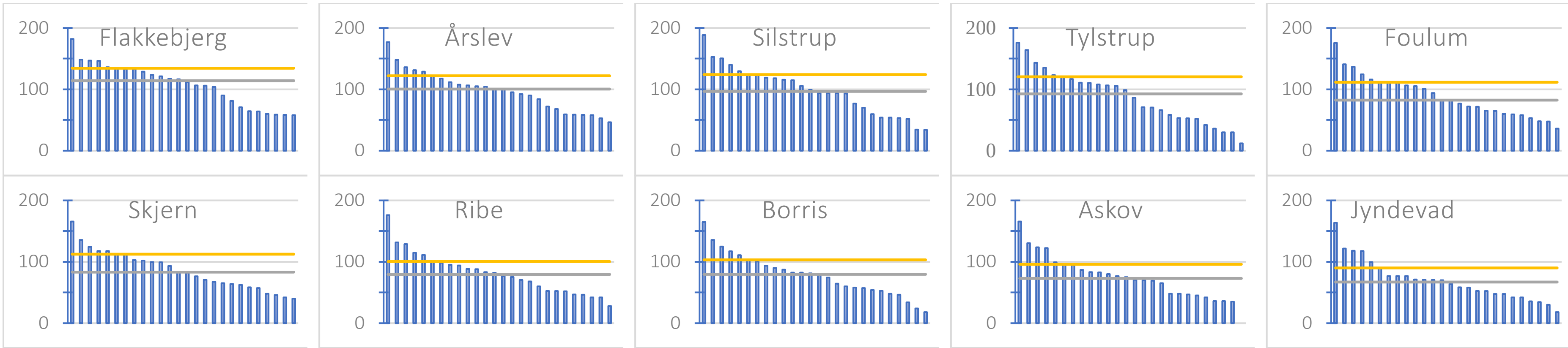
31 Appendix II – C2. Annual GIWR (mm) for the model potato farm at RZC 80



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	122	82	188	134	145	150	153	133	83	83	146	126	78	82	80
Årslev	125	97	195	115	113	148	148	127	64	75	70	116	73	106	83
Silstrup	130	132	202	131	155	157	161	142	51	74	96	73	67	68	122
Tylstrup	127	109	192	118	145	140	165	116	42	50	65	60	74	64	102
Foulum	134	83	185	130	147	157	152	114	62	76	70	112	50	63	84
Skjern	94	87	166	102	100	137	130	93	64	50	85	78	56	57	86
Ribe	73	73	180	80	108	134	118	103	43	50	94	79	50	64	76
Borris	100	85	169	102	98	131	135	88	60	51	85	83	75	51	87
Askov	88	70	177	80	109	139	97	97	52	61	65	81	29	61	90
Jyndevad	65	45	172	80	97	128	112	89	42	66	86	78	40	78	53

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	108	116	80	147	139	107	84	100	124	152	125	118	18	100
Årslev	115	114	68	134	128	111	62	63	114	168	119	110	25	85
Silstrup	116	130	81	113	109	121	72	64	129	116	61	110	25	85
Tylstrup	74	116	65	126	58	113	28	33	128	140	96	98	23	75
Foulum	86	105	74	117	106	87	72	53	102	116	61	100	18	82
Skjern	76	133	69	127	117	121	85	52	124	142	90	97	26	71
Ribe	83	134	57	134	107	110	66	49	111	113	96	92	28	64
Borris	89	119	74	105	153	67	46	53	124	76	35	90	25	65
Askov	65	126	50	88	92	88	54	54	106	126	101	86	37	49
Jyndevad	64	127	56	136	62	86	52	46	82	72	81	81	34	47

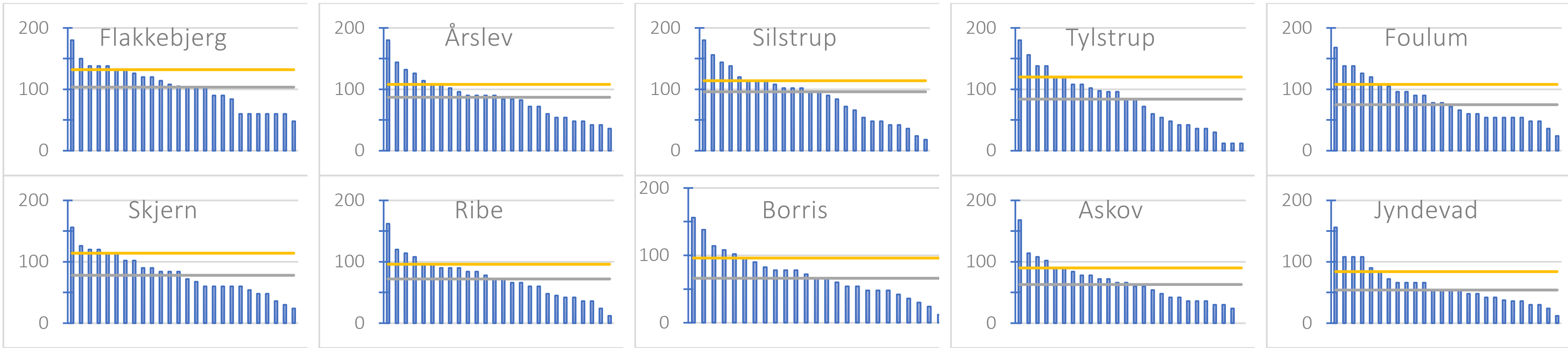
32 Appendix II – C3. Annual GIWR (mm) for the model potato farm at RZC 100



Station/year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Flakkebjerg	112	60	182	121	146	148	147	129	81	64	136	124	59	71	58
Årslev	105	90	177	104	106	131	136	122	59	72	68	108	46	92	59
Silstrup	119	124	188	115	140	153	150	130	34	54	93	70	60	54	99
Tylstrup	111	108	176	106	135	143	164	117	12	30	70	53	52	66	86
Foulum	111	72	176	116	124	137	141	106	58	60	59	101	48	72	82
Skjern	68	84	166	103	102	124	118	93	57	42	76	71	46	48	82
Ribe	53	60	176	68	94	132	111	88	28	42	75	77	47	52	70
Borris	90	82	165	103	78	125	117	94	58	54	81	82	53	48	60
Askov	75	48	166	71	96	130	80	99	35	48	70	65	0	42	83
Jyndevad	53	42	164	70	90	118	100	71	34	42	70	64	36	71	58

Station/year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	106	117	58	133	134	104	64	90	106	133	116	108	13	95
Årslev	84	112	58	129	118	95	53	58	101	148	100	97	15	82
Silstrup	94	124	77	116	94	94	53	52	118	106	34	98	18	80
Tylstrup	58	111	53	120	42	99	30	36	106	123	71	88	16	72
Foulum	65	105	65	112	77	83	53	36	94	111	48	89	13	76
Skjern	62	112	58	118	100	99	64	40	112	136	65	86	21	65
Ribe	82	129	52	115	83	95	42	46	100	98	88	81	25	56
Borris	74	111	64	87	136	46	18	34	100	57	24	79	22	57
Askov	45	124	47	87	69	77	36	36	95	122	83	74	28	46
Jyndevad	52	118	48	122	48	77	30	18	77	58	77	69	27	42

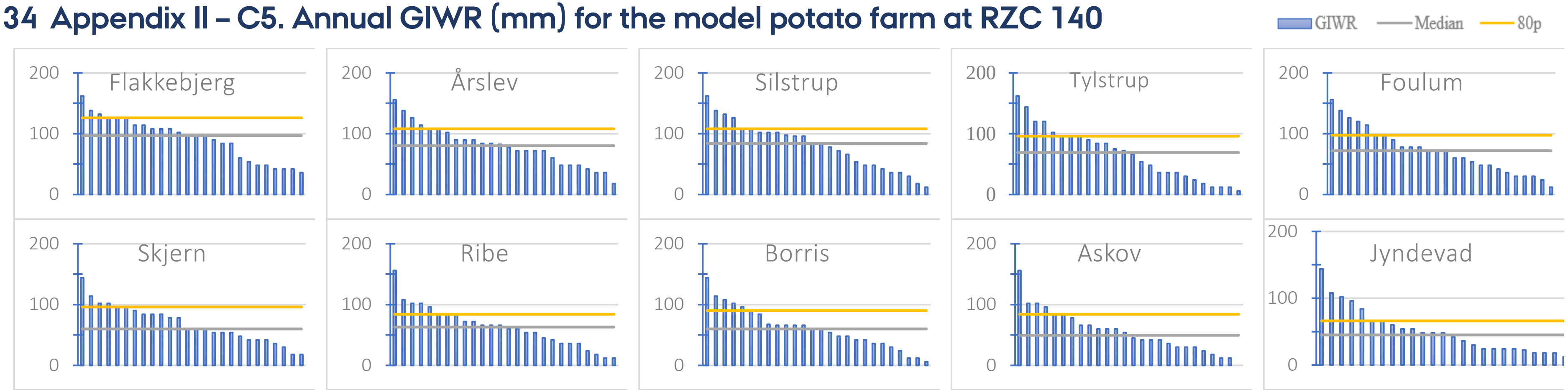
33 Appendix II – C4. Annual GIWR (mm) for the model potato farm at RZC 120



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	105	60	180	126	132	138	150	114	84	48	138	120	60	60	60
Årslev	83	72	180	108	90	126	132	96	54	48	54	90	48	90	60
Silstrup	120	108	180	114	138	144	156	114	36	42	72	54	48	48	102
Tylstrup	98	96	180	108	138	138	156	102	12	30	60	36	42	42	84
Foulum	105	54	168	120	126	138	138	96	48	54	54	90	48	54	60
Skjern	68	72	156	90	84	126	120	84	60	36	60	60	30	48	84
Ribe	45	60	162	72	90	108	96	90	12	42	72	66	36	48	60
Borris	83	72	156	90	66	108	114	78	54	30	78	66	48	48	60
Askov	60	42	168	66	90	108	78	78	36	42	54	48	0	24	72
Jyndevad	38	42	156	72	84	108	90	54	24	42	54	66	30	66	36

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	108	102	60	132	120	90	60	90	102	138	102	108	10	98
Årslev	72	102	42	114	108	84	42	36	90	144	84	72	9	63
Silstrup	96	102	66	96	84	90	42	24	114	102	18	96	8	88
Tylstrup	48	84	54	120	36	96	12	12	108	120	72	48	13	35
Foulum	60	90	66	108	72	78	54	24	78	96	36	60	9	51
Skjern	60	114	48	114	102	90	60	24	102	120	54	60	15	45
Ribe	66	114	36	120	84	84	42	24	96	90	78	66	17	49
Borris	54	96	48	78	138	36	12	24	102	42	12	54	15	39
Askov	36	114	30	84	72	60	30	36	90	102	66	36	20	16
Jyndevad	54	108	36	108	48	66	30	12	54	48	66	54	20	34

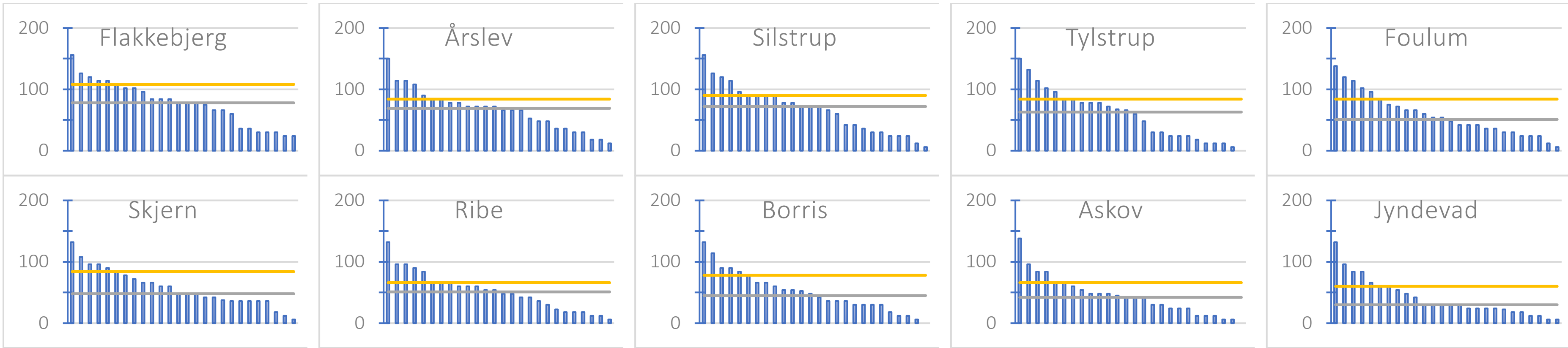
34 Appendix II – C5. Annual GIWR (mm) for the model potato farm at RZC 140



Station/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Flakkebjerg	98	48	162	108	126	138	126	114	60	42	114	108	36	48	42
Årslev	83	72	156	108	90	126	114	90	36	48	48	84	48	72	60
Silstrup	98	102	162	102	126	138	132	108	30	42	66	36	48	48	78
Tylstrup	75	96	162	84	120	120	144	96	12	12	48	24	36	36	66
Foulum	98	48	156	114	126	138	120	72	30	30	36	78	30	42	60
Skjern	60	54	144	84	78	102	102	78	42	18	60	48	30	36	60
Ribe	45	42	156	60	84	102	96	66	12	18	66	54	24	36	60
Borris	68	60	144	84	66	108	96	66	36	30	60	66	48	48	42
Askov	45	30	156	42	84	102	60	78	30	42	42	30	0	24	60
Jyndevad	23	18	144	66	66	102	84	54	24	24	48	42	12	48	24

Station/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	84	96	54	132	108	90	42	84	102	126	96	92	6	86
Årslev	72	90	42	108	102	72	18	36	84	138	78	80	8	72
Silstrup	96	102	54	84	72	84	36	18	108	96	12	80	6	74
Tylstrup	36	72	30	90	18	96	6	12	84	102	54	67	8	59
Foulum	60	78	54	96	72	72	48	12	78	90	24	72	6	66
Skjern	54	90	42	96	96	84	54	18	84	114	42	68	11	57
Ribe	66	108	36	102	72	84	36	12	72	84	54	63	14	49
Borris	54	90	42	66	114	24	12	6	102	36	12	61	14	47
Askov	36	96	12	66	60	54	18	12	84	102	66	55	13	42
Jyndevad	30	96	18	108	24	60	18	12	48	36	54	49	12	37

35 Appendix II – C6. Annual GIWR (mm) for the model potato farm at RZC 160



Station/year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Flakkebjerg	75	30	156	102	102	120	126	96	60	30	114	84	24	36	24
Årslev	53	66	150	84	66	114	108	72	30	30	48	78	36	72	36
Silstrup	90	96	156	90	114	120	126	90	24	24	42	30	24	36	78
Tylstrup	68	84	150	84	102	114	132	78	0	12	30	24	18	24	60
Foulum	75	42	138	96	102	120	114	66	24	30	30	60	12	36	42
Skjern	38	48	132	66	60	108	96	60	36	18	48	36	12	36	48
Ribe	23	30	132	48	66	96	84	66	6	18	48	42	18	36	42
Borris	53	60	132	66	54	90	90	54	30	30	48	42	18	36	36
Askov	45	24	138	42	66	96	60	54	12	30	30	24	0	24	48
Jyndevad	23	18	132	60	60	96	66	30	12	24	30	30	12	48	24

Station/year	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	µ GIWR	µ increase. D	µ NIWR
Flakkebjerg	78	84	36	108	84	66	30	66	78	114	78	77	4	73
Årslev	48	66	18	90	84	72	12	18	78	114	72	66	3	63
Silstrup	72	78	42	60	72	66	30	6	90	72	12	67	4	63
Tylstrup	24	66	30	78	12	72	6	12	78	96	48	58	3	55
Foulum	36	66	42	84	48	54	24	6	54	72	24	58	4	54
Skjern	36	84	36	90	72	66	42	6	78	96	42	57	7	50
Ribe	54	90	18	96	60	60	12	12	60	66	54	51	10	41
Borris	30	84	30	66	114	12	6	0	78	36	12	50	7	43
Askov	12	84	6	48	48	42	6	12	66	84	42	44	8	36
Jyndevad	30	84	18	84	24	54	6	6	30	24	42	41	9	32