Are Alberta irrigation producers meeting optimum crop water requirements?

Jennifer Nitschelm

Government of Alberta

Agriculture and Rural Development

1996-2000 Alberta Ag. study

Conclusion

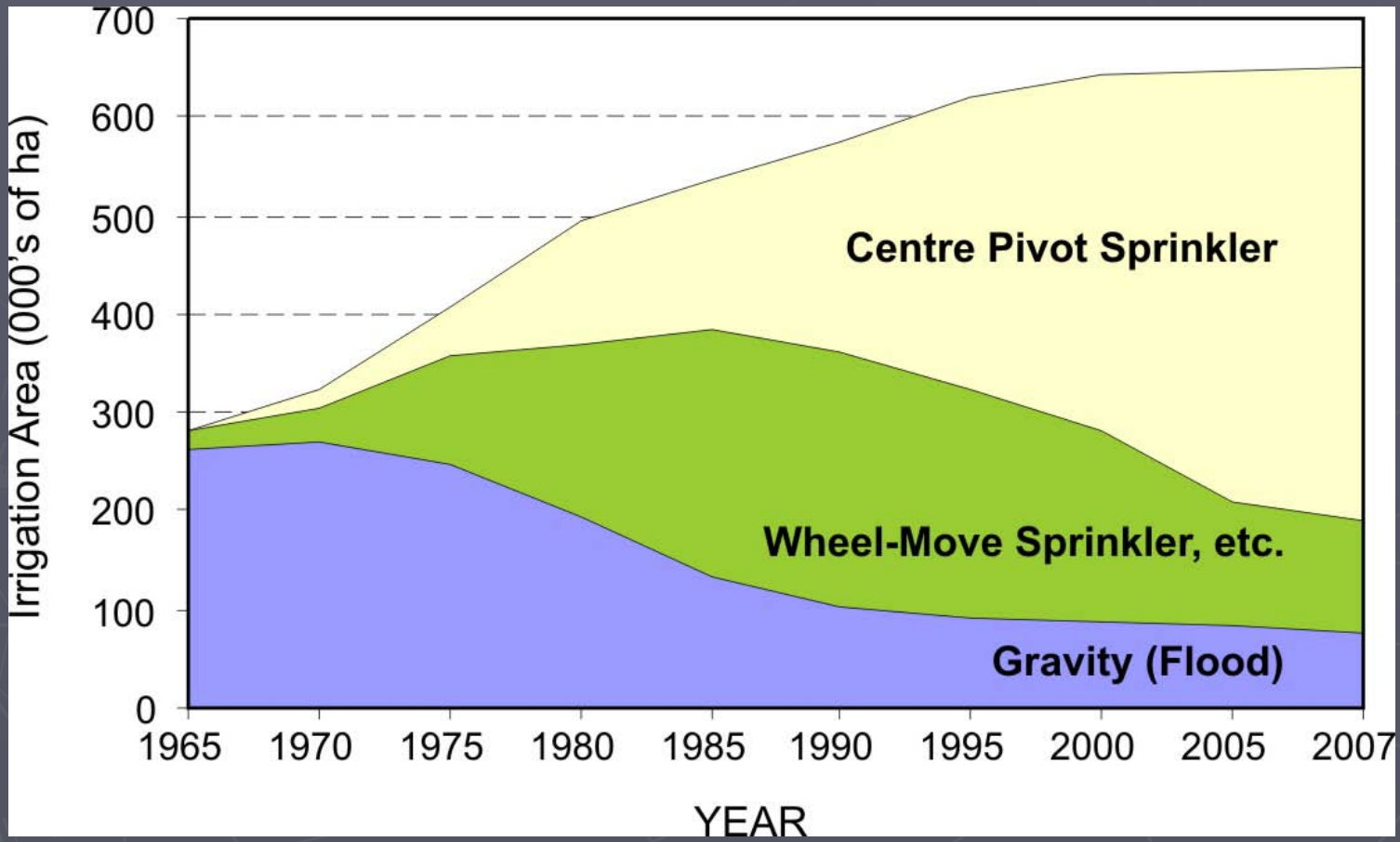
“Producer irrigation practices met 84% of water needs for optimum crop production.

With further improvements in application and delivery, producers will reach 90% of water needed in the near future.”

Questions

- How much irrigation water is being applied to crops?
- What is the actual crop water use?
- Is optimum crop water use being achieved?

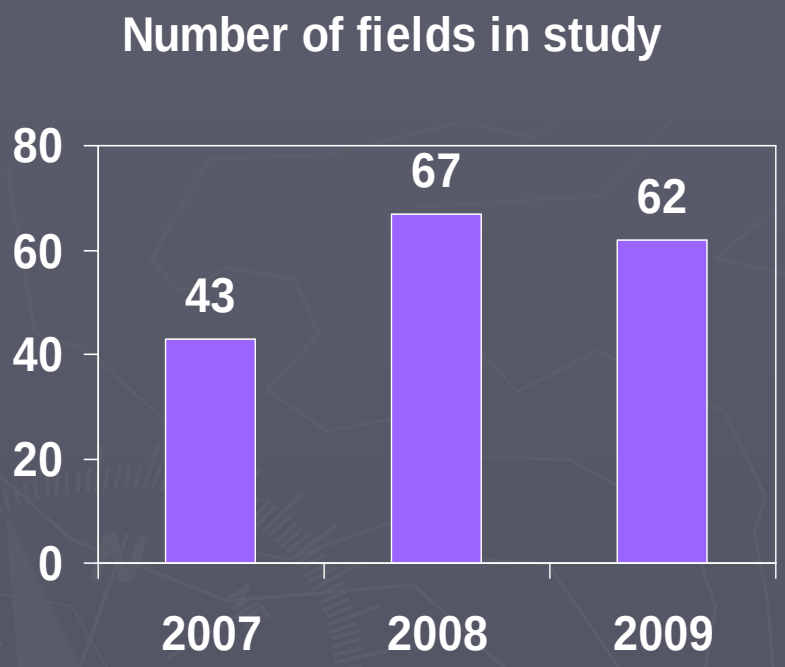
On-farm technology



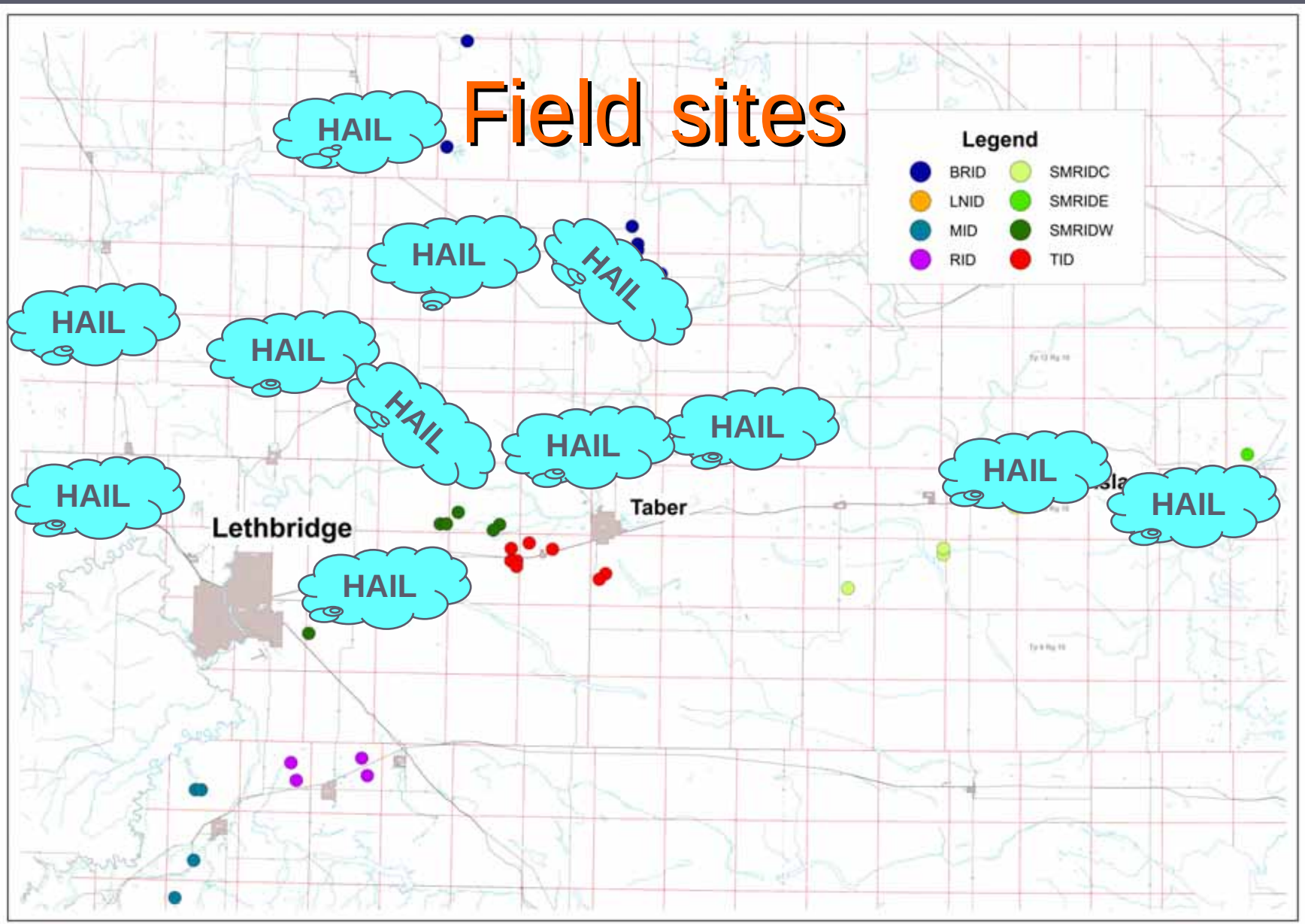
Eligible sites: Low Pressure Pivots

Eligible sites: Irrigation District Pipeline Delivery

Field research



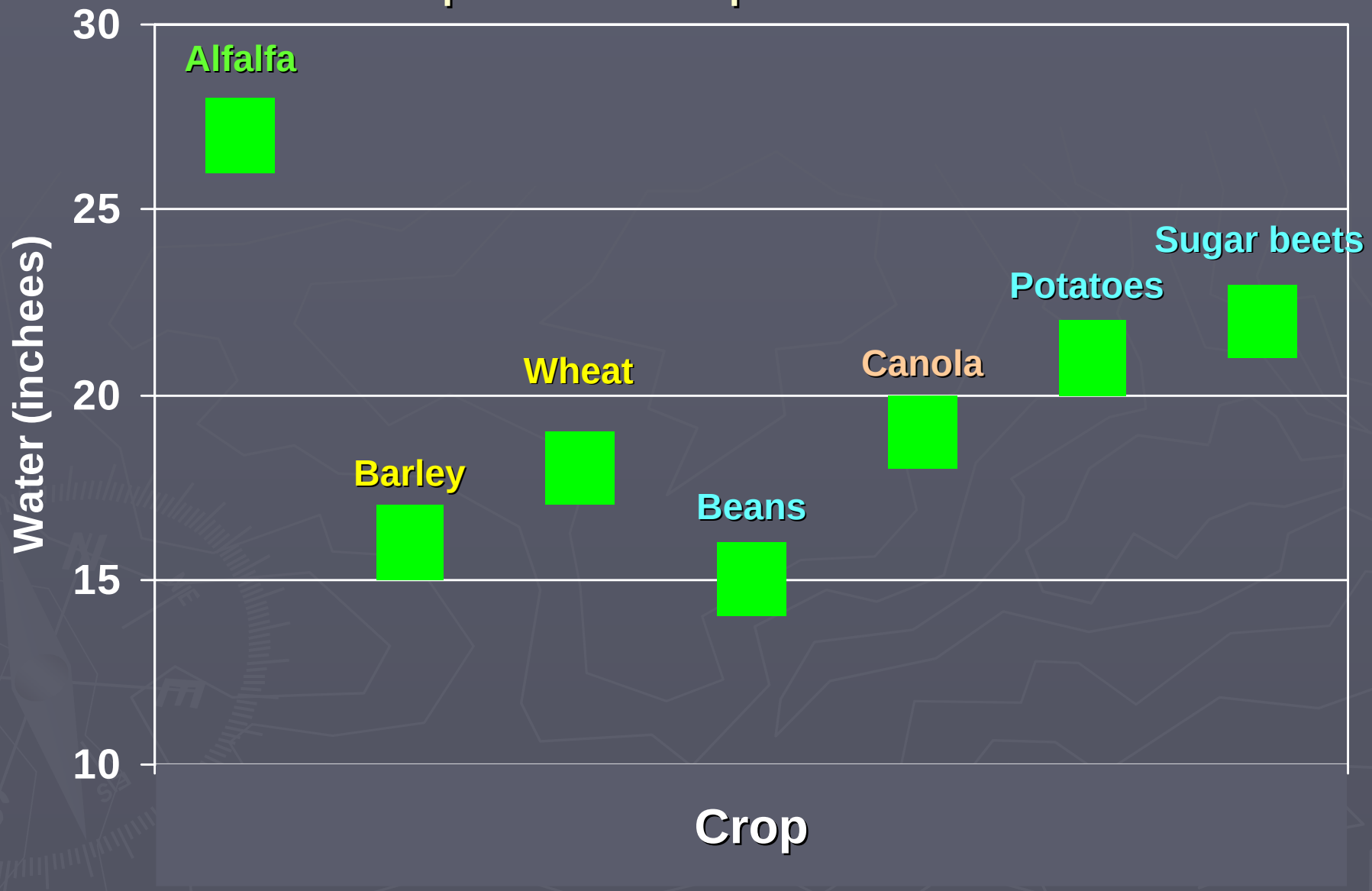
- Producer made irrigation decisions
- We recorded irrigation amounts, timings
- Yield data reported by producer
- Fields with hail or agronomic problems were excluded


Field sites
Legend
BRID
LNID
MID
RID
SMRIDC
SMRIDE
SMRIDW
TID
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
HAIL
Lethbridge
Taber

Factors affecting crop water use and yield potential

- Weather parameters
  - Solar radiation
  - Air temperature
  - Humidity
  - Wind speed
- Management and environmental factors
  - Soil – salinity, fertility, structure
  - Pests – diseases, weeds, insects
- Crop – type, variety
- Soil moisture content

Estimates of optimum crop water use - Alberta



Methods: Actual crop water use

General soil moisture balance:

$$Et = (P + I) - R - D \pm \Delta S$$

Et = Evapotranspiration (mm)

P = Rainfall

I = Irrigation

R = Runoff

D = Drainage

ΔS = Change in soil moisture

Methods: measuring pivot output

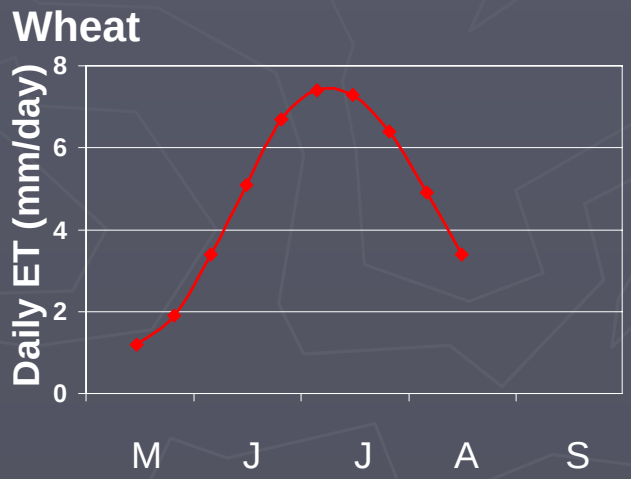
Methods: pivot on-off times

Flow monitor (Aquasystems 2000 Lethbridge)


23-08

Methods: optimum crop water use

- Input each actual field data in AIMM
- Delete the producer's actual irrigations
- Track daily crop water use and soil moisture
- Add irrigations to avoid any moisture stress to crop

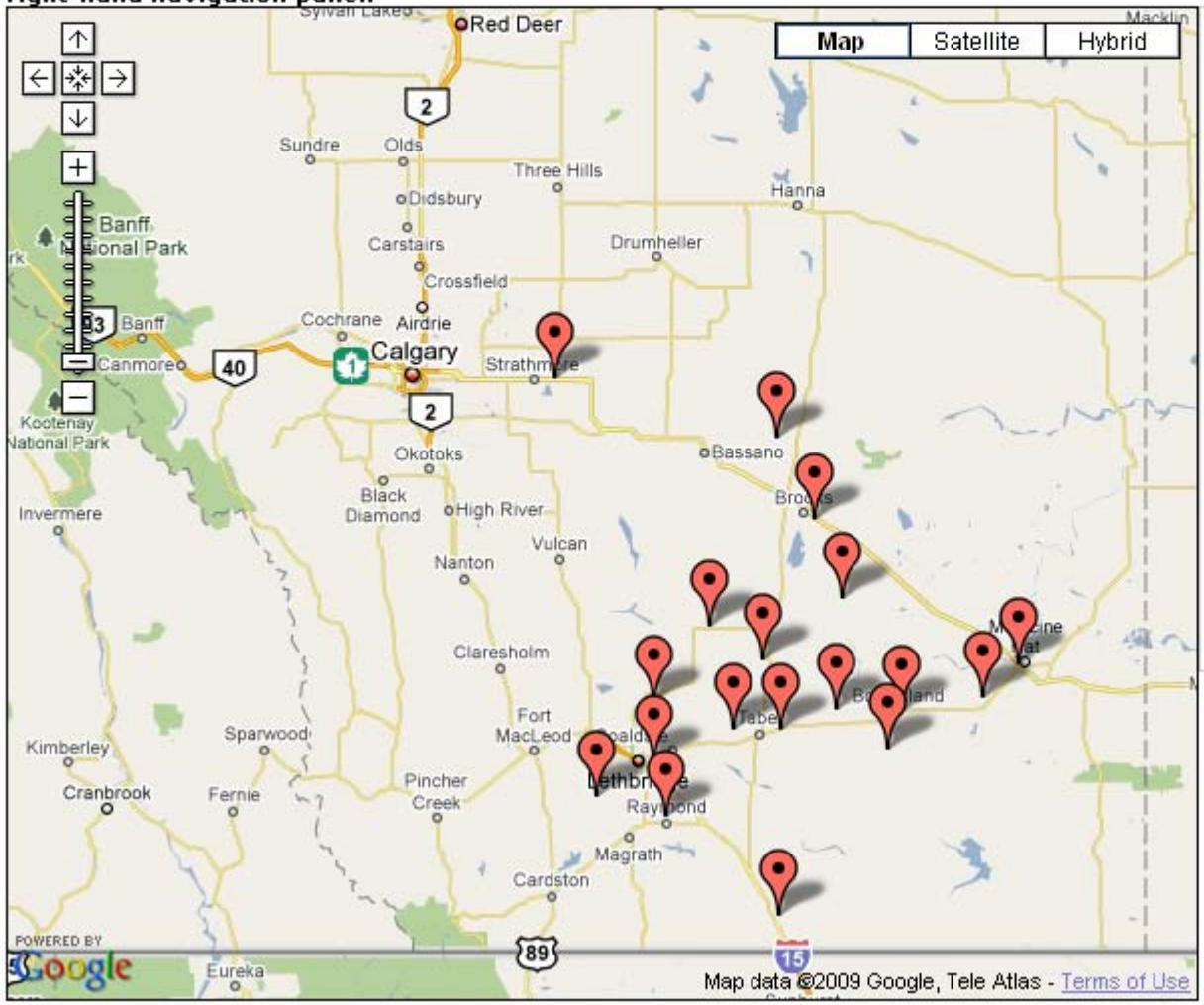


- AIMM input data required
  - Soil type
  - Starting soil moisture
  - Crop type
  - Seeding date
  - Rainfall
  - Climate data

IMCIN - Irrigation Management Climate Information Network

IMCIN Stations 2009

Click on the markers of the map to view station information or click on the station name in the right-hand navigation panel.



- Barnwell, AB
- Blood Tribe Ag. Project, AB
- Bow Island - North, AB
- Bow Island - South, AB
- Brooks, AB
- Enchant, AB
- Fincastle - Taber, AB
- Grassy Lake
- Iron Springs, AB
- Lethbridge Demo Farm, AB
- Medicine Hat, AB
- Milk River, AB
- Raymond, AB
- Rolling Hills, AB
- Rosemary, AB
- Seven Persons, AB
- Strathmore, AB
- Vauxhall, AB

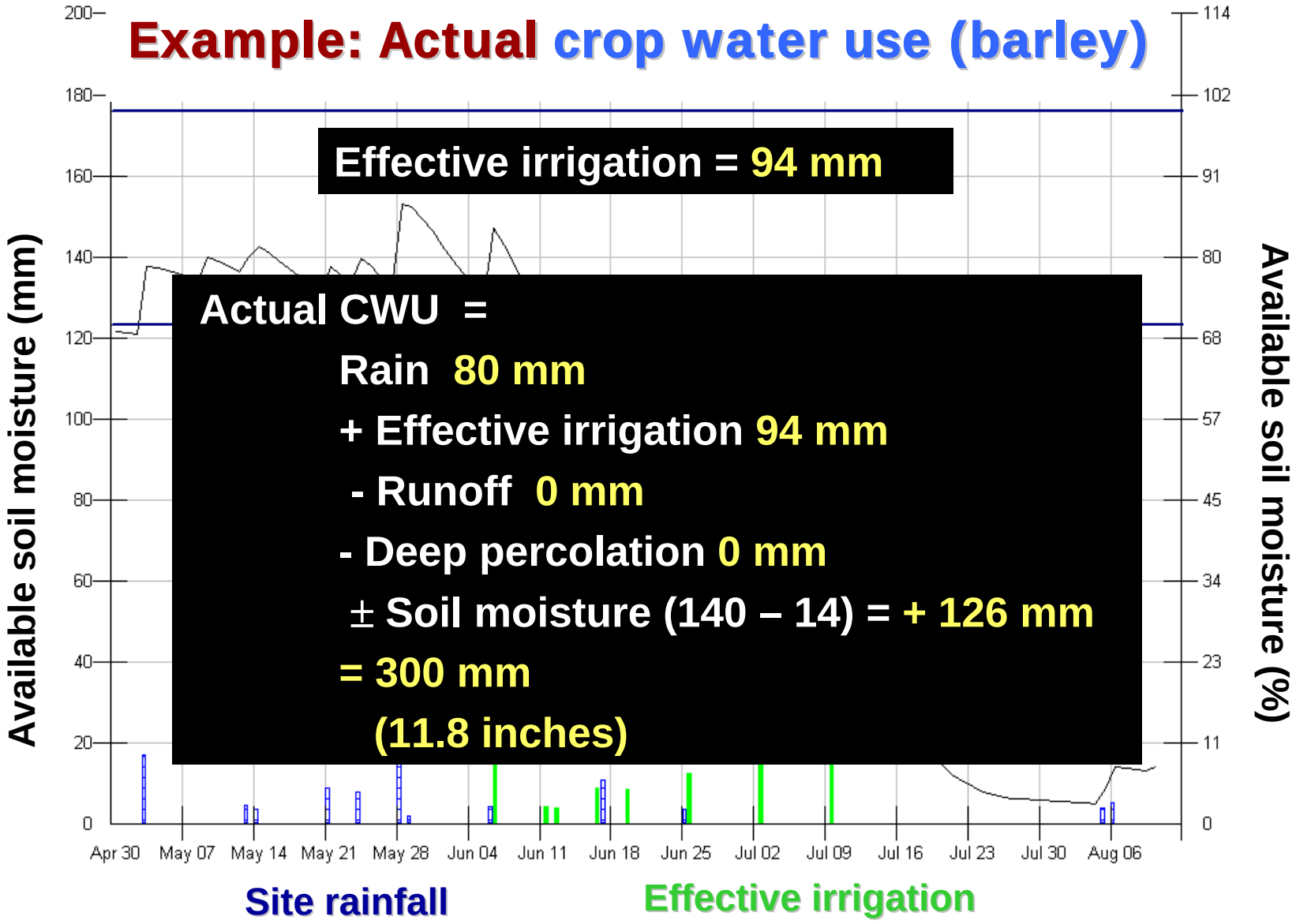
Optimum crop water use scenarios in AIMM

1. Start of season: upper root zone 70% available soil moisture
2. Early season: Fill maximum root zone to 90%
3. Rest of season: Ensure upper and maximum root zone 70%
4. Stop irrigation 1-2 weeks before harvest depending on crop

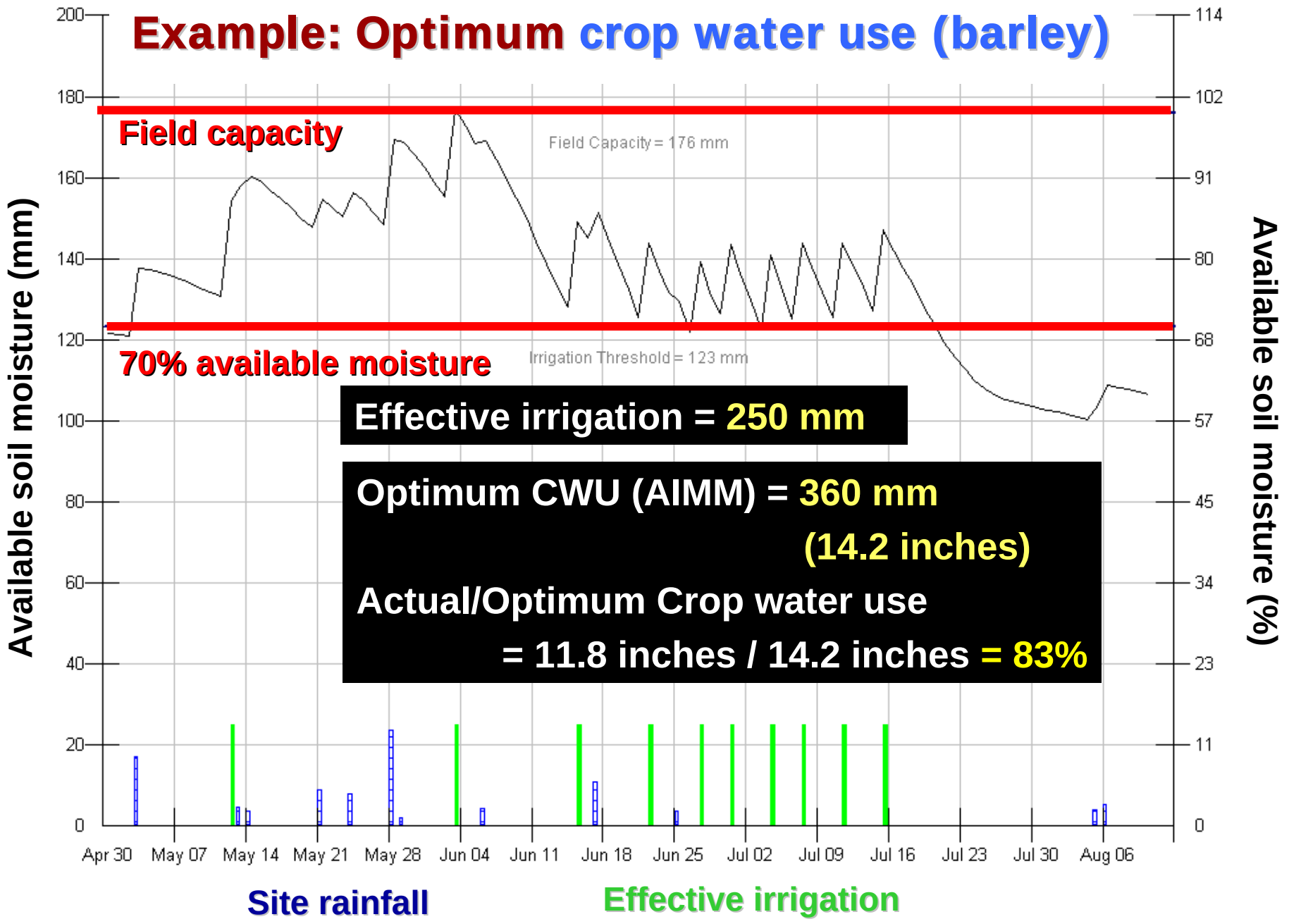
Crop root zones for optimum scenario

	Upper (cm)	Full (cm)
Dry beans	30	60
Potatoes	40	80
Barley	50	100
Canola	50	100
Wheat	50	100
Sugar beet	50	100
Alfalfa		120

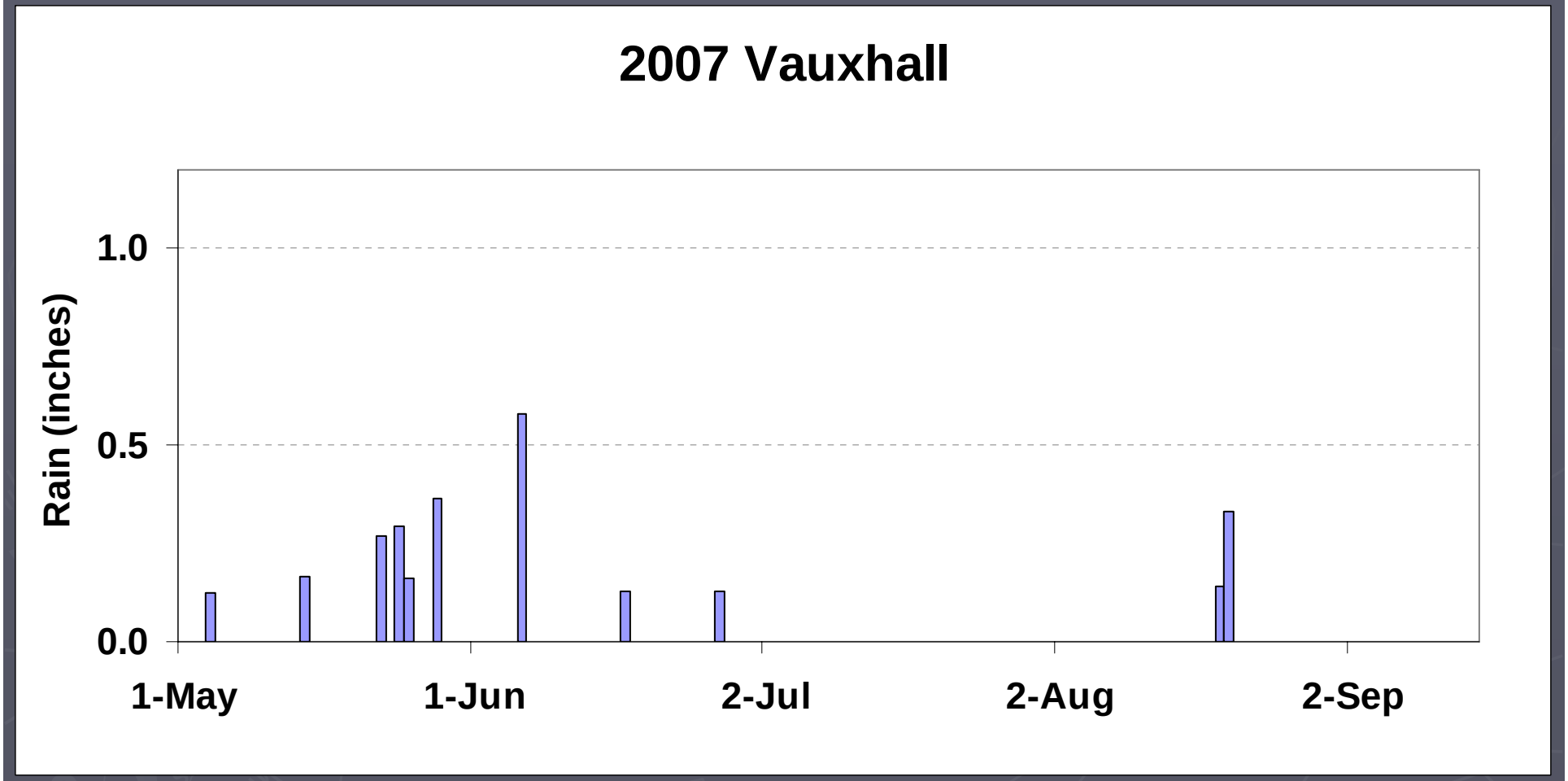
Example: Actual crop water use (barley)



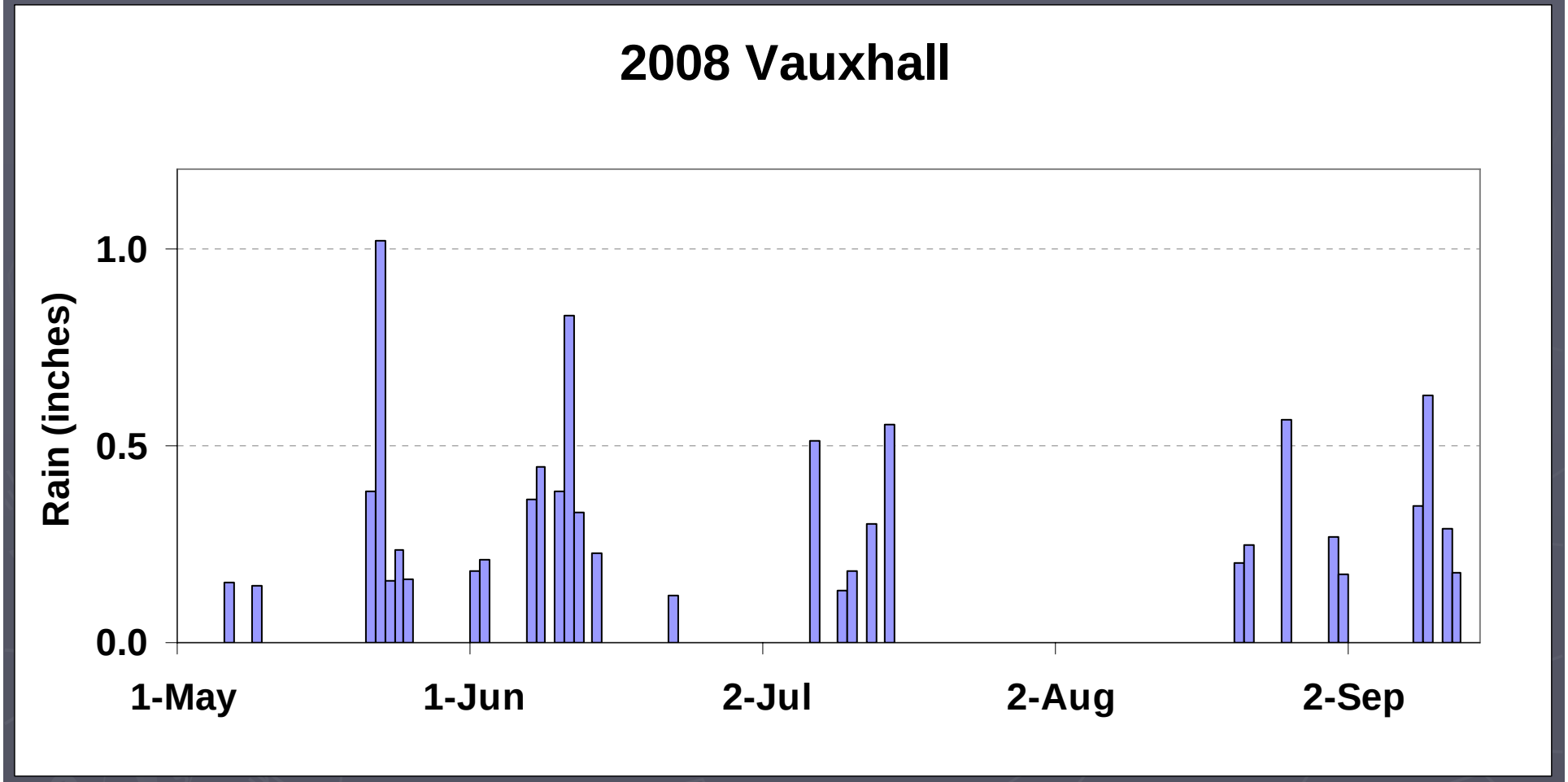
Example: Optimum crop water use (barley)



Rainfall in 2007 and 2008



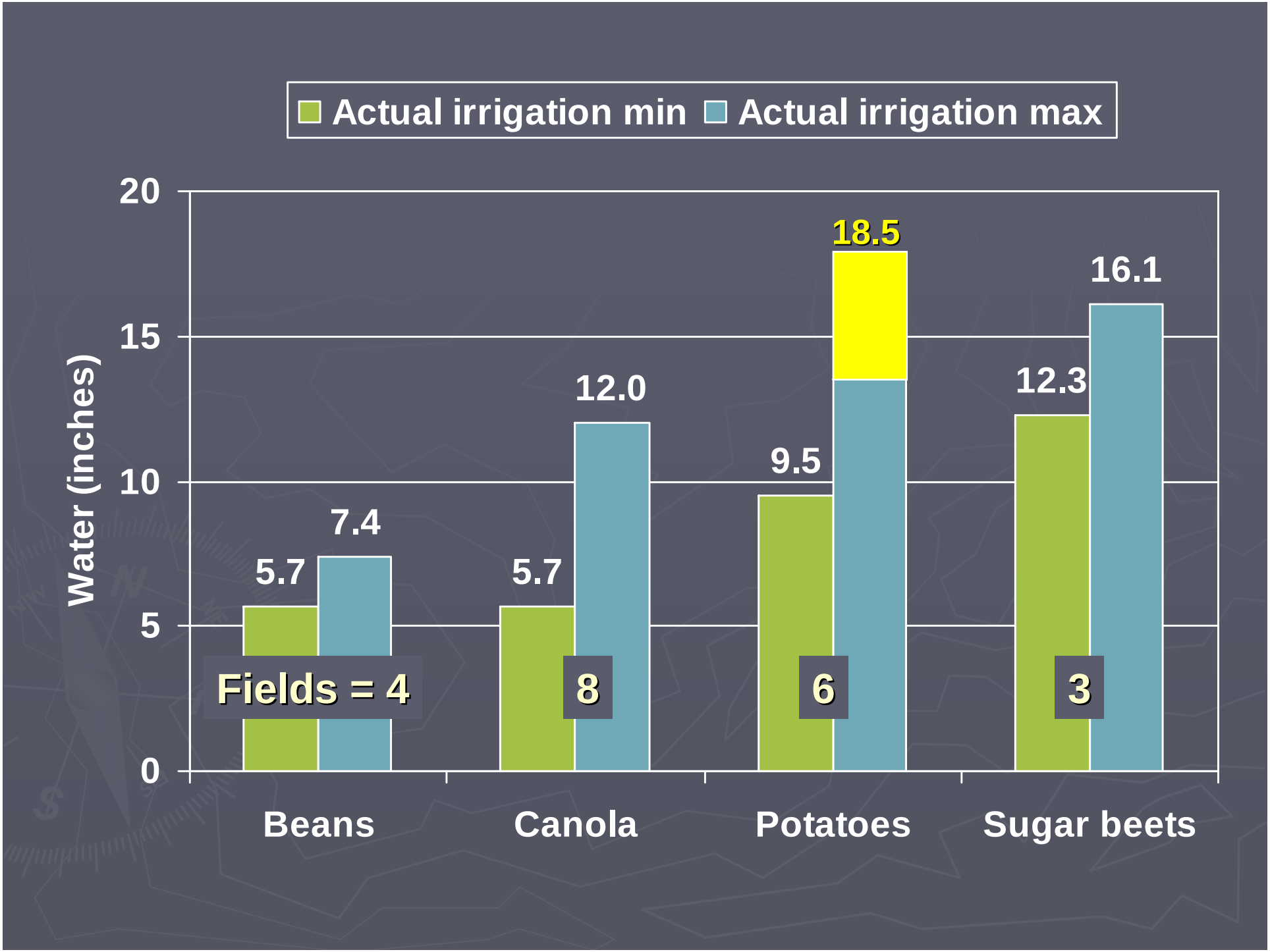
Rainfall in 2007 and 2008

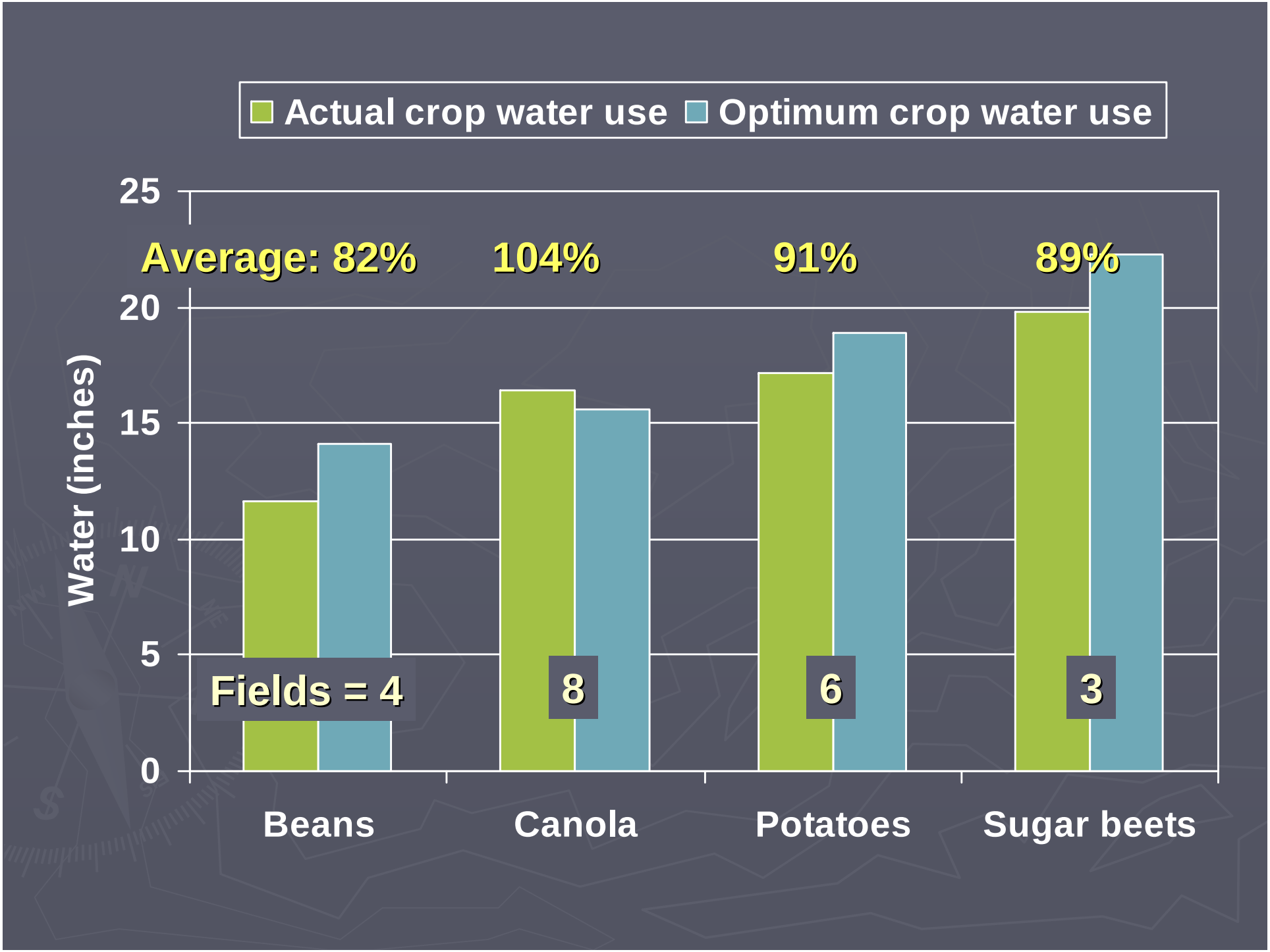


2007 & 2008 results

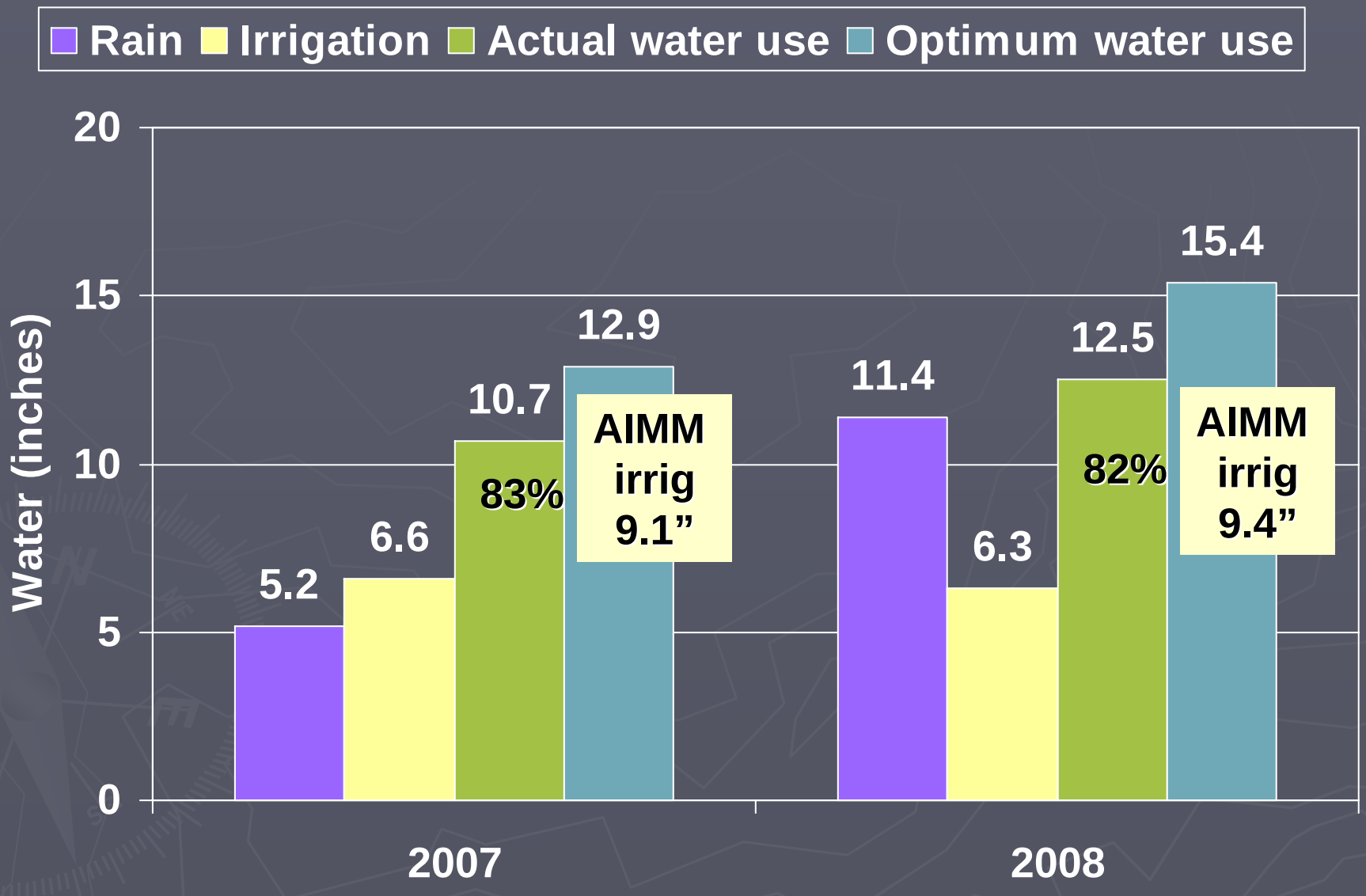
Study findings: Over-irrigation

Fields		Over-irrigation (mm)	
Total	Over-irrigated	Max	Ave
56	**3**	**5.0”**	**2.7”**


Actual irrigation min
Actual irrigation max
Water (inches)
20
15
10
5
0
5.7
7.4
5.7
12.0
9.5
18.5
12.3
16.1
Fields = 4
8
6
3
Beans
Canola
Potatoes
Sugar beets


Actual crop water use
Optimum crop water use
25
20
15
10
5
0
Water (inches)
Average: 82%
104%
91%
89%
Fields = 4
8
6
3
Beans
Canola
Potatoes
Sugar beets

Dry beans

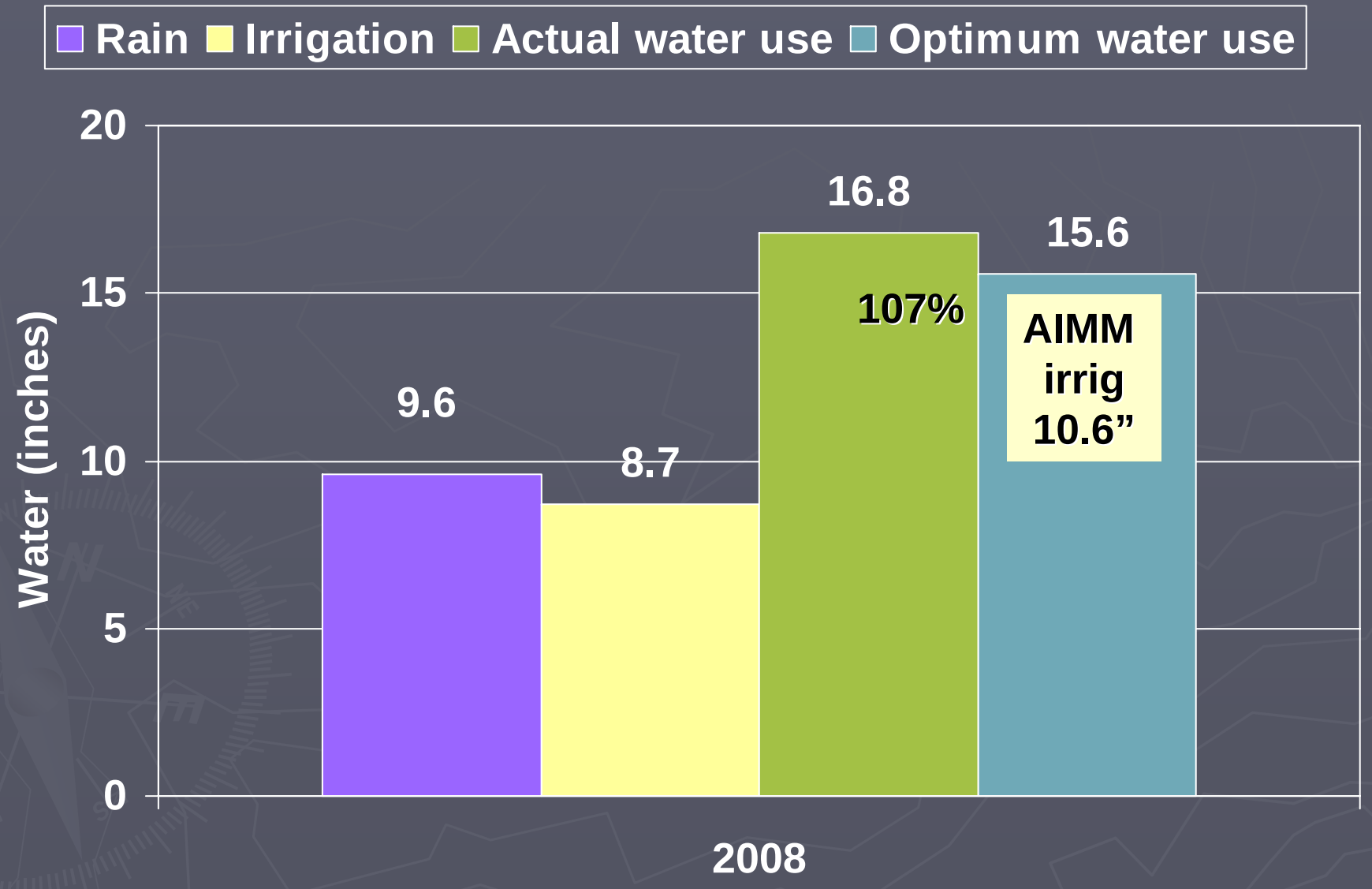

Rain
Irrigation
Actual water use
Optimum water use
Water (inches)
20
15
10
5
0
5.2
6.6
10.7
12.9
83%
AIMM irrig 9.1”
11.4
6.3
12.5
15.4
82%
AIMM irrig 9.4”
2007
2008

Dry beans

- Actual crop water use: 75-85% of optimum

- Insufficient data for yield assessment
- Reported yields:
  - 2007: 2450 and 3000 lbs/ac
  - 2008: 2500 lbs/ac

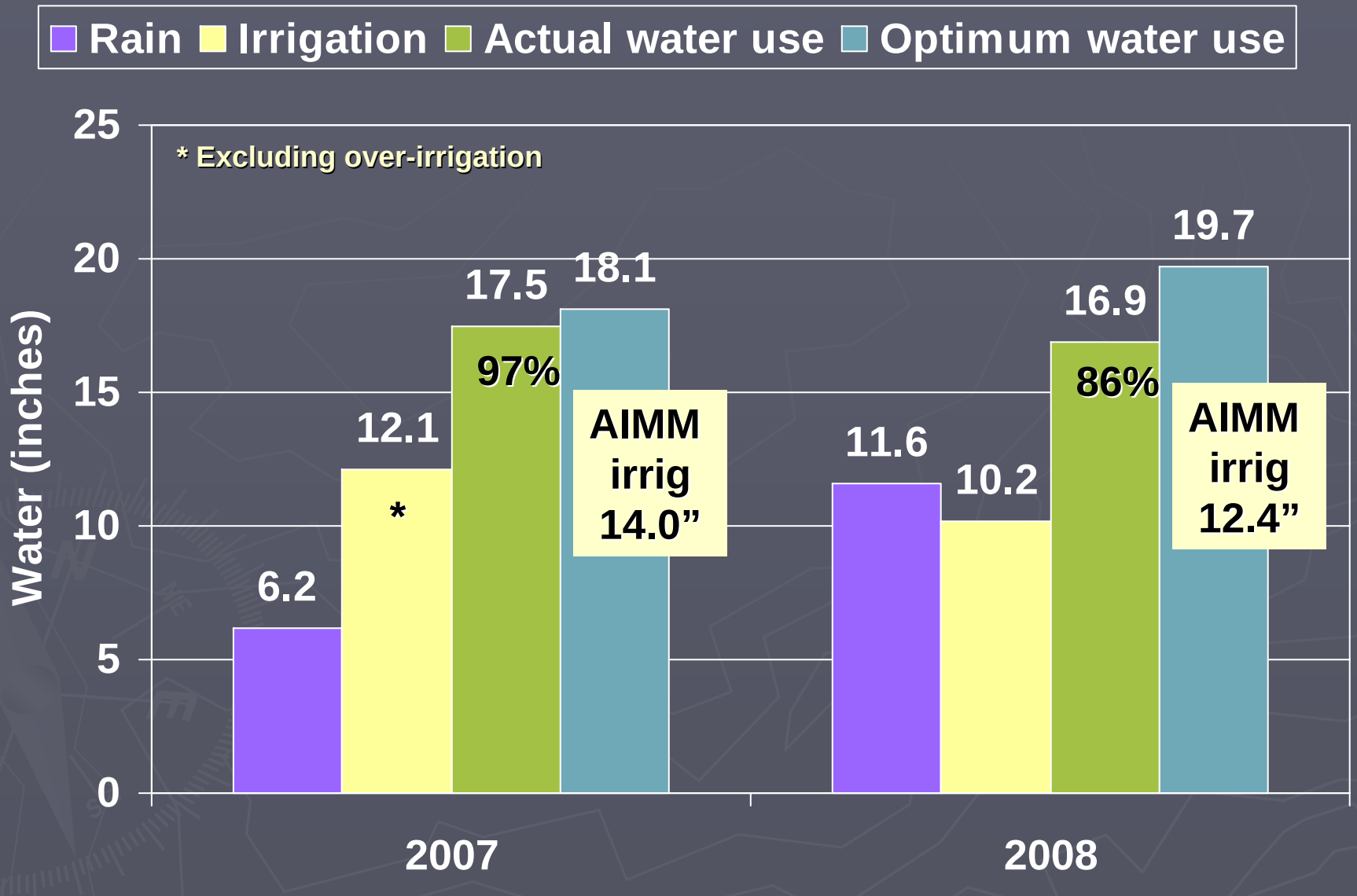
Seed canola

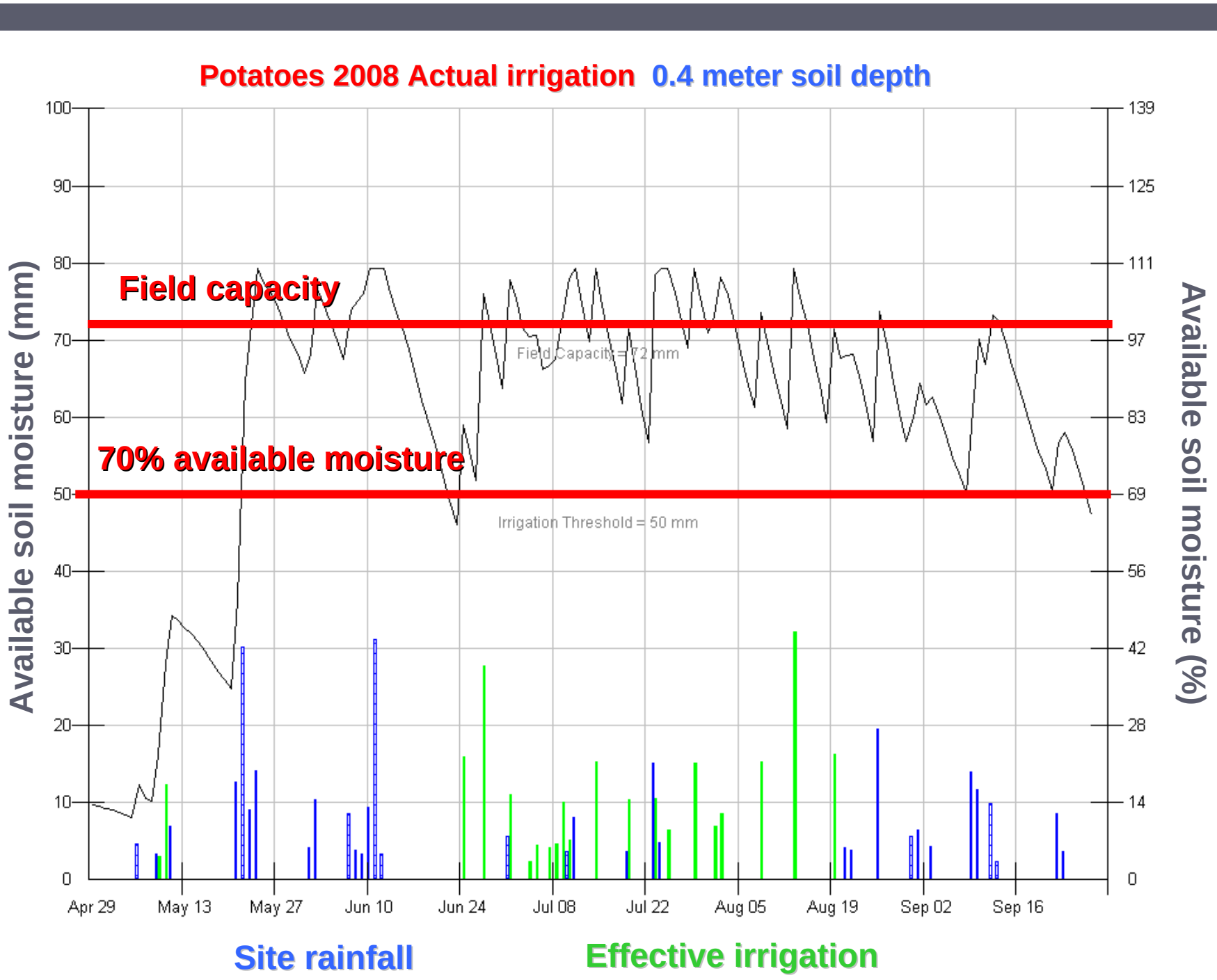

Rain
Irrigation
Actual water use
Optimum water use
Water (inches)
20
15
10
5
0
9.6
8.7
16.8
15.6
107%
AIMM irrig 10.6”
2008

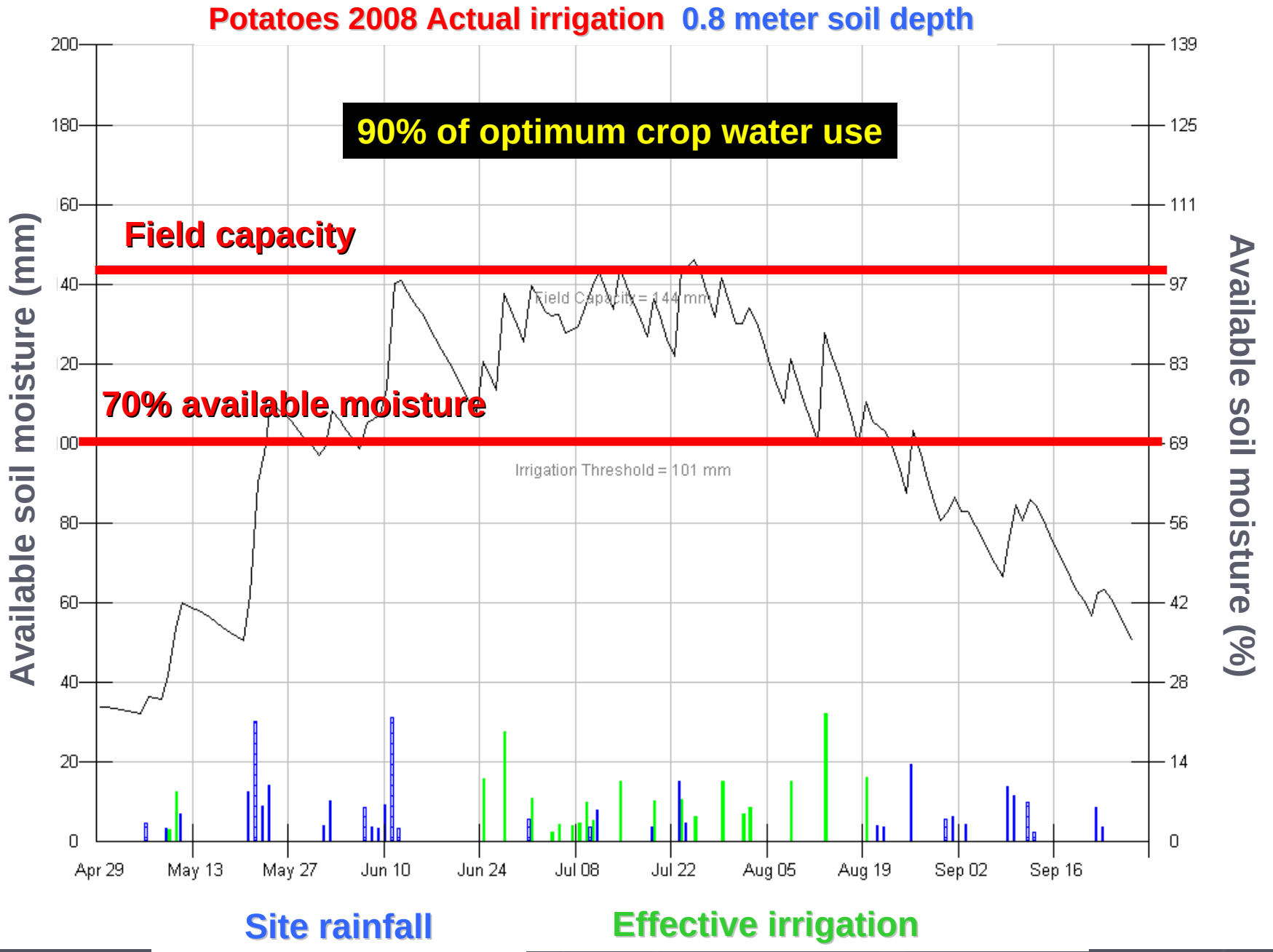
Commercial and seed canola

- Actual crop water use:
  - Commercial: 80-115% of optimum
  - Seed: 95-115% of optimum
- Insufficient data for yield assessment

Potatoes


Rain
Irrigation
Actual water use
Optimum water use
* Excluding over-irrigation
Water (inches)
25
20
15
10
5
0
6.2
12.1
*
17.5
97%
18.1
AIMM irrig 14.0”
11.6
10.2
16.9
86%
19.7
AIMM irrig 12.4”
2007
2008


Potatoes 2008 Actual irrigation 0.4 meter soil depth
Field capacity
70% available moisture
Field Capacity = 72 mm
Irrigation Threshold = 50 mm
Available soil moisture (mm)
Available soil moisture (%)
100
90
80
70
60
50
40
30
20
10
0
139
125
111
97
83
69
56
42
28
14
0
Apr 29
May 13
May 27
Jun 10
Jun 24
Jul 08
Jul 22
Aug 05
Aug 19
Sep 02
Sep 16
Site rainfall
Effective irrigation

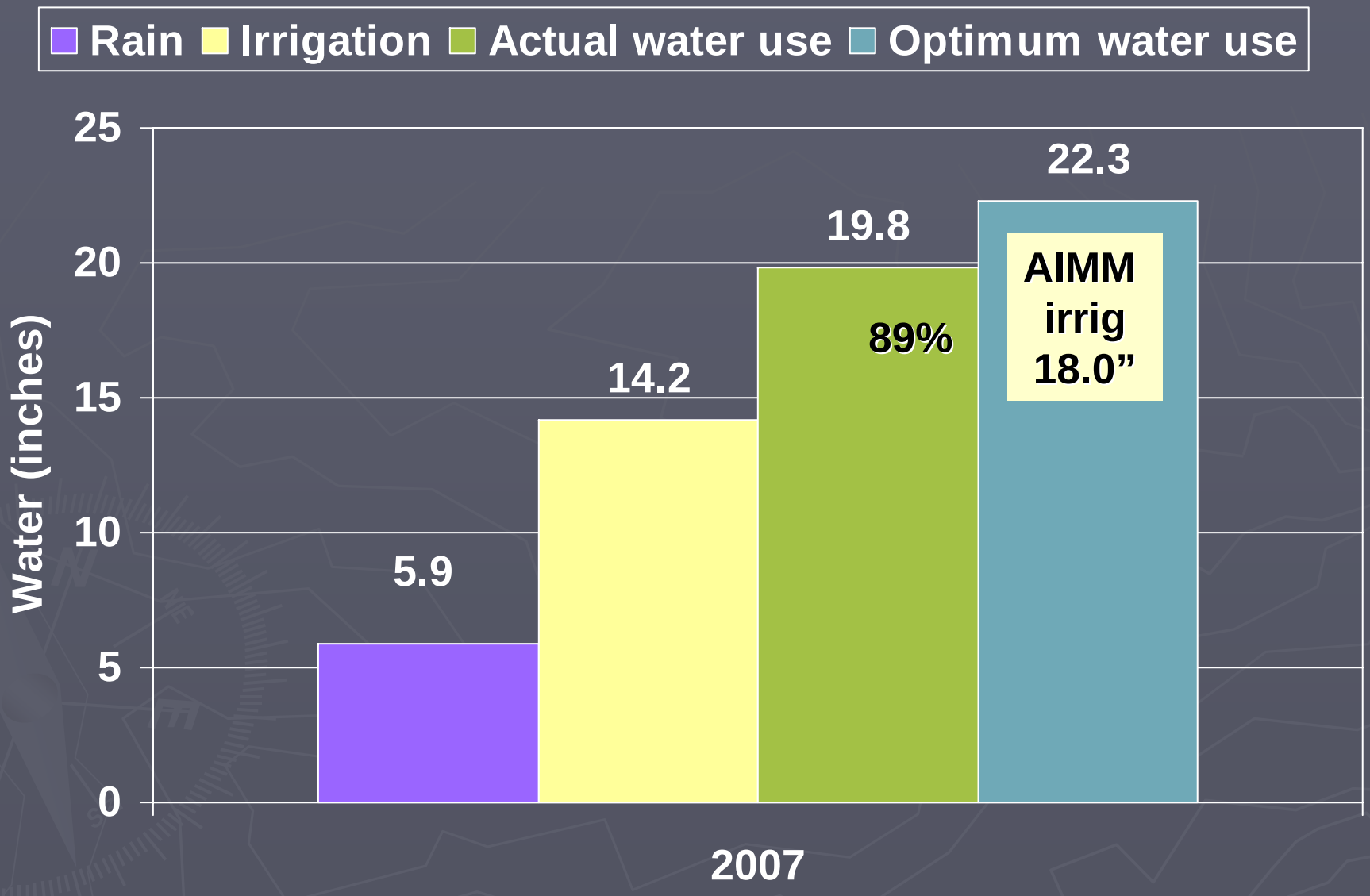

Potatoes 2008 Actual irrigation 0.8 meter soil depth
90% of optimum crop water use
Field capacity
70% available moisture
Field Capacity = 144 mm
Irrigation Threshold = 101 mm
Available soil moisture (mm)
Available soil moisture (%)
200
180
160
140
120
100
80
60
40
20
0
139
125
111
97
83
69
56
42
28
14
0
Apr 29
May 13
May 27
Jun 10
Jun 24
Jul 08
Jul 22
Aug 05
Aug 19
Sep 02
Sep 16
Site rainfall
Effective irrigation

Potatoes

- Actual crop water use: 80-100% of optimum

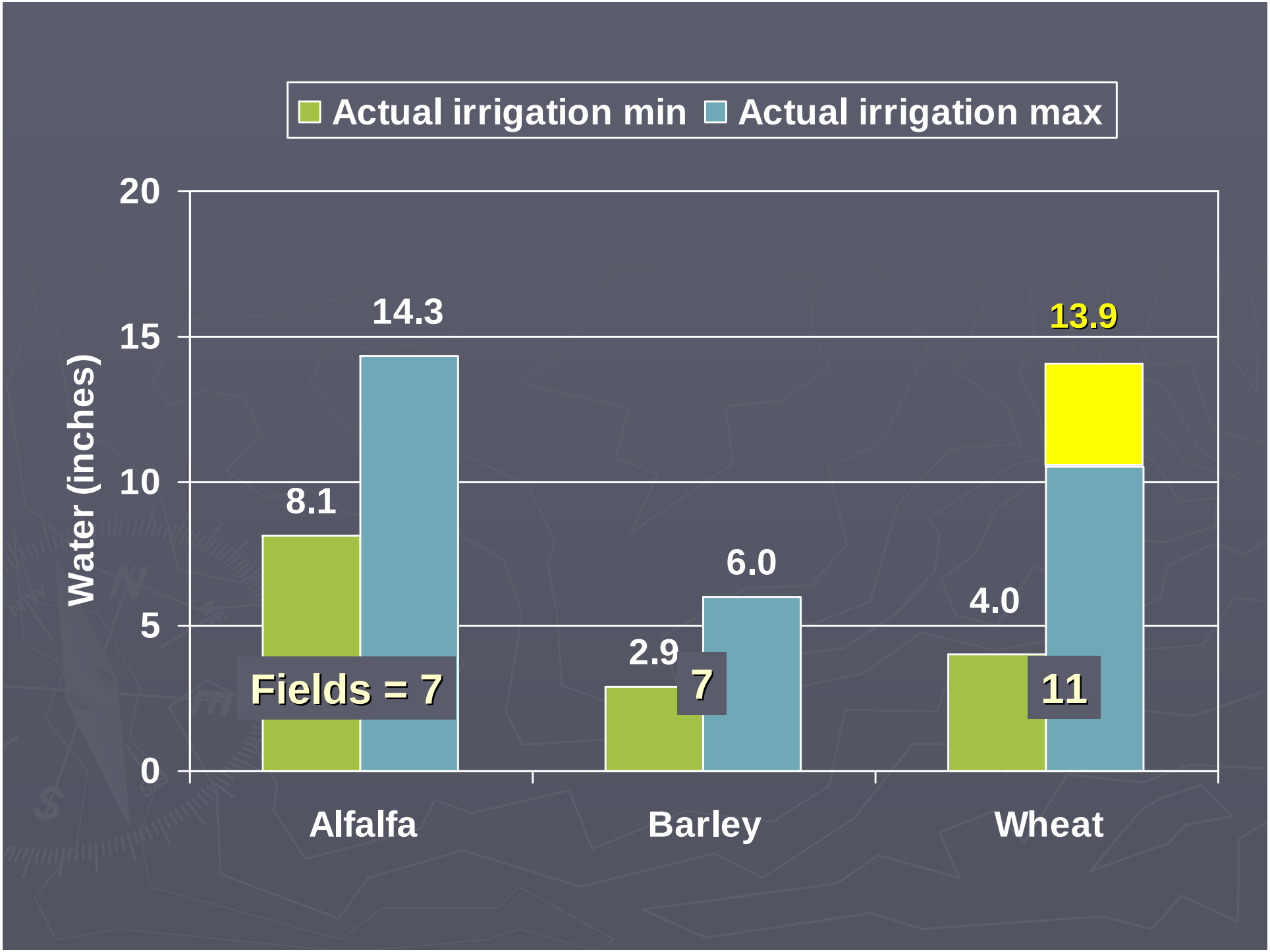
- No obvious trend with yield
- Reported yields:
  - 2007: 16.5 to 27 ton/ac
  - 2008: 20 to 22 ton/ac

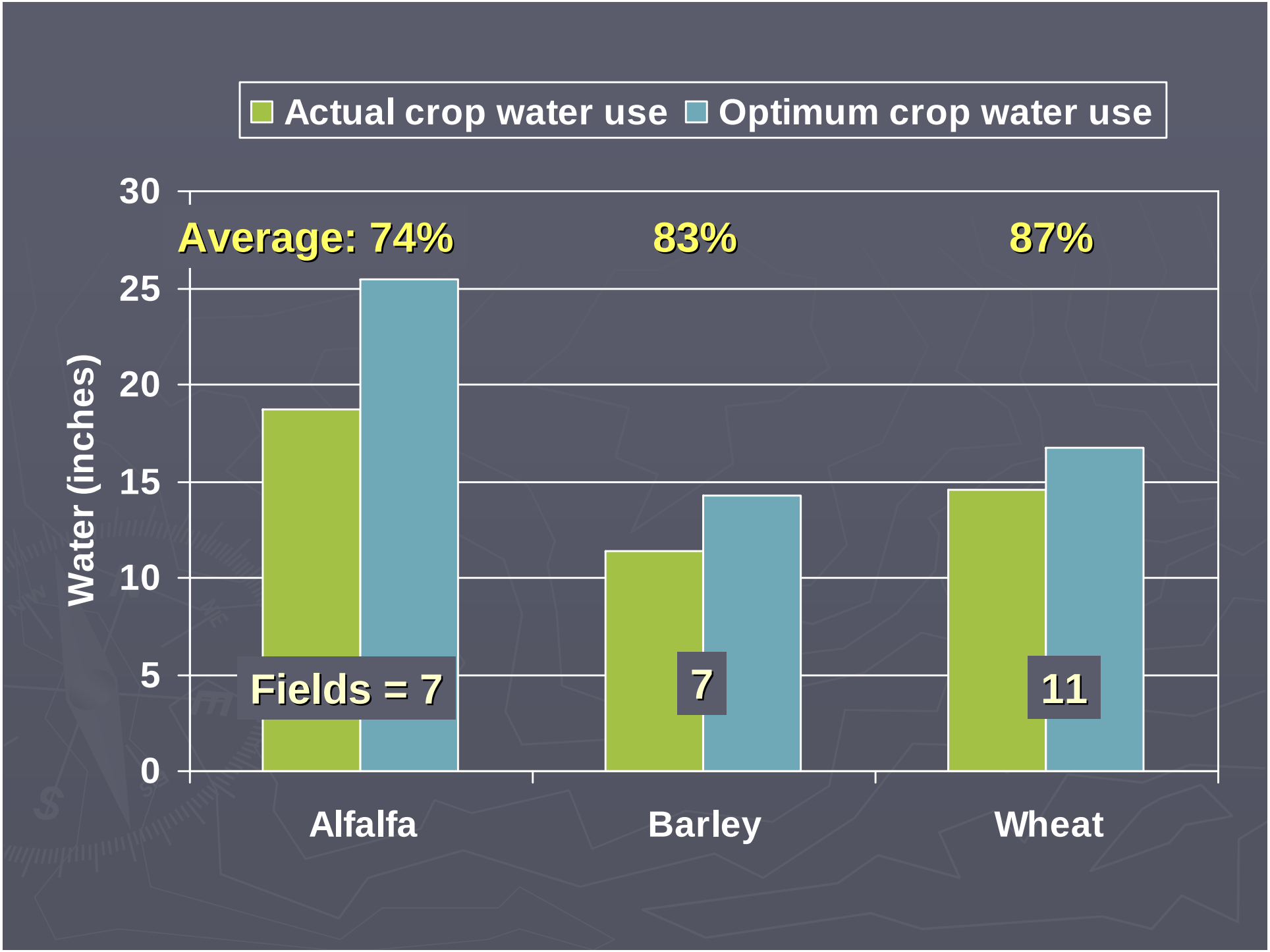
Sugar beets


Rain
Irrigation
Actual water use
Optimum water use
Water (inches)
25
20
15
10
5
0
5.9
14.2
19.8
22.3
89%
AIMM
irrig
18.0”
2007

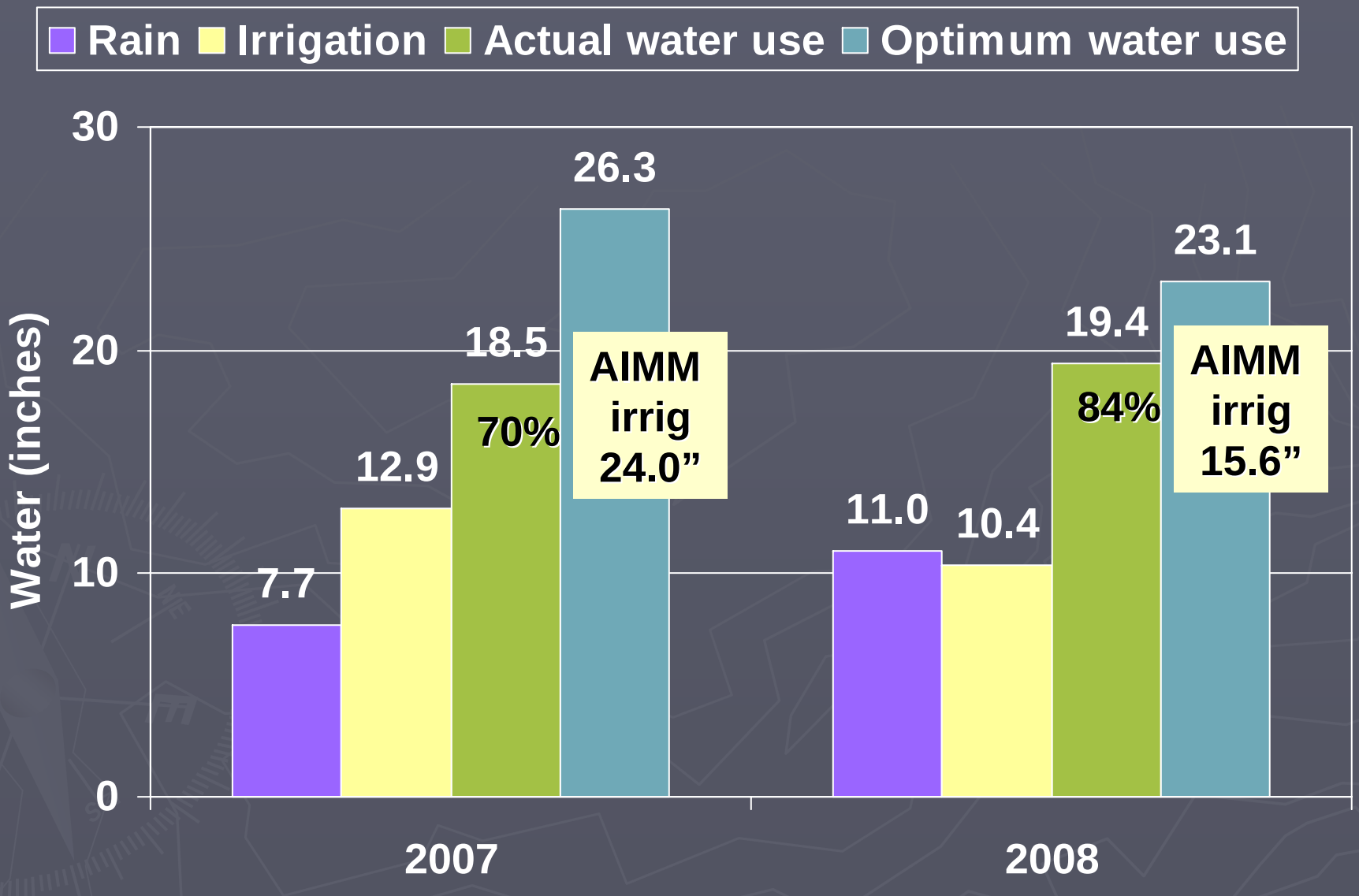
Sugar beets

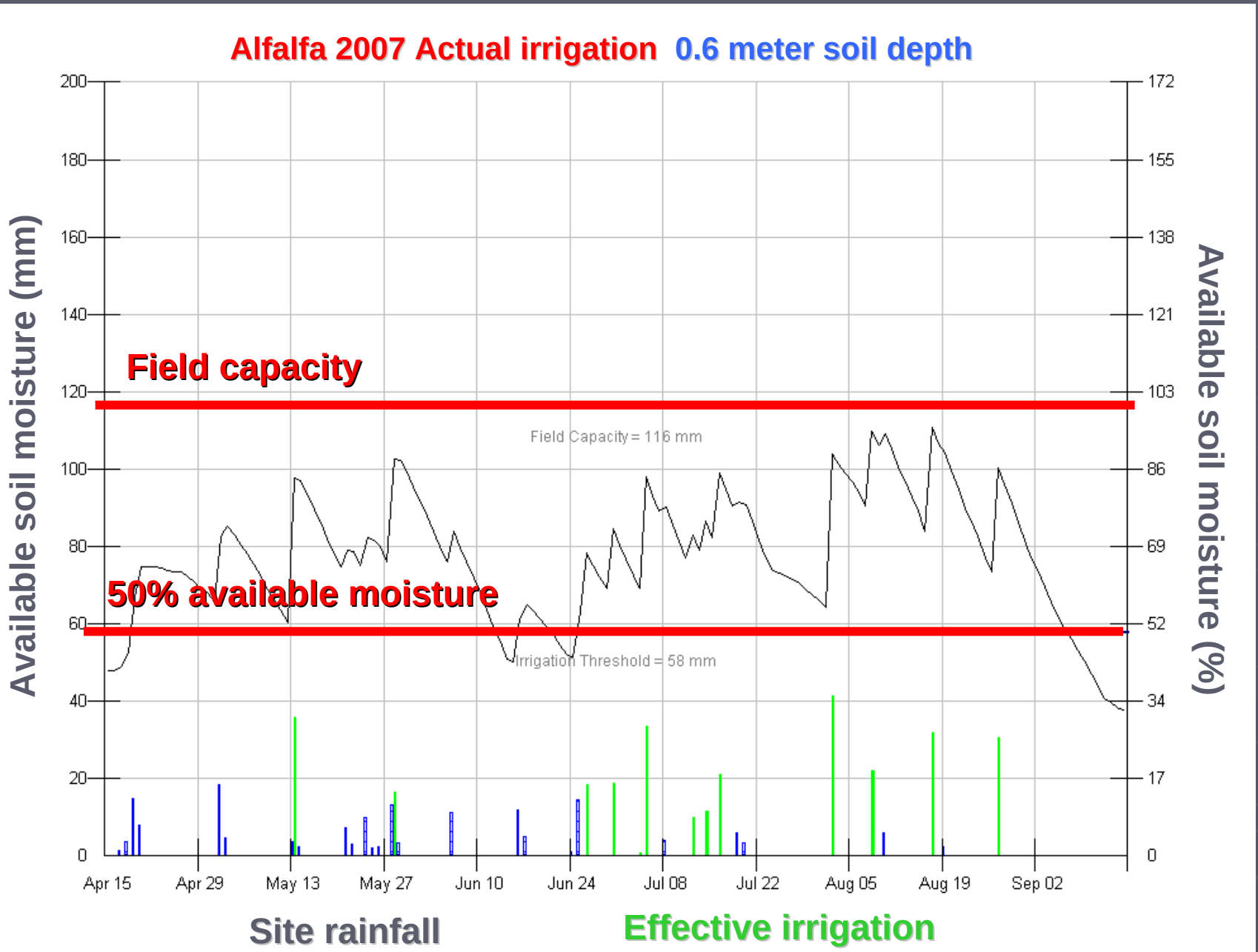
- Actual crop water use: 80-90% of optimum
- Reported yields:
  - 2007: 25.5 to 31 mt/ac

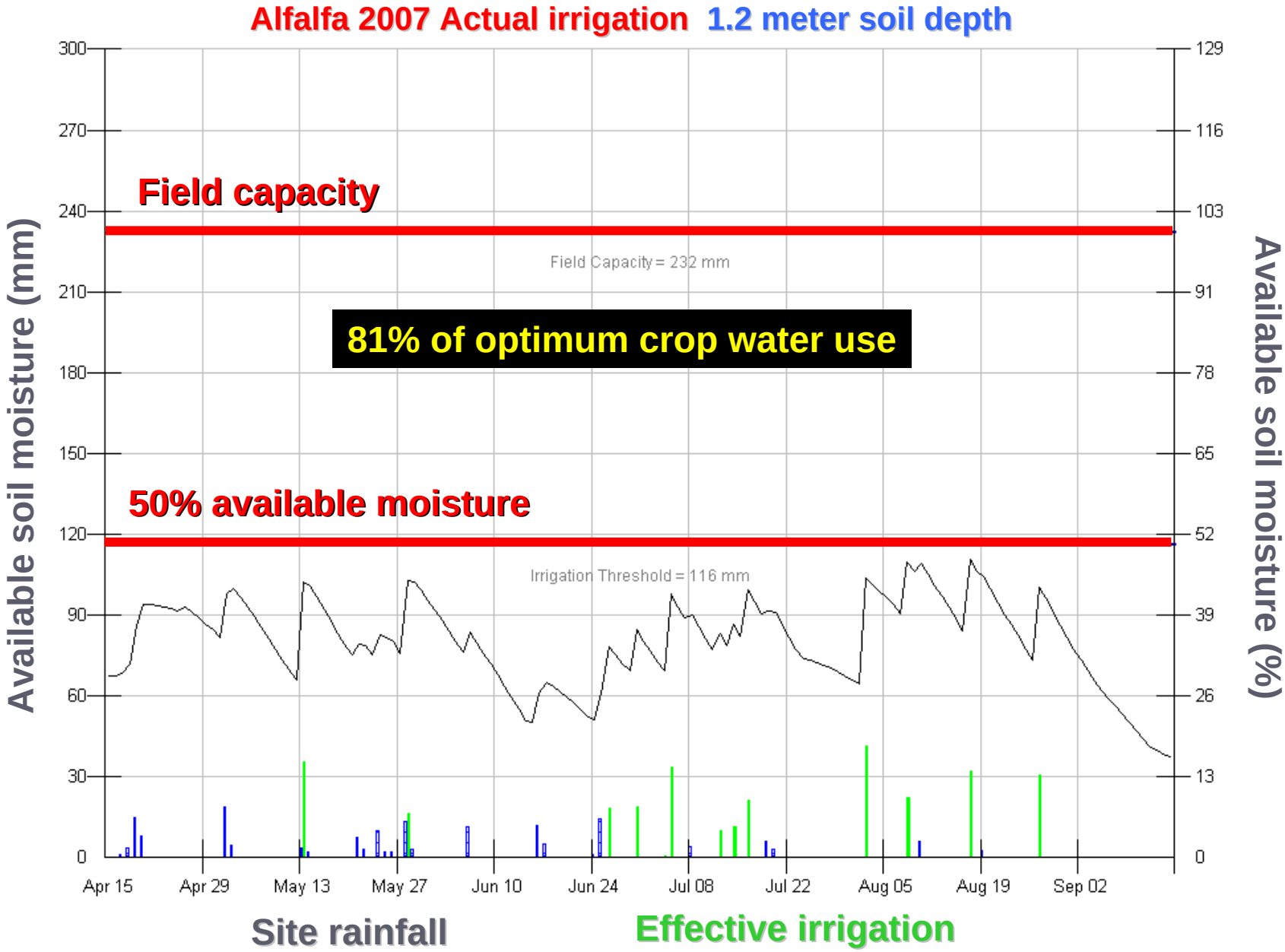

Actual irrigation min
Actual irrigation max
Water (inches)
20
15
10
5
0
14.3
13.9
8.1
6.0
4.0
2.9
Fields = 7
7
11
Alfalfa
Barley
Wheat


Actual crop water use
Optimum crop water use
Water (inches)
30
25
20
15
10
5
0
Average: 74%
83%
87%
Fields = 7
7
11
Alfalfa
Barley
Wheat

Alfalfa


Rain
Irrigation
Actual water use
Optimum water use
Water (inches)
30
20
10
0
7.7
12.9
18.5
26.3
70%
AIMM irrig 24.0”
11.0
10.4
19.4
23.1
84%
AIMM irrig 15.6”
2007
2008


Alfalfa 2007 Actual irrigation 0.6 meter soil depth
Available soil moisture (mm)
Available soil moisture (%)
200
180
160
140
120
100
80
60
40
20
0
172
155
138
121
103
86
69
52
34
17
0
Field capacity
50% available moisture
Field Capacity = 116 mm
Irrigation Threshold = 58 mm
Apr 15
Apr 29
May 13
May 27
Jun 10
Jun 24
Jul 08
Jul 22
Aug 05
Aug 19
Sep 02
Site rainfall
Effective irrigation

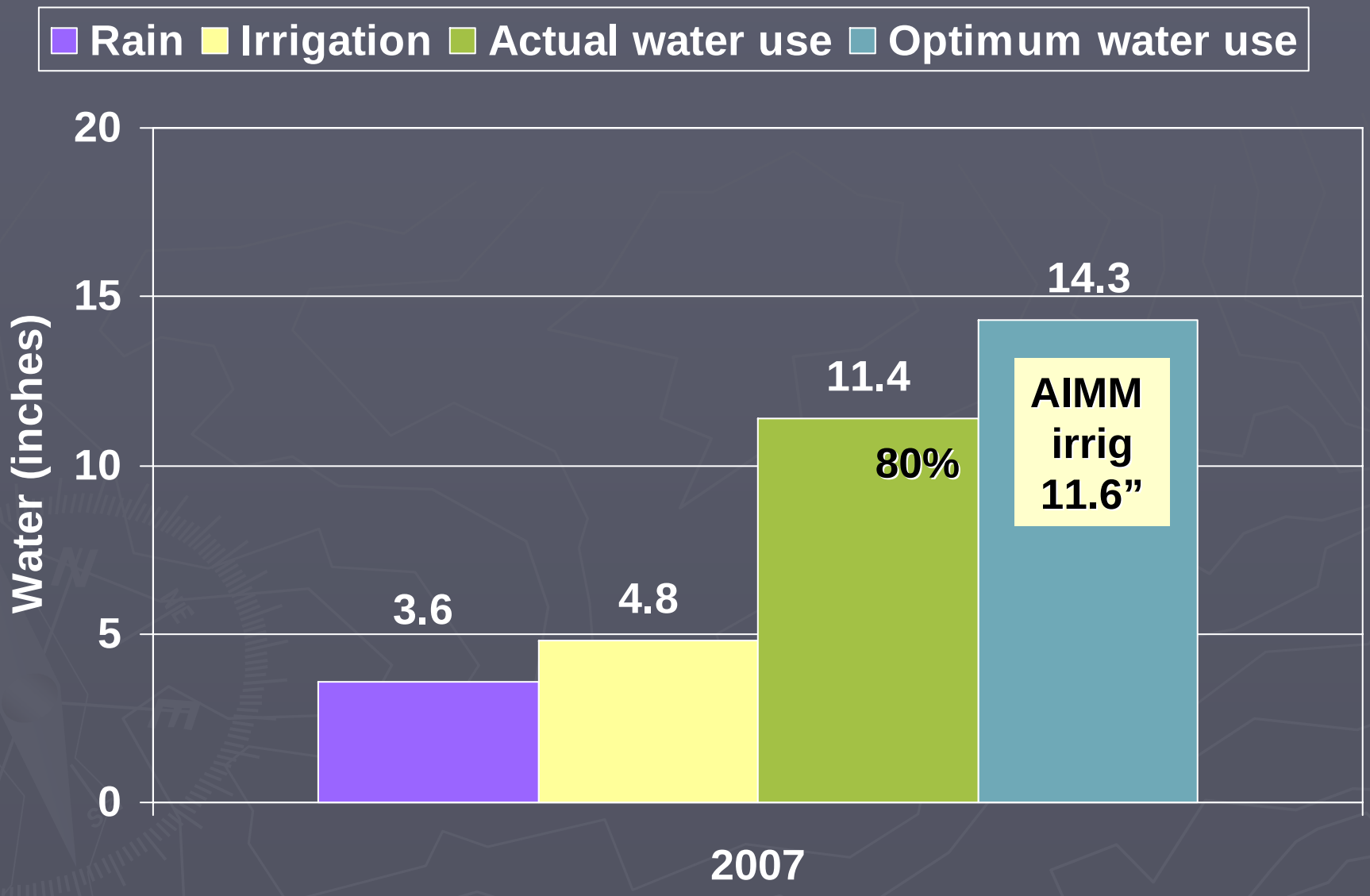

Alfalfa 2007 Actual irrigation 1.2 meter soil depth
Field capacity
Field Capacity = 232 mm
81% of optimum crop water use
50% available moisture
Irrigation Threshold = 116 mm
Available soil moisture (mm)
Available soil moisture (%)
300
270
240
210
180
150
120
90
60
30
0
129
116
103
91
78
65
52
39
26
13
0
Apr 15
Apr 29
May 13
May 27
Jun 10
Jun 24
Jul 08
Jul 22
Aug 05
Aug 19
Sep 02
Site rainfall
Effective irrigation

Alfalfa

- Actual crop water use: 60-85% of optimum

- No obvious trend with yield
- Reported yields:
  - 2007: 4.7 to 5.9 mt/ac
  - 2008: 3.8 to 4.7 mt/ac

Barley

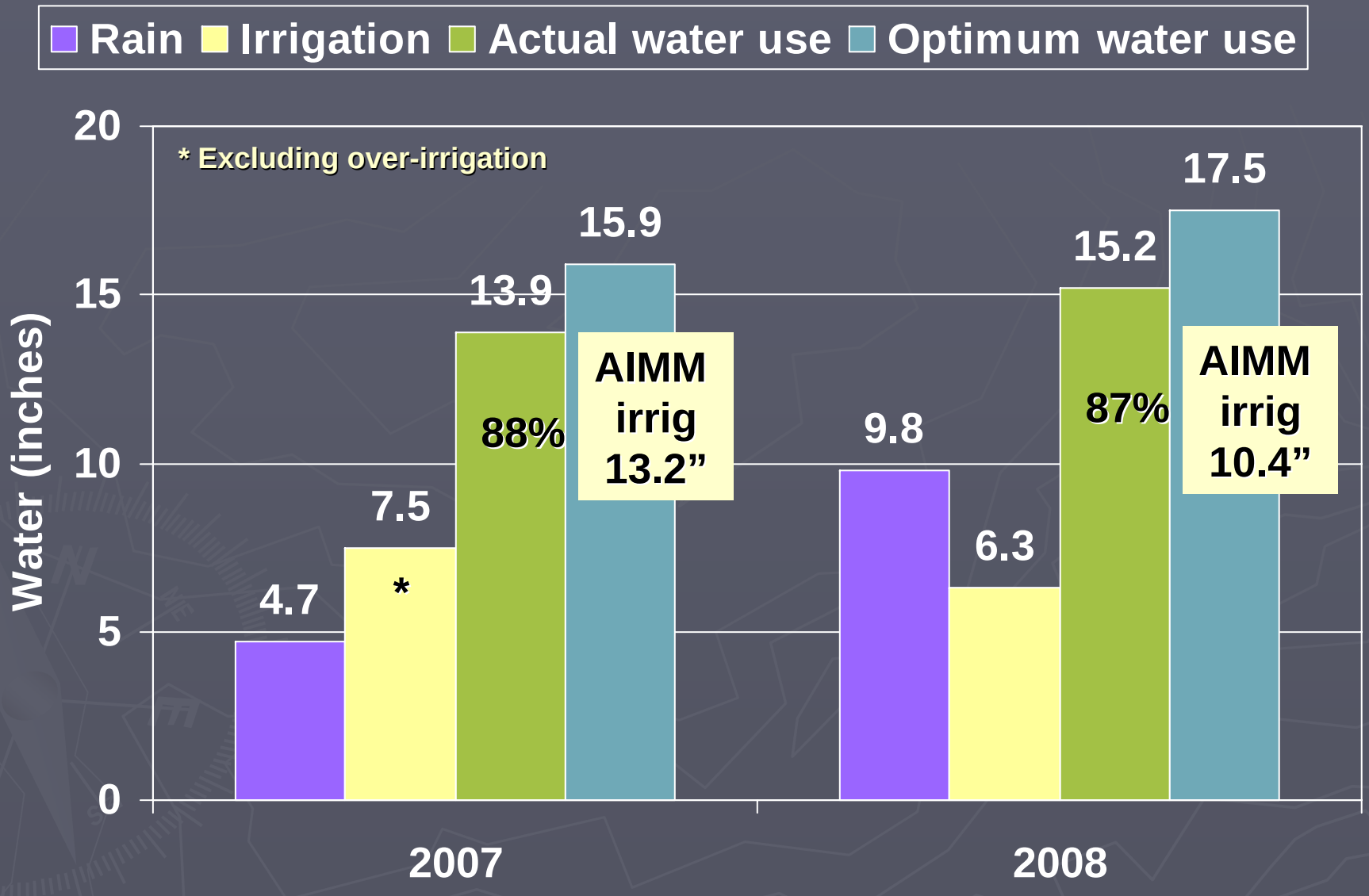

Rain
Irrigation
Actual water use
Optimum water use
Water (inches)
20
15
10
5
0
3.6
4.8
11.4
80%
14.3
AIMM irrig 11.6”
2007

Barley

- Actual crop water use: 70-105% of optimum

- No obvious trend with yield
- 2007 reported yields: 80 to 125 bu/ac

HRS Wheat


Rain
Irrigation
Actual water use
Optimum water use
* Excluding over-irrigation
Water (inches)
20
15
10
5
0
4.7
7.5
*
13.9
88%
15.9
AIMM irrig 13.2”
9.8
6.3
15.2
87%
17.5
AIMM irrig 10.4”
2007
2008

HRS and Durum wheat

- Actual crop water use: 60-110% of optimum

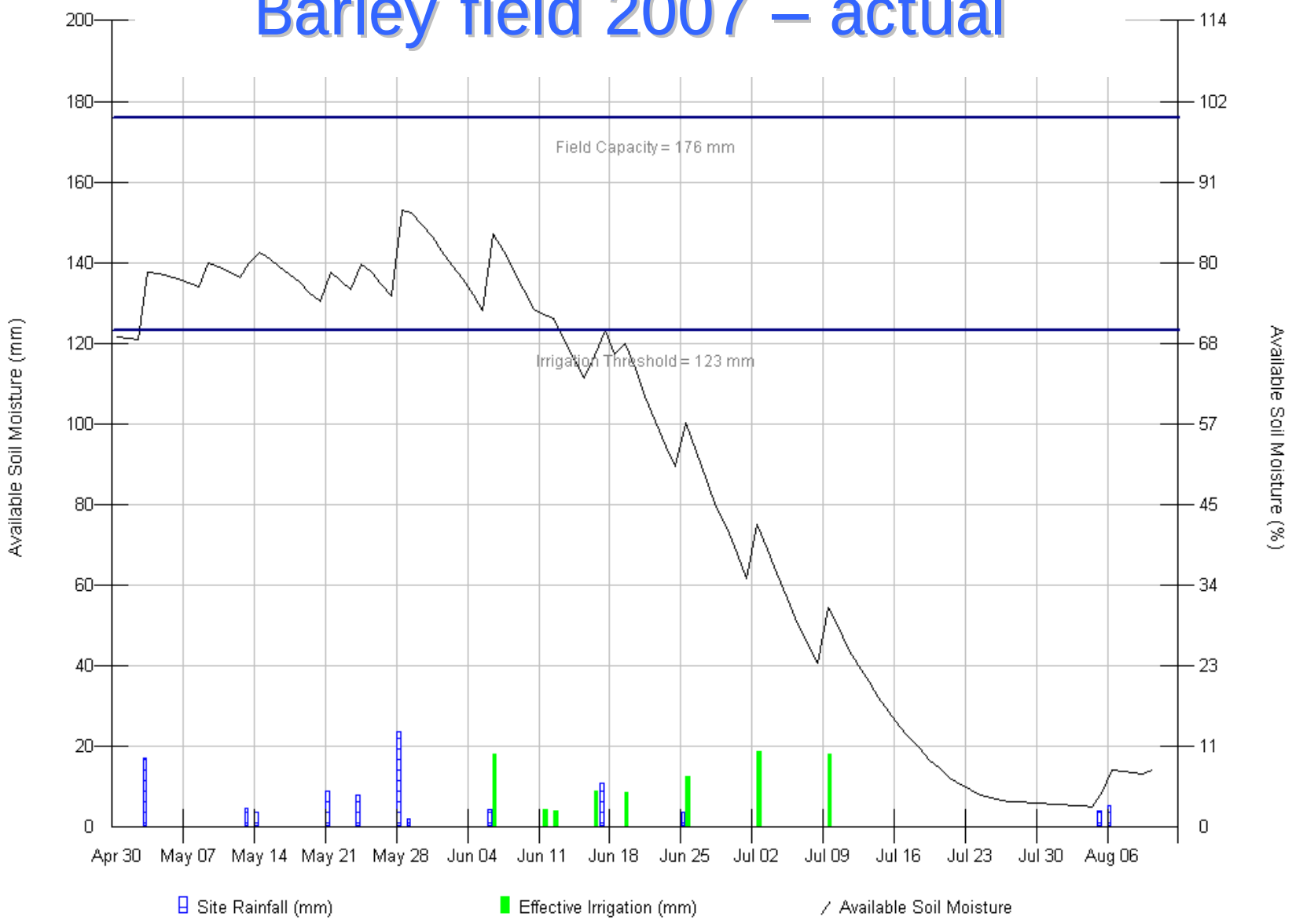
- No obvious trend with yield
- Reported yields:
  - Durum: 65 to 110 bu/ac
  - HRS: 65 to 92 bu/ac

Summary

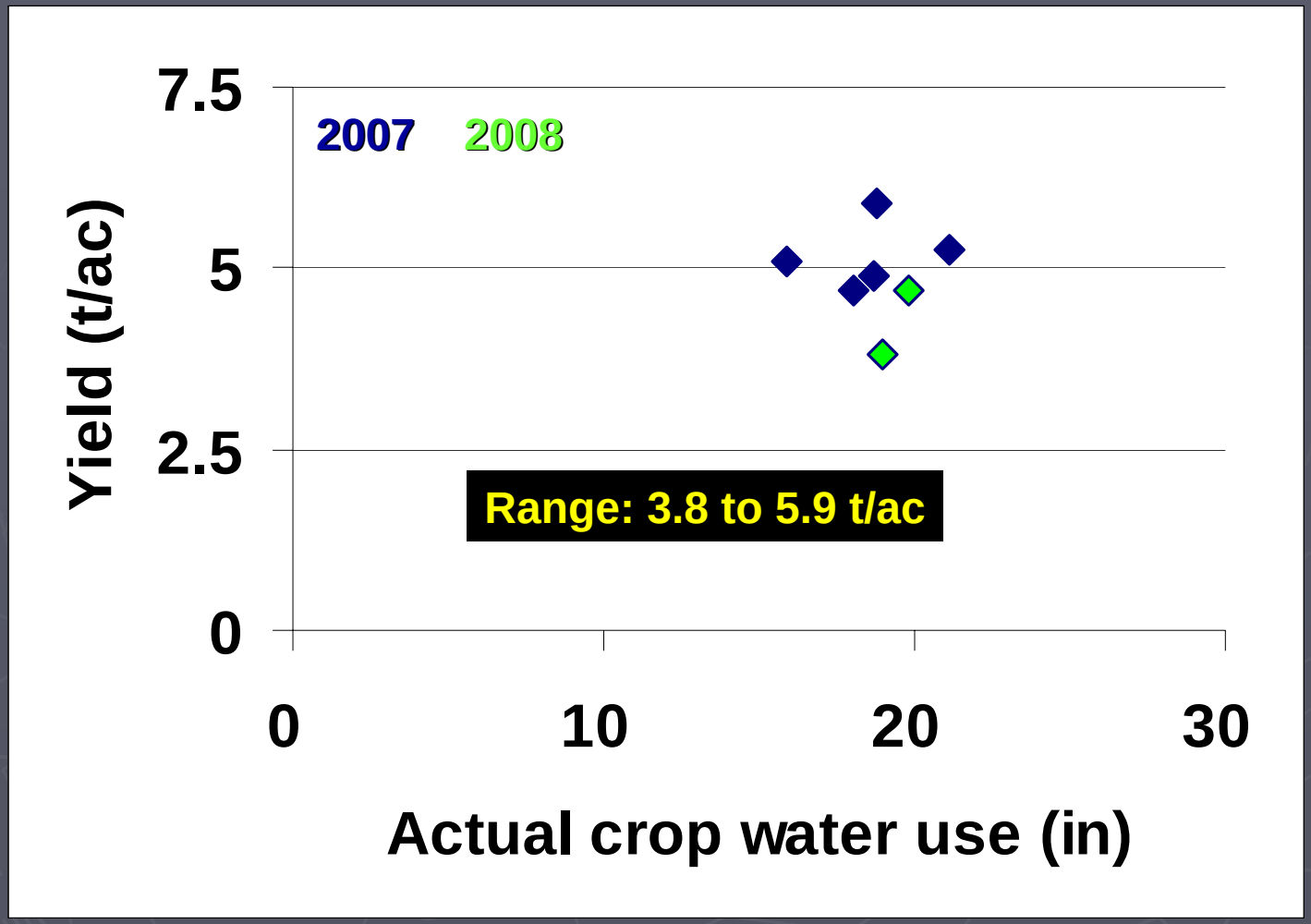
- For the 56 fields analyzed in 2007 & 2008:
- On average, producers with low pressure pivots and pipeline delivery are meeting 86% –94% of optimum crop water use
- Timely rains can help!
- Higher value crops are irrigated more closely to optimum crop water use
- 2009 data to be analyzed

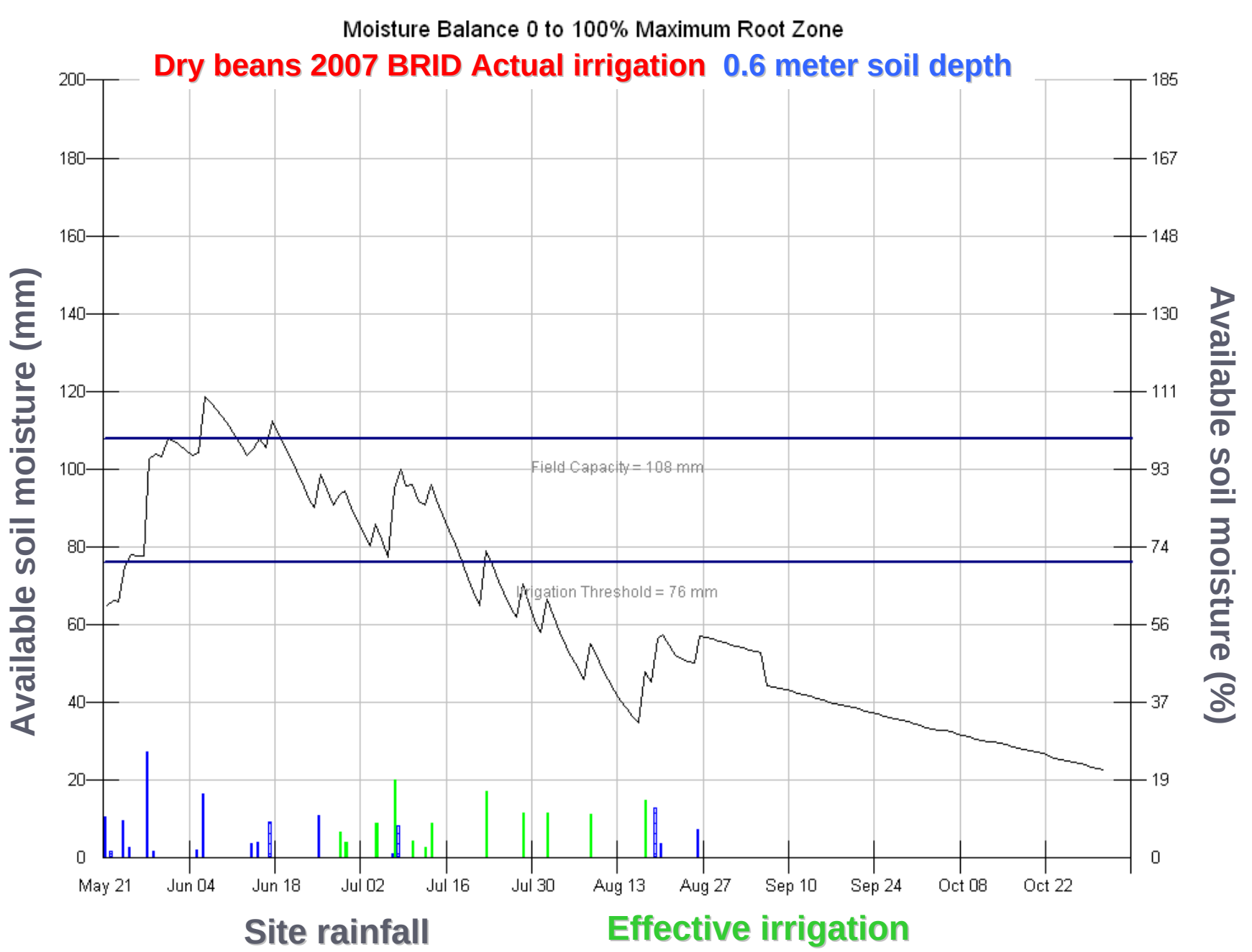

Thank-you:
Co-operating producers
BRID, LNID, MID, RID, SMRID, TID
Alberta Agriculture staff

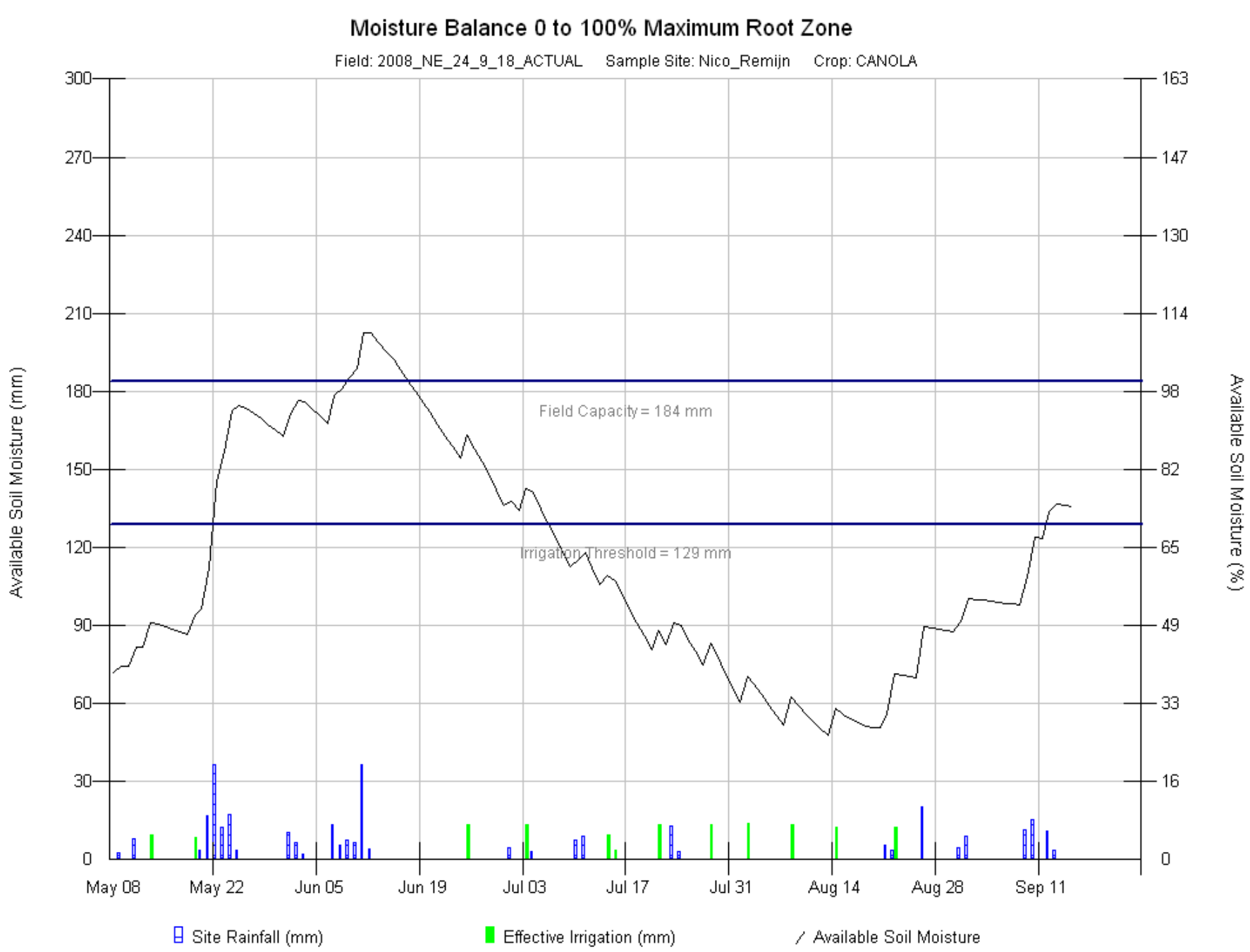
Barley field 2007 – actual



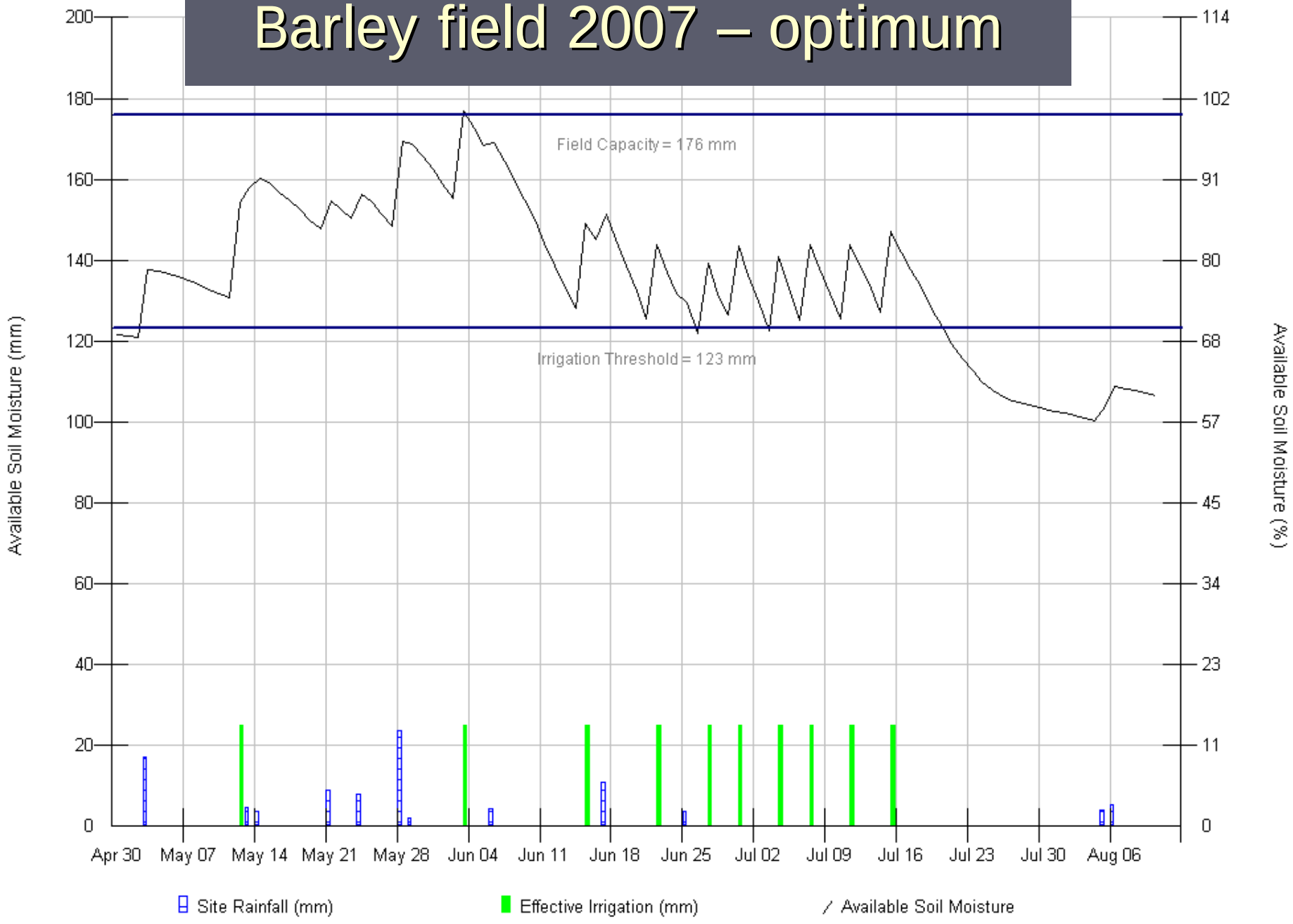
Alfalfa yield

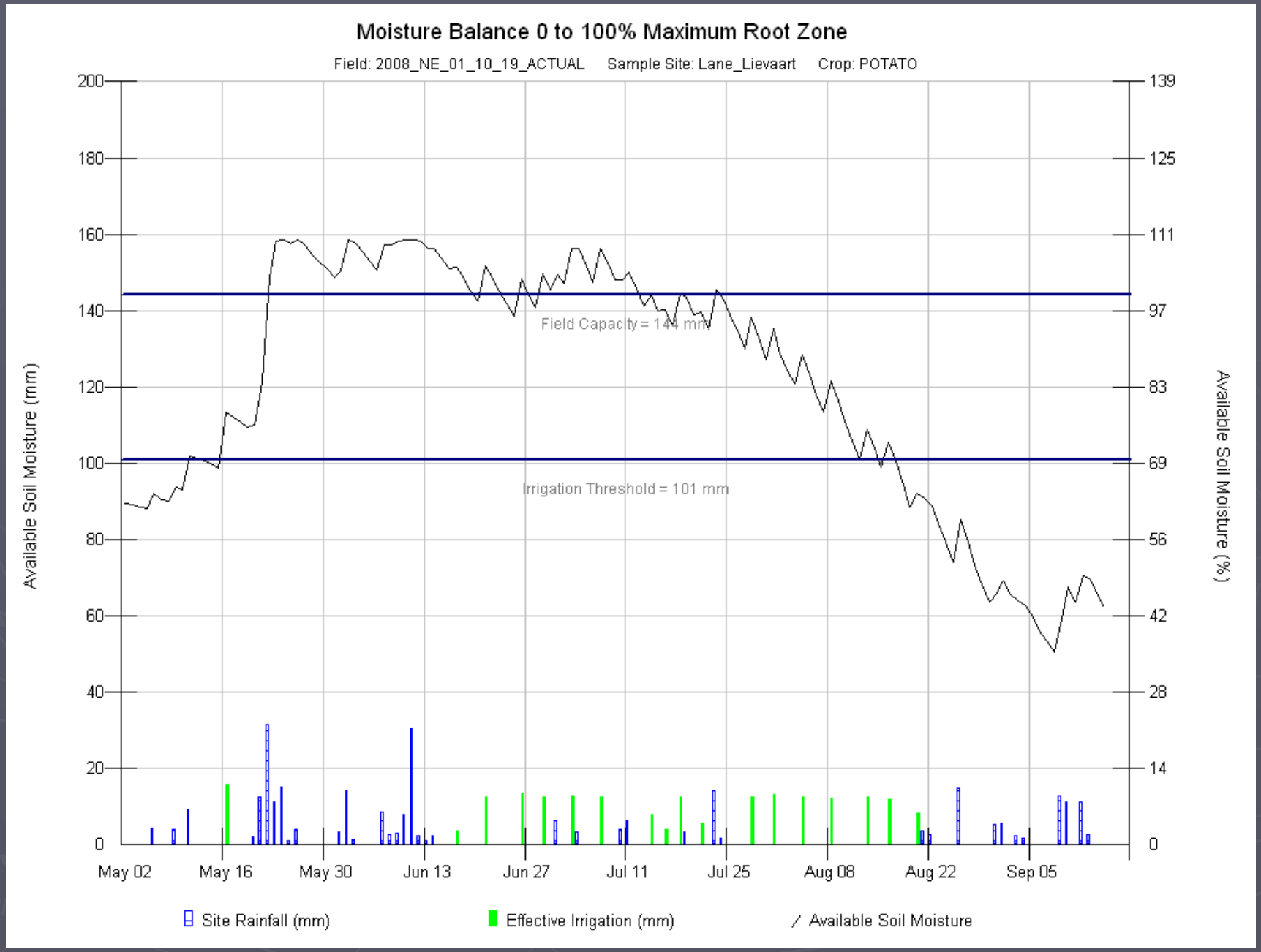


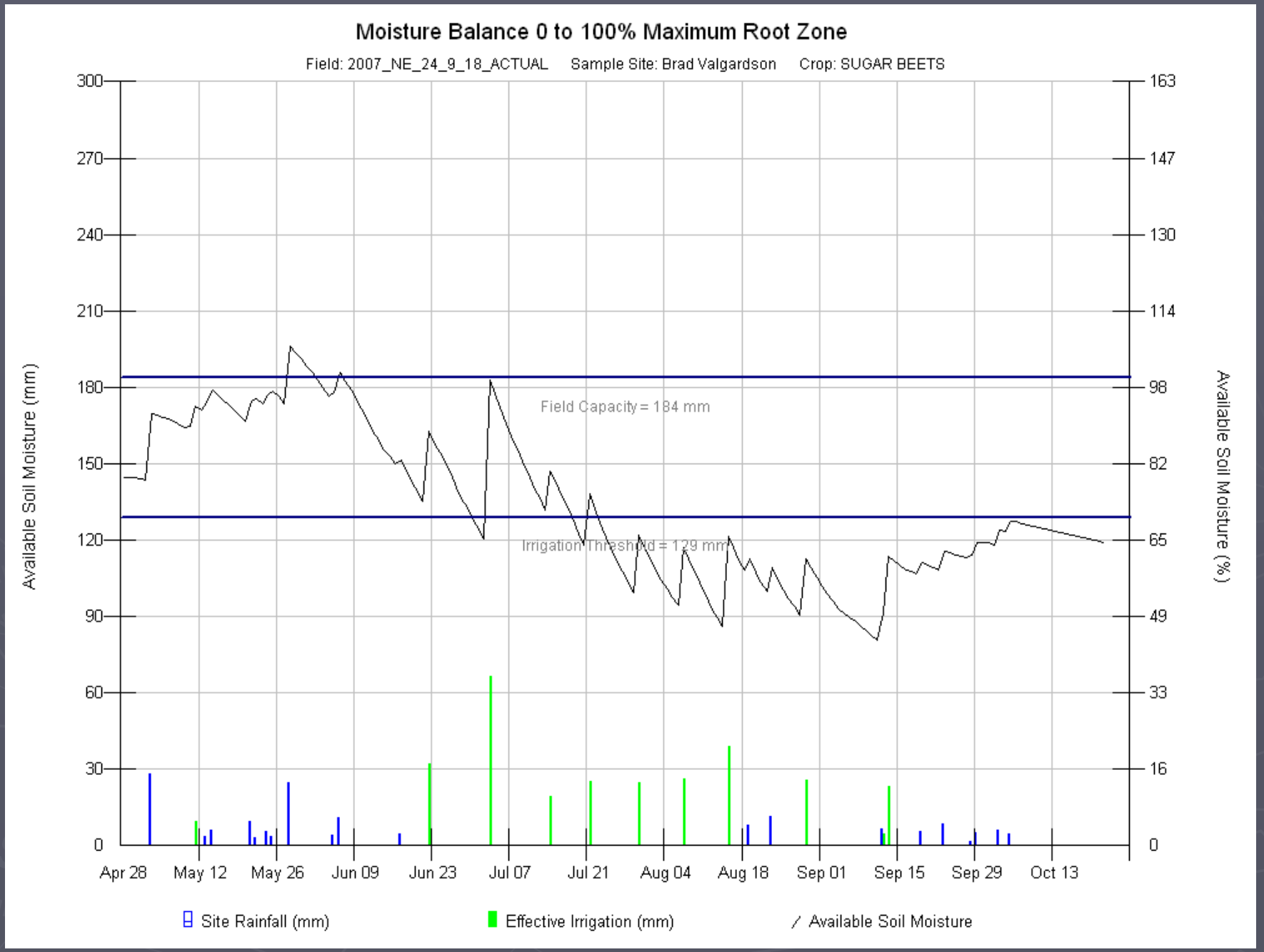

Moisture Balance 0 to 100% Maximum Root Zone
Dry beans 2007 BRID Actual irrigation 0.6 meter soil depth
Available soil moisture (mm)
Available soil moisture (%)
200
180
160
140
120
100
80
60
40
20
0
185
167
148
130
111
93
74
56
37
19
0
Field Capacity = 108 mm
Irrigation Threshold = 76 mm
May 21
Jun 04
Jun 18
Jul 02
Jul 16
Jul 30
Aug 13
Aug 27
Sep 10
Sep 24
Oct 08
Oct 22
Site rainfall
Effective irrigation

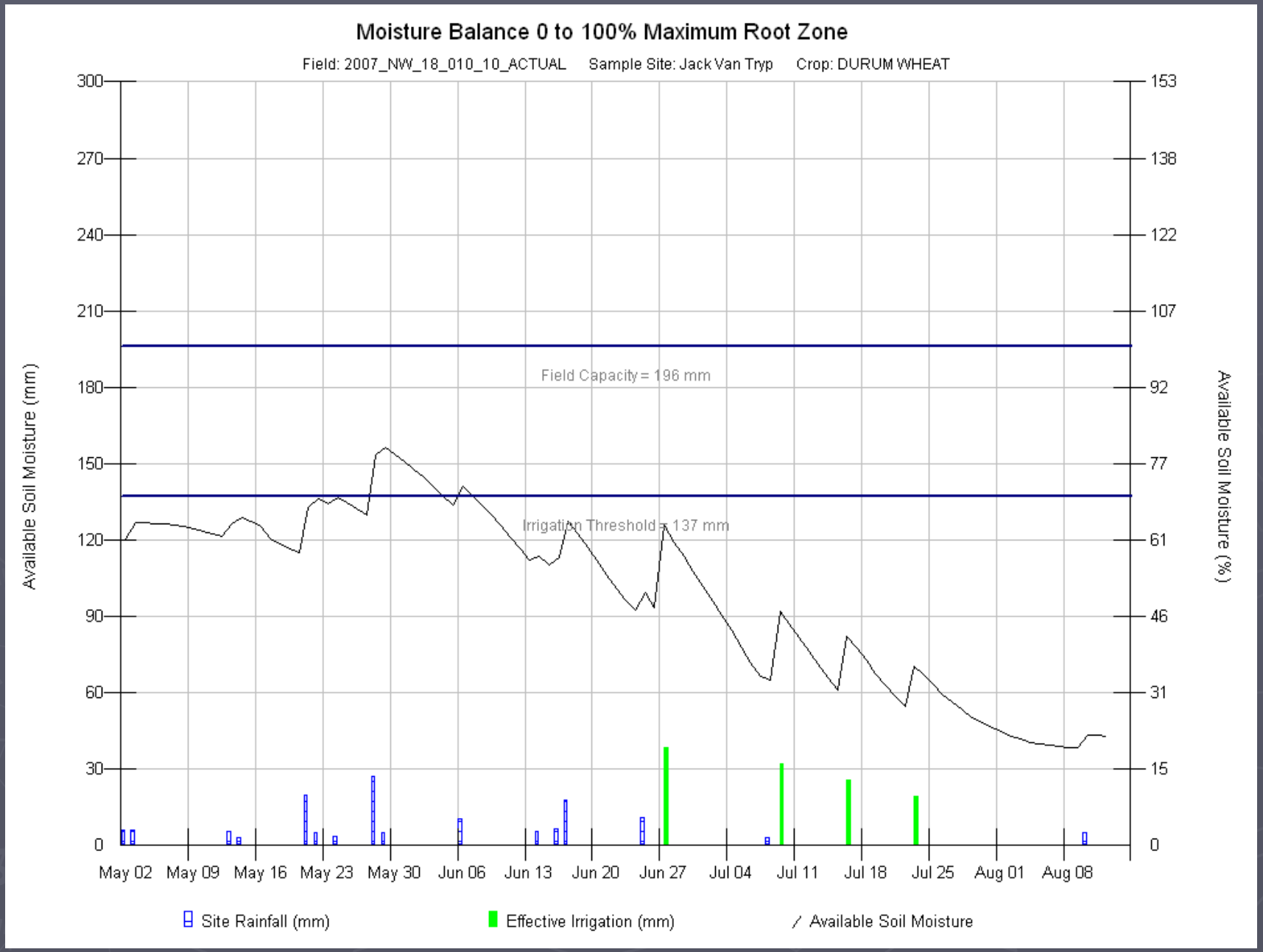

Moisture Balance 0 to 100% Maximum Root Zone
Field: 2008_NE_24_9_18_ACTUAL Sample Site: Nico_Remijn Crop: CANOLA
Available Soil Moisture (mm)
Available Soil Moisture (%)
300
270
240
210
180
150
120
90
60
30
0
163
147
130
114
98
82
65
49
33
16
0
Field Capacity = 184 mm
Irrigation Threshold = 129 mm
May 08
May 22
Jun 05
Jun 19
Jul 03
Jul 17
Jul 31
Aug 14
Aug 28
Sep 11
Site Rainfall (mm)
Effective Irrigation (mm)
Available Soil Moisture

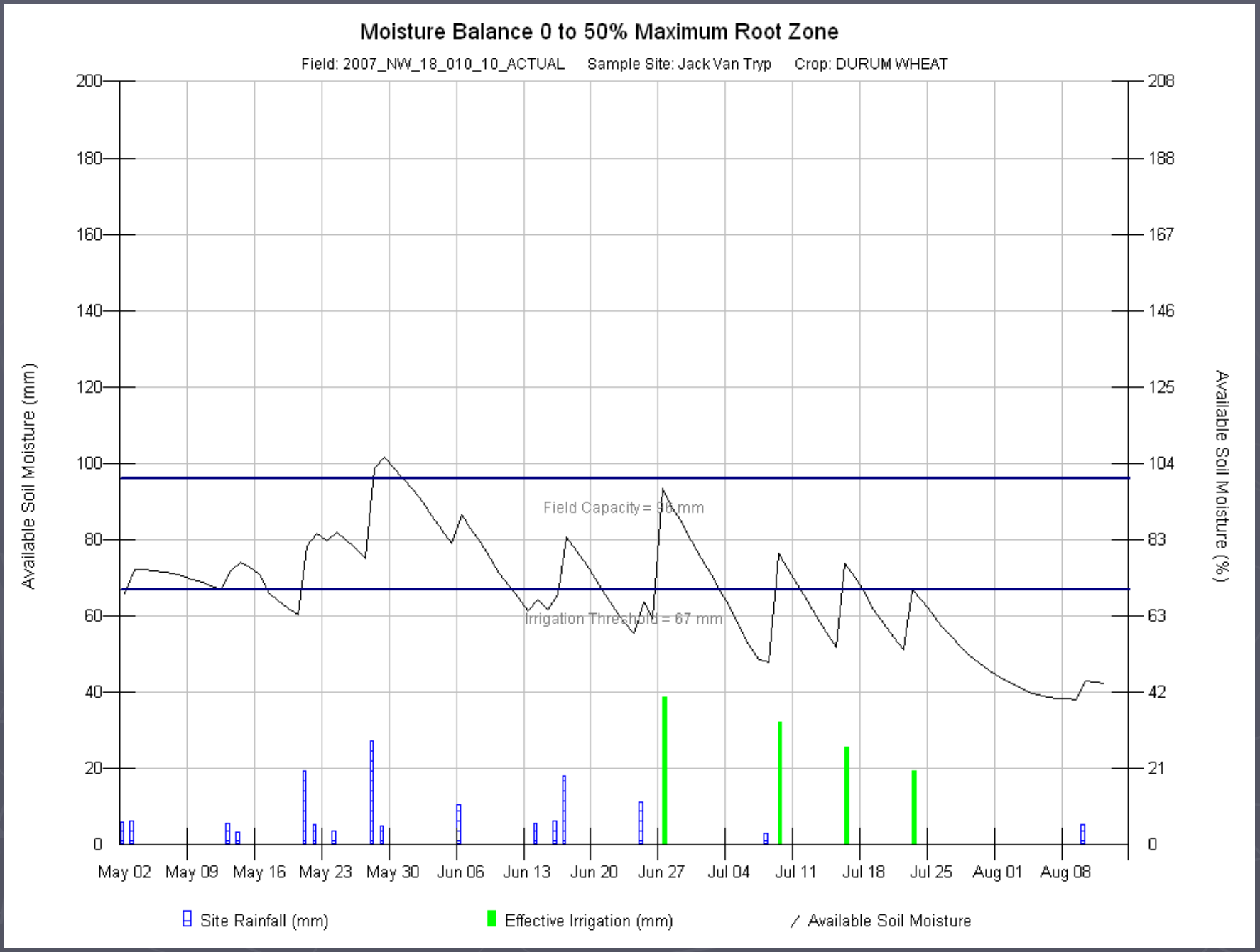
Barley field 2007 – optimum



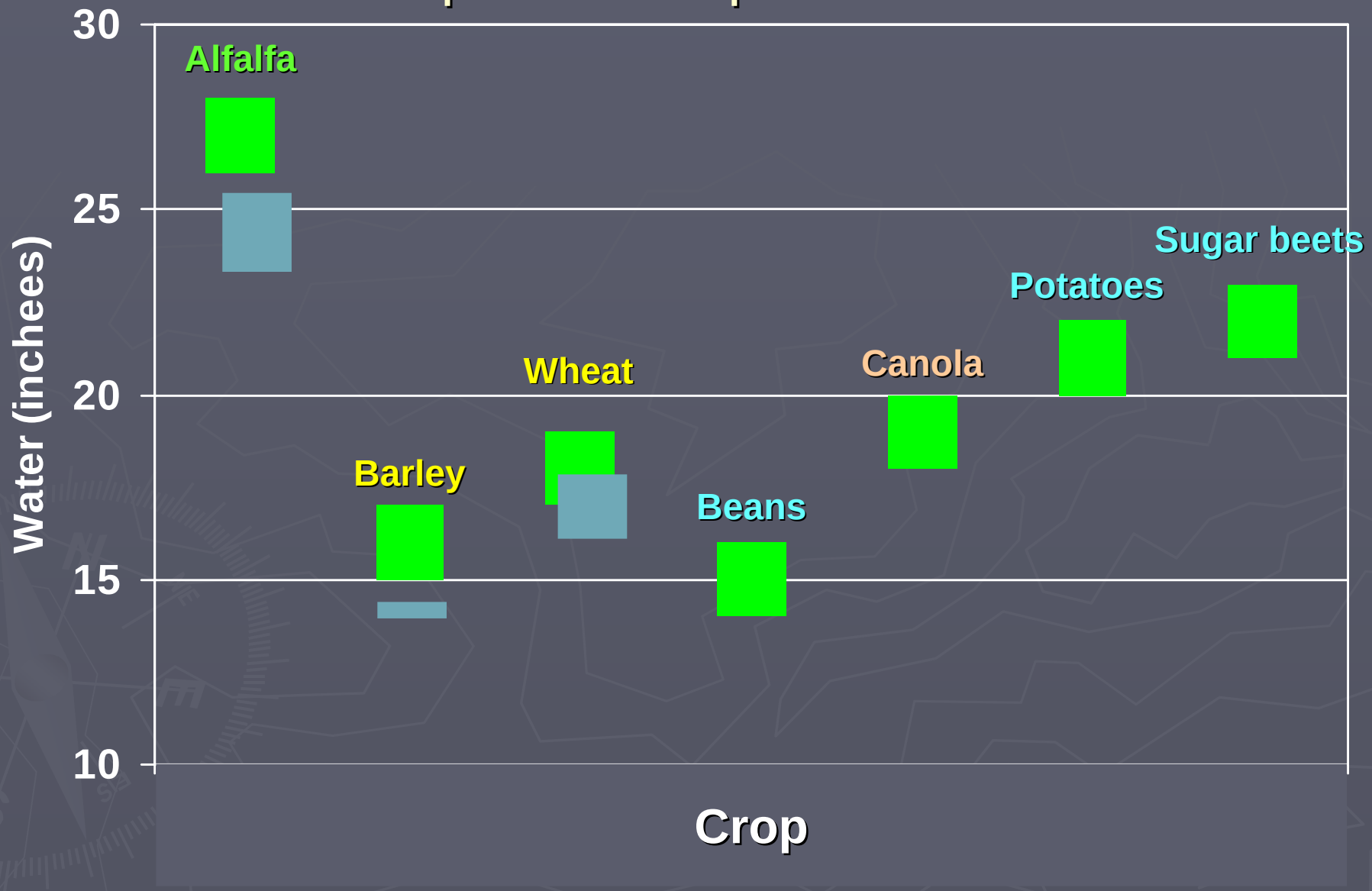

Moisture Balance 0 to 100% Maximum Root Zone
Field: 2008_NE_01_10_19_ACTUAL Sample Site: Lane_Lievaart Crop: POTATO
Available Soil Moisture (mm)
Available Soil Moisture (%)
200
180
160
140
120
100
80
60
40
20
0
139
125
111
97
83
69
56
42
28
14
0
Field Capacity = 144 mm
Irrigation Threshold = 101 mm
May 02
May 16
May 30
Jun 13
Jun 27
Jul 11
Jul 25
Aug 08
Aug 22
Sep 05
Site Rainfall (mm)
Effective Irrigation (mm)
Available Soil Moisture

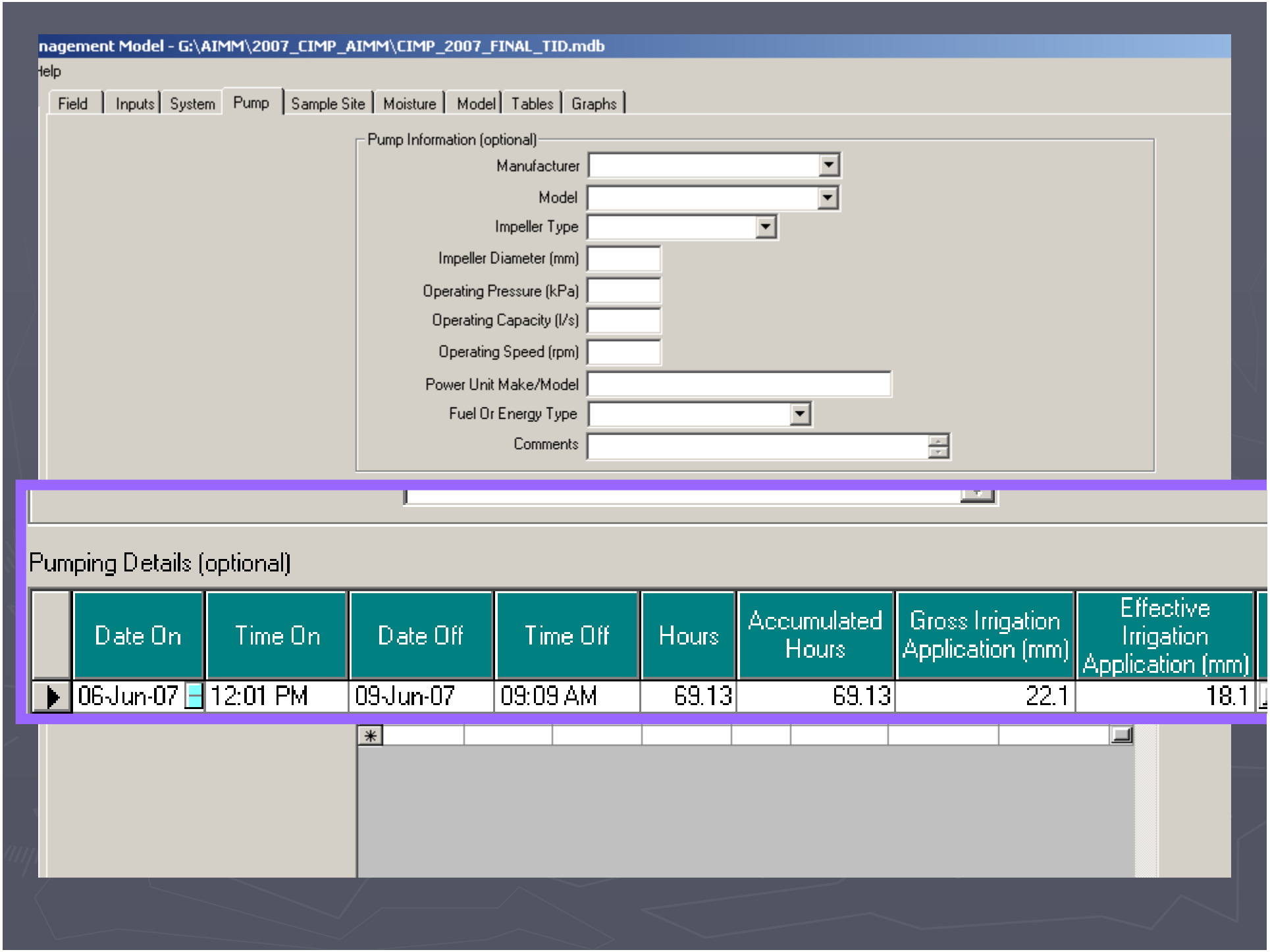

Moisture Balance 0 to 100% Maximum Root Zone
Field: 2007_NE_24_9_18_ACTUAL Sample Site: Brad Valgardson Crop: SUGAR BEETS
Available Soil Moisture (mm)
Available Soil Moisture (%)
300
270
240
210
180
150
120
90
60
30
0
163
147
130
114
98
82
65
49
33
16
0
Field Capacity = 184 mm
Irrigation Threshold = 129 mm
Apr 28
May 12
May 26
Jun 09
Jun 23
Jul 07
Jul 21
Aug 04
Aug 18
Sep 01
Sep 15
Sep 29
Oct 13
Site Rainfall (mm)
Effective Irrigation (mm)
Available Soil Moisture


Moisture Balance 0 to 100% Maximum Root Zone
Field: 2007_NW_18_010_10_ACTUAL Sample Site: Jack Van Tryp Crop: DURUM WHEAT
Available Soil Moisture (mm)
Available Soil Moisture (%)
300
270
240
210
180
150
120
90
60
30
0
153
138
122
107
92
77
61
46
31
15
0
Field Capacity = 196 mm
Irrigation Threshold = 137 mm
May 02
May 09
May 16
May 23
May 30
Jun 06
Jun 13
Jun 20
Jun 27
Jul 04
Jul 11
Jul 18
Jul 25
Aug 01
Aug 08
Site Rainfall (mm)
Effective Irrigation (mm)
Available Soil Moisture


Moisture Balance 0 to 50% Maximum Root Zone
Field: 2007_NW_18_010_10_ACTUAL Sample Site: Jack Van Tryp Crop: DURUM WHEAT
Available Soil Moisture (mm)
Available Soil Moisture (%)
200
180
160
140
120
100
80
60
40
20
0
208
188
167
146
125
104
83
63
42
21
0
Field Capacity = 96 mm
Irrigation Threshold = 67 mm
May 02
May 09
May 16
May 23
May 30
Jun 06
Jun 13
Jun 20
Jun 27
Jul 04
Jul 11
Jul 18
Jul 25
Aug 01
Aug 08
Site Rainfall (mm)
Effective Irrigation (mm)
Available Soil Moisture

Estimates of optimum crop water use - Alberta




nagement Model - G:\AIMM\2007_CIMP_AIMM\CIMP_2007_FINAL_TID.mdb
Help
Field
Inputs
System
Pump
Sample Site
Moisture
Model
Tables
Graphs
Pump Information (optional)
Manufacturer
Model
Impeller Type
Impeller Diameter (mm)
Operating Pressure (kPa)
Operating Capacity (l/s)
Operating Speed (rpm)
Power Unit Make/Model
Fuel Or Energy Type
Comments
Pumping Details (optional)
Date On
Time On
Date Off
Time Off
Hours
Accumulated Hours
Gross Irrigation Application (mm)
Effective Irrigation Application (mm)
06-Jun-07
12:01 PM
09-Jun-07
09:09 AM
69.13
69.13
22.1
18.1

Results – Irrigation Method

Table 2. Influence of technology on water application.

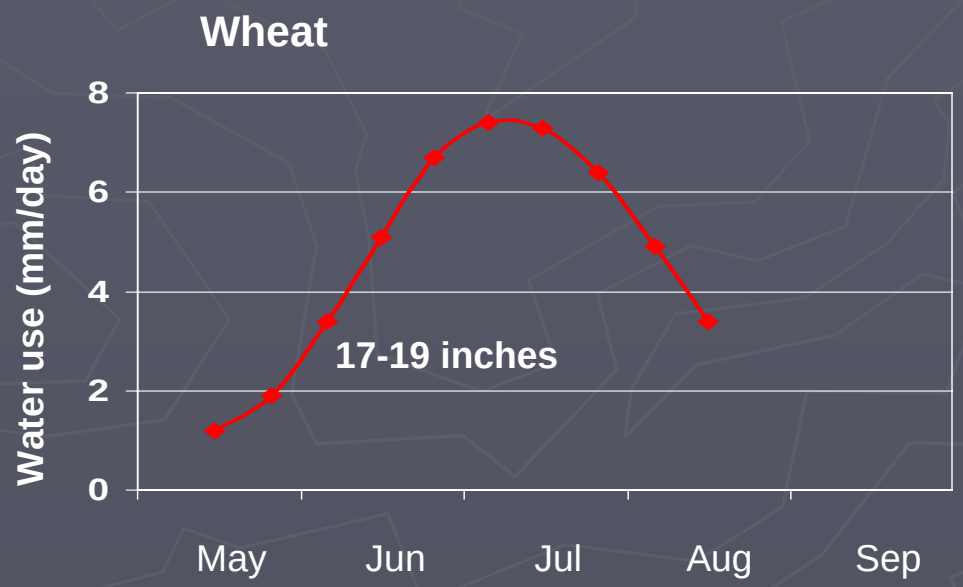
	Center Pivot	Side Wheel Roll	Surface
No. of fields monitored	**248**	**50**	**10**
Average Annual application (mm)	**230 ± 117**	**207 ± 124**	**403 ± 122**
Fields over-irrigated	**11 %**	**34 %**	**100 %**
Ave. over-irrigation amount (mm)	**23**	**39**	**158**
Fields under-irrigated	**57 %**	**60 %**	**20 %**
Ave. under-irrigation amount (mm)	**44**	**57**	**64**

Producer survey

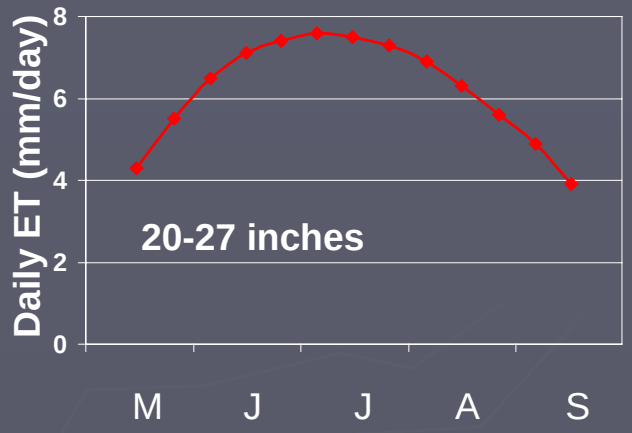
- *"What factors influence your irrigation management?"*
  1. Maximizing yield
  2. Managing input costs
  3. Crop quality
  4. Minimizing disease

Crop water use

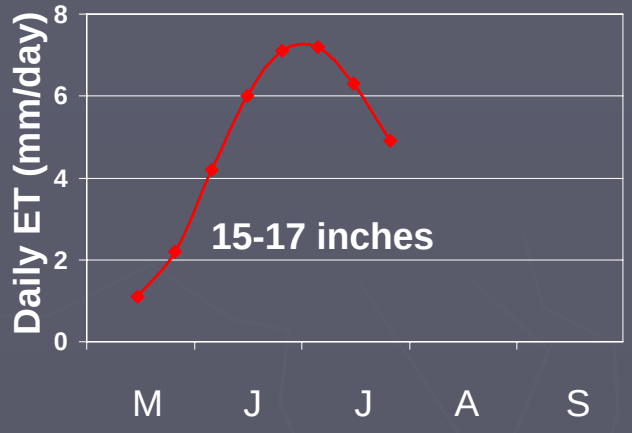
- The depth of water needed to meet the water loss through evapotranspiration of a crop
- Water stress impacts evapotranspiration and crop yield



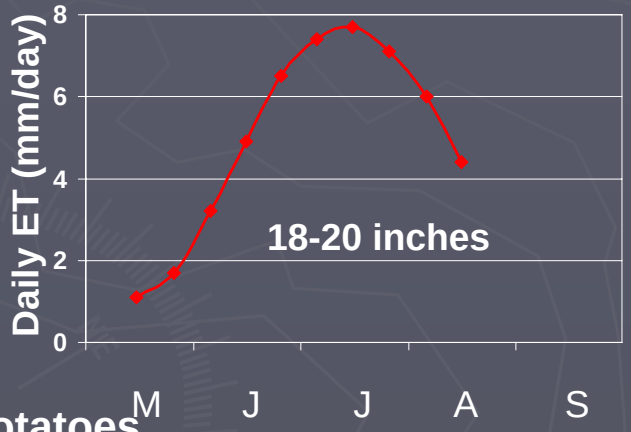
Alfalfa



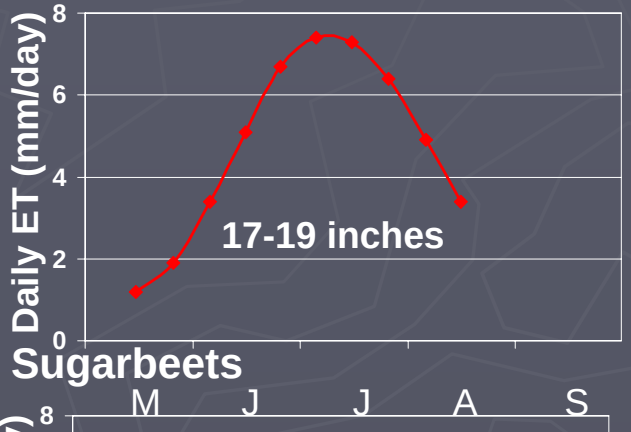
Barley



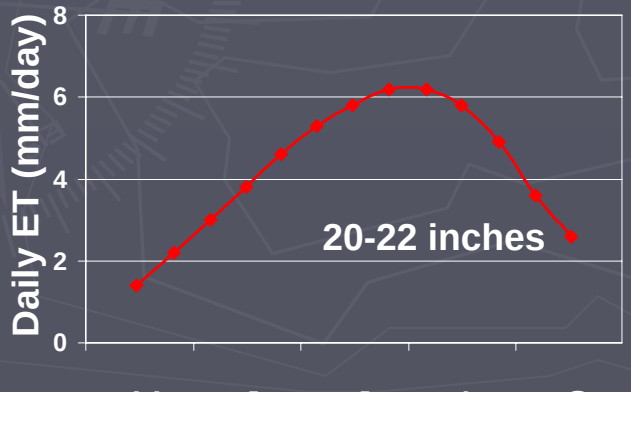
Canola



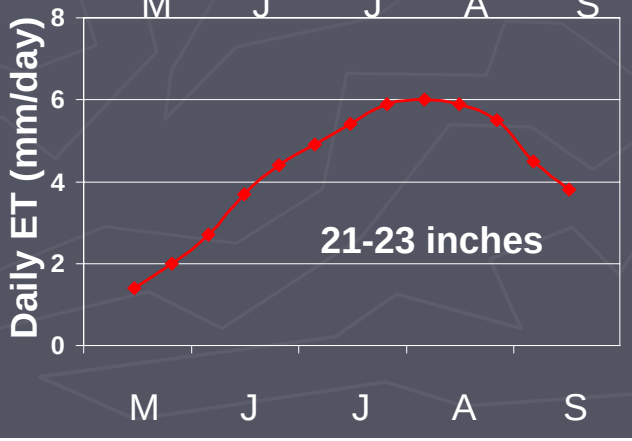
Wheat

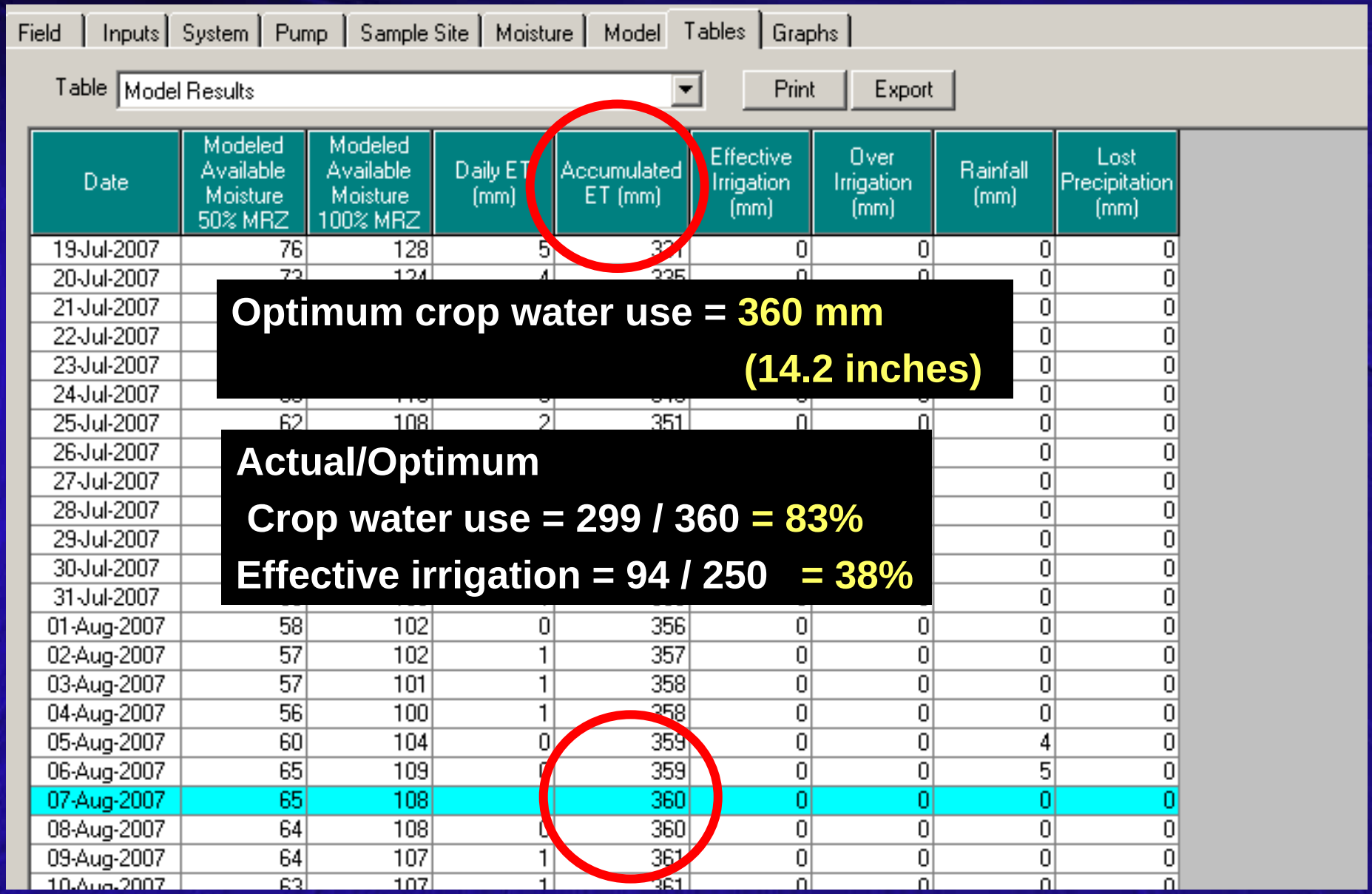


Potatoes



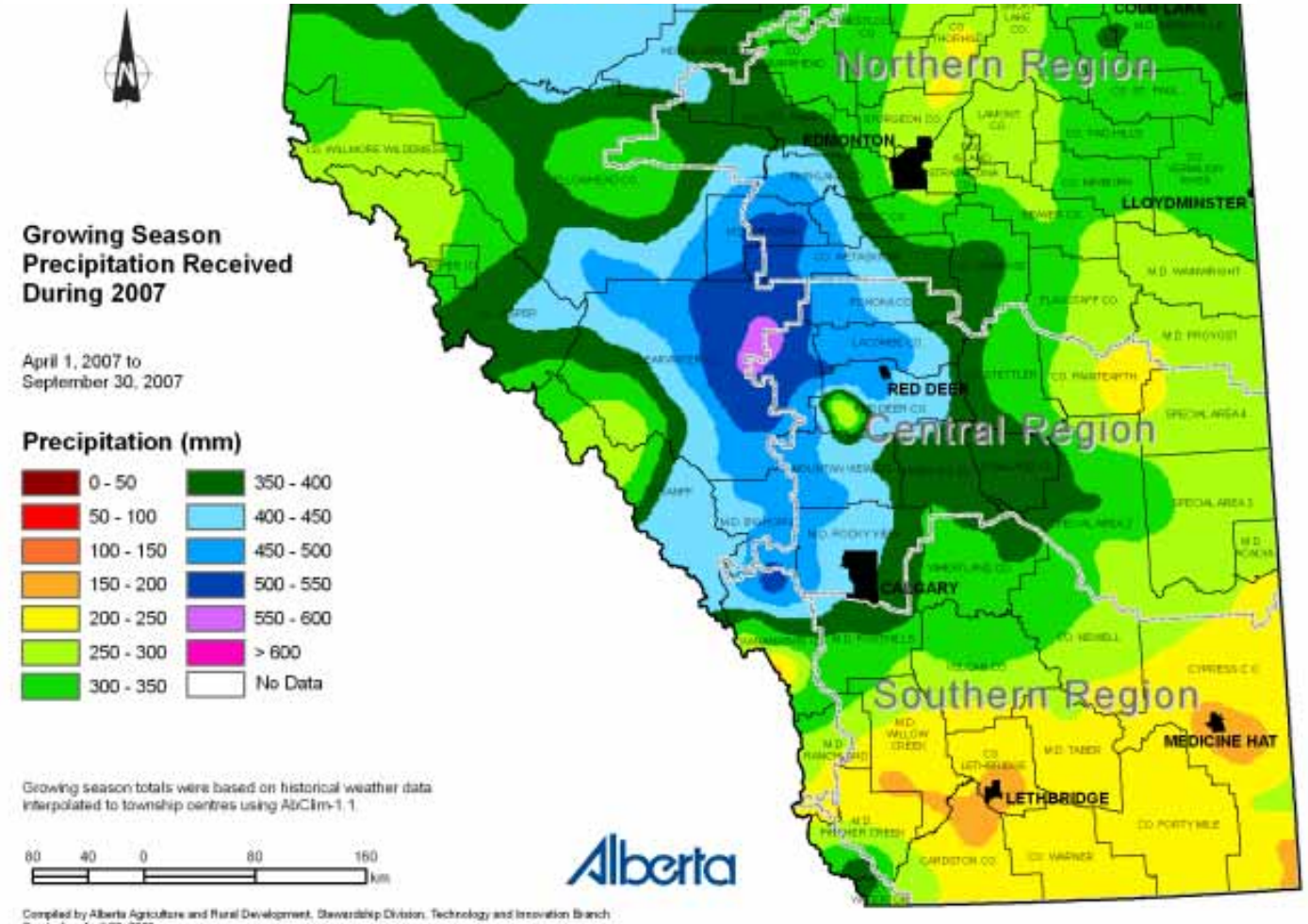
Sugarbeets





Date	Modeled Available Moisture 50% MRZ	Modeled Available Moisture 100% MRZ	Daily ET (mm)	Accumulated ET (mm)	Effective Irrigation (mm)	Over Irrigation (mm)	Rainfall (mm)	Lost Precipitation (mm)
19-Jul-2007	76	128	5	321	0	0	0	0
20-Jul-2007	73	124	4	325	0	0	0	0
21-Jul-2007							0	0
22-Jul-2007							0	0
23-Jul-2007							0	0
24-Jul-2007							0	0
25-Jul-2007	62	108	2	351	0	0	0	0
26-Jul-2007							0	0
27-Jul-2007							0	0
28-Jul-2007							0	0
29-Jul-2007							0	0
30-Jul-2007							0	0
31-Jul-2007							0	0
01-Aug-2007	58	102	0	356	0	0	0	0
02-Aug-2007	57	102	1	357	0	0	0	0
03-Aug-2007	57	101	1	358	0	0	0	0
04-Aug-2007	56	100	1	358	0	0	0	0
05-Aug-2007	60	104	0	359	0	0	4	0
06-Aug-2007	65	109	0	359	0	0	5	0
07-Aug-2007	65	108	0	360	0	0	0	0
08-Aug-2007	64	108	0	360	0	0	0	0
09-Aug-2007	64	107	1	361	0	0	0	0
10-Aug-2007	63	107	1	361	0	0	0	0

2007 Growing season precipitation



2008 Growing season precipitation