NC STATE UNIVERSITY

Bio&Ag ENGINEERING

Drainage Water Management

Dr. R. Wayne Skaggs

Agricultural Outlook Forum
Washington DC,
February 22, 2013

THE NEWS

"I've known that all our rivers had some problems for a while."

"There are too many people that benefit from degrading the river."

The mighty Neuse, made vulnerable

NC Water Management Studies: 1975 to 1990

Conetoe Creek

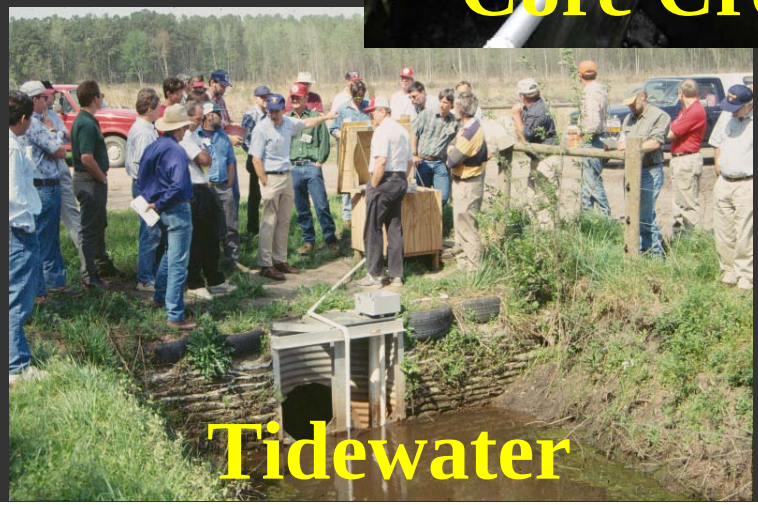
Fabridam

Aurora

Core Creek

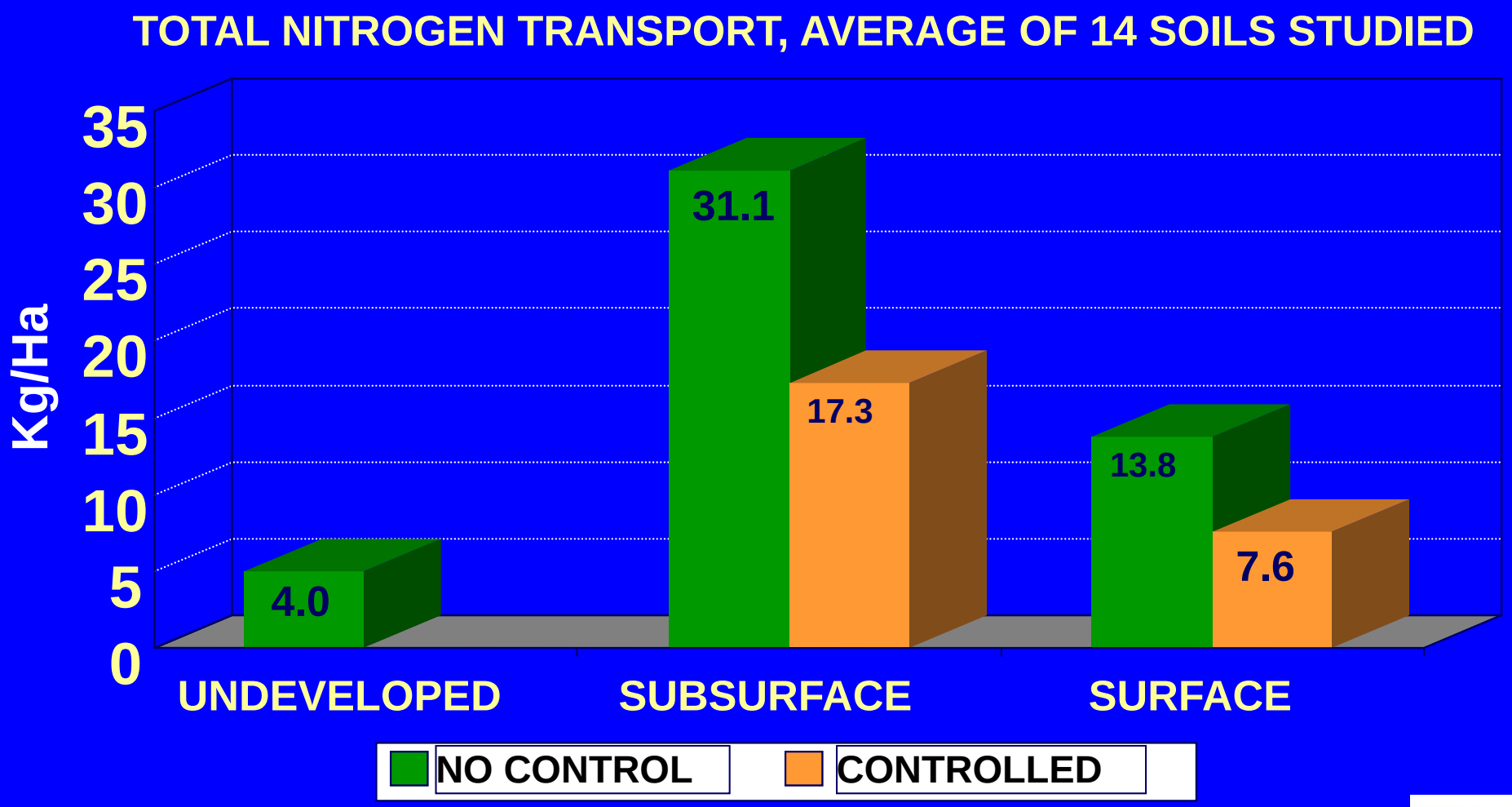
Pamlico RCA

Camden RCA

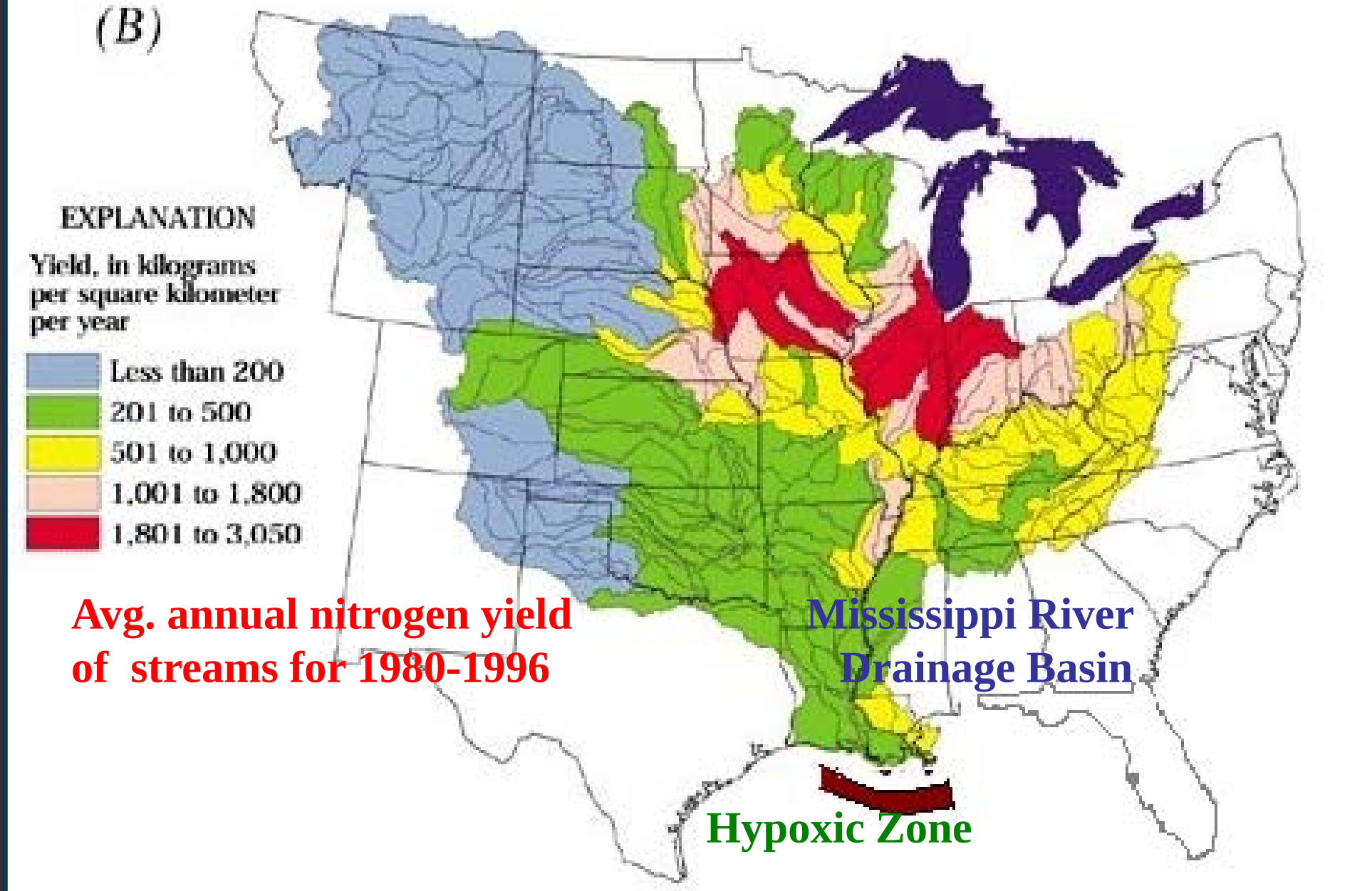

Tidewater

NC STATE UNIVERSITY
Bio&Ag ENGINEERING

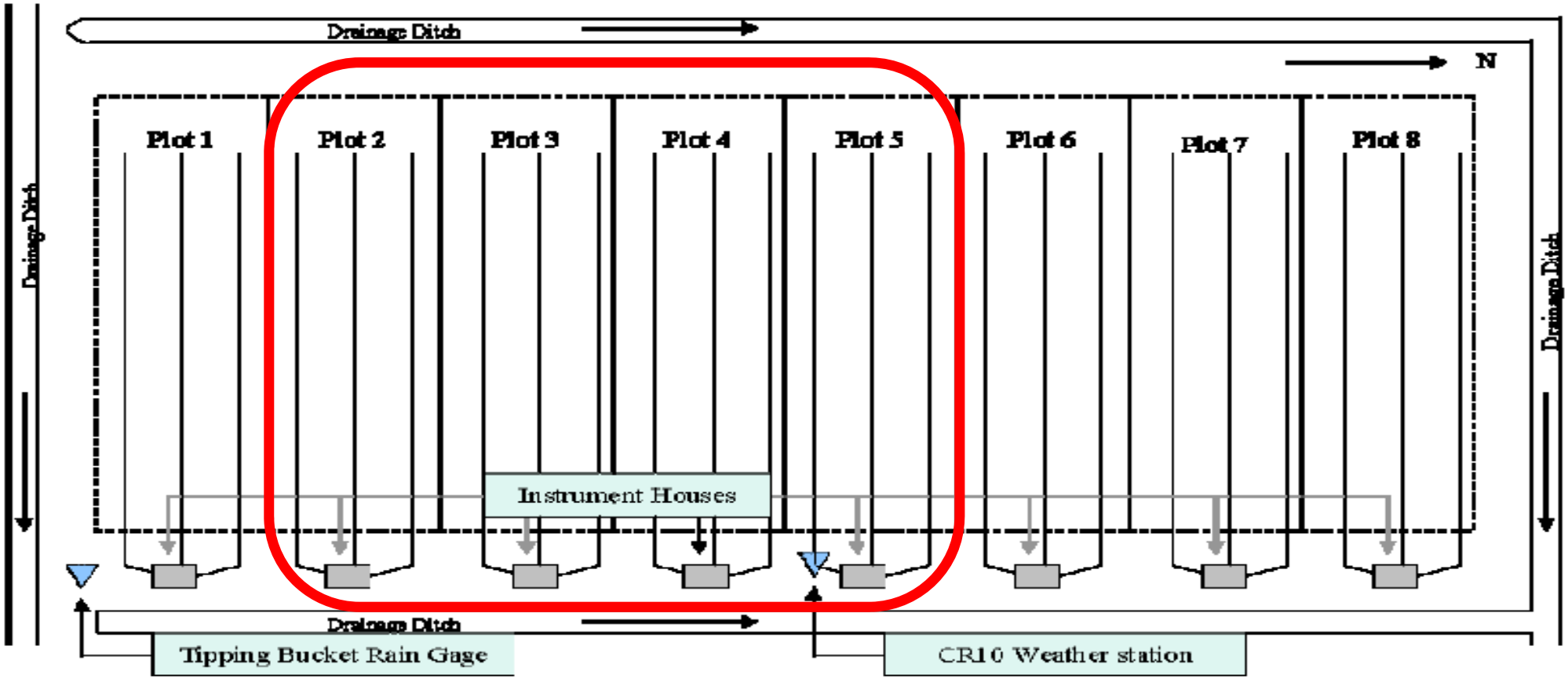
EFFECT OF DWM ON NITROGEN LOSSES IN AGRICULTURAL DRAINAGE WATER



NC STATE UNIVERSITY Bio&Ag ENGINEERING


(B)
EXPLANATION
Yield, in kilograms per square kilometer per year
Less than 200
201 to 500
501 to 1,000
1,001 to 1,800
1,801 to 3,050
Avg. annual nitrogen yield of streams for 1980-1996
Mississippi River Drainage Basin
Hypoxic Zone

Site Infrastructure-TRS

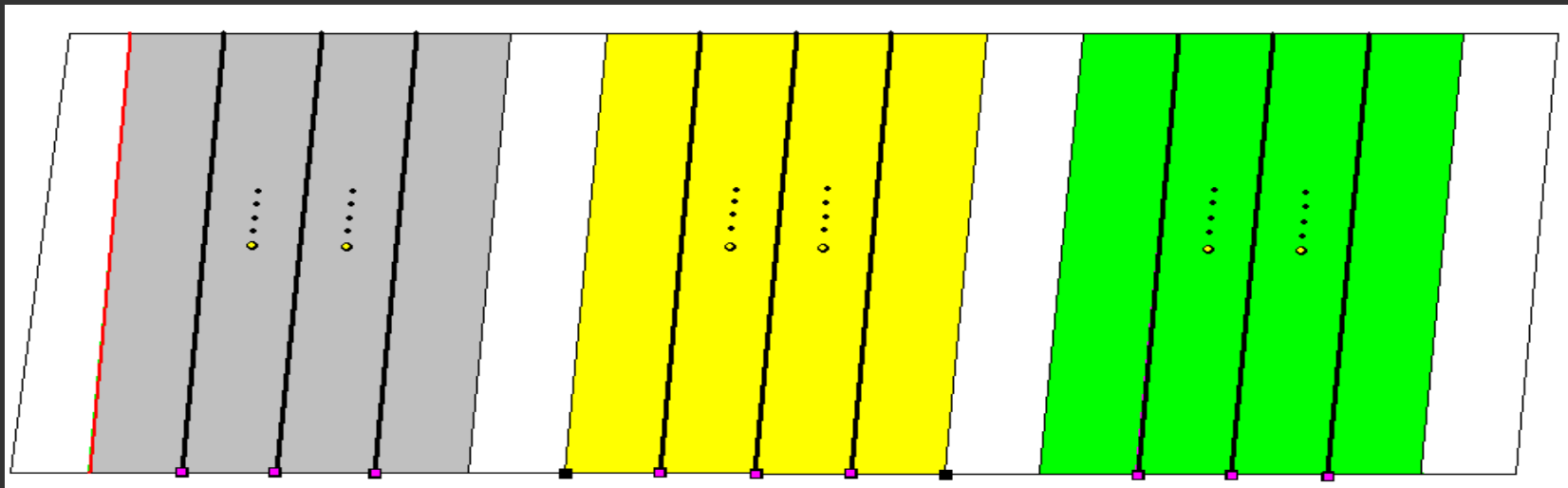


13.8 ha site – 8-Plots, Drain depth (1.2 m), 23 m spacing

Plots (2-5) for this study, Portsmouth Sandy Loam

NC STATE UNIVERSITY Bio&Ag

Bath Site



88 ac Field Site

9 - Measured Plots

5.5 ac/plot

Site 2: BATH

Open Ditch Drainage System

Installed April 2008
-Bath, NC

Portsmouth Sandy Loam Soil

Drainage Management:

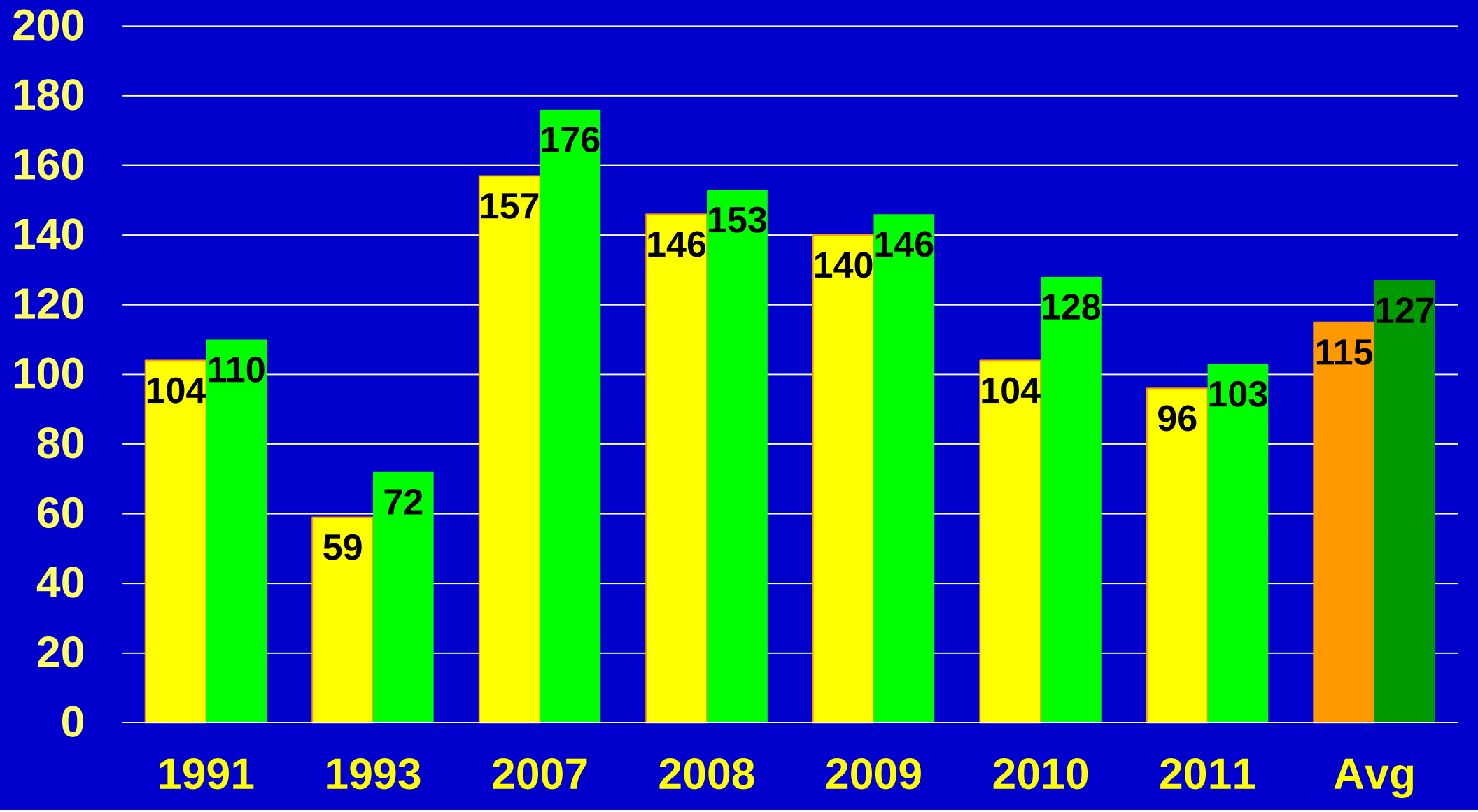
A. Conventional Deep Drainage / Surface Improvement

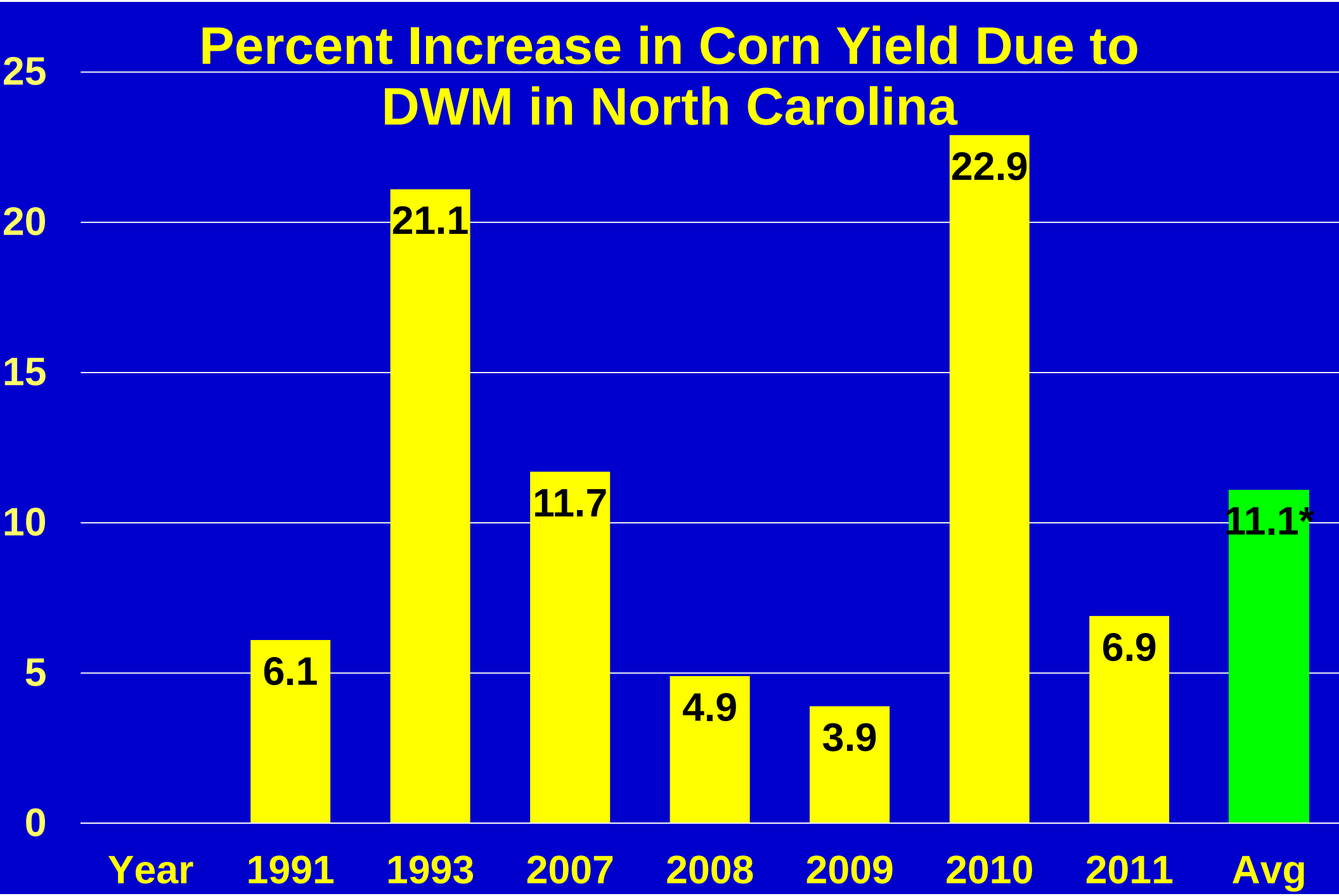
B. Controlled Drainage / Surface Improvement

C. Shallow Drainage / Laser Grade Surface Leveling

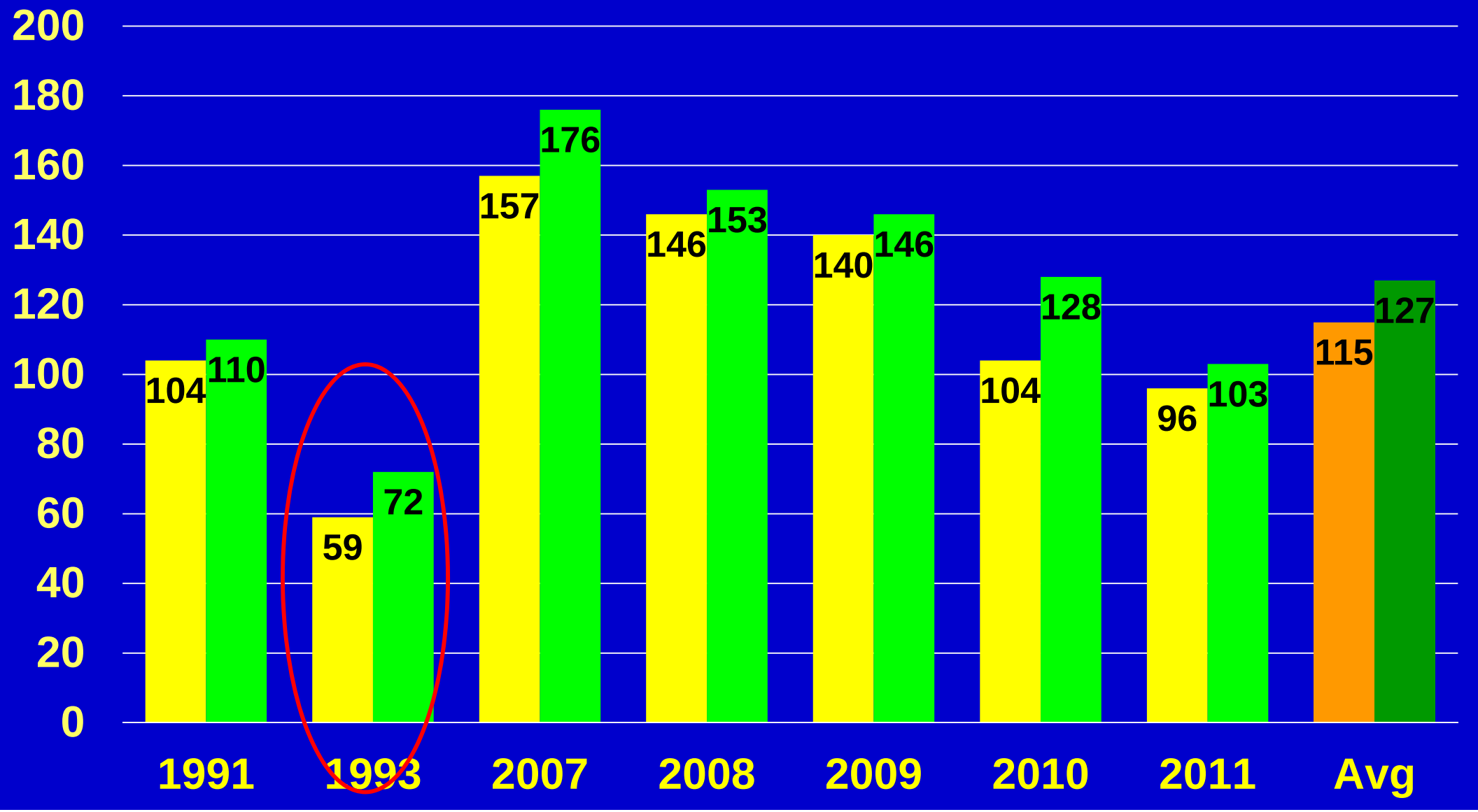
NC STATE UNIVERSITY
Bio&Ag ENGINEERING

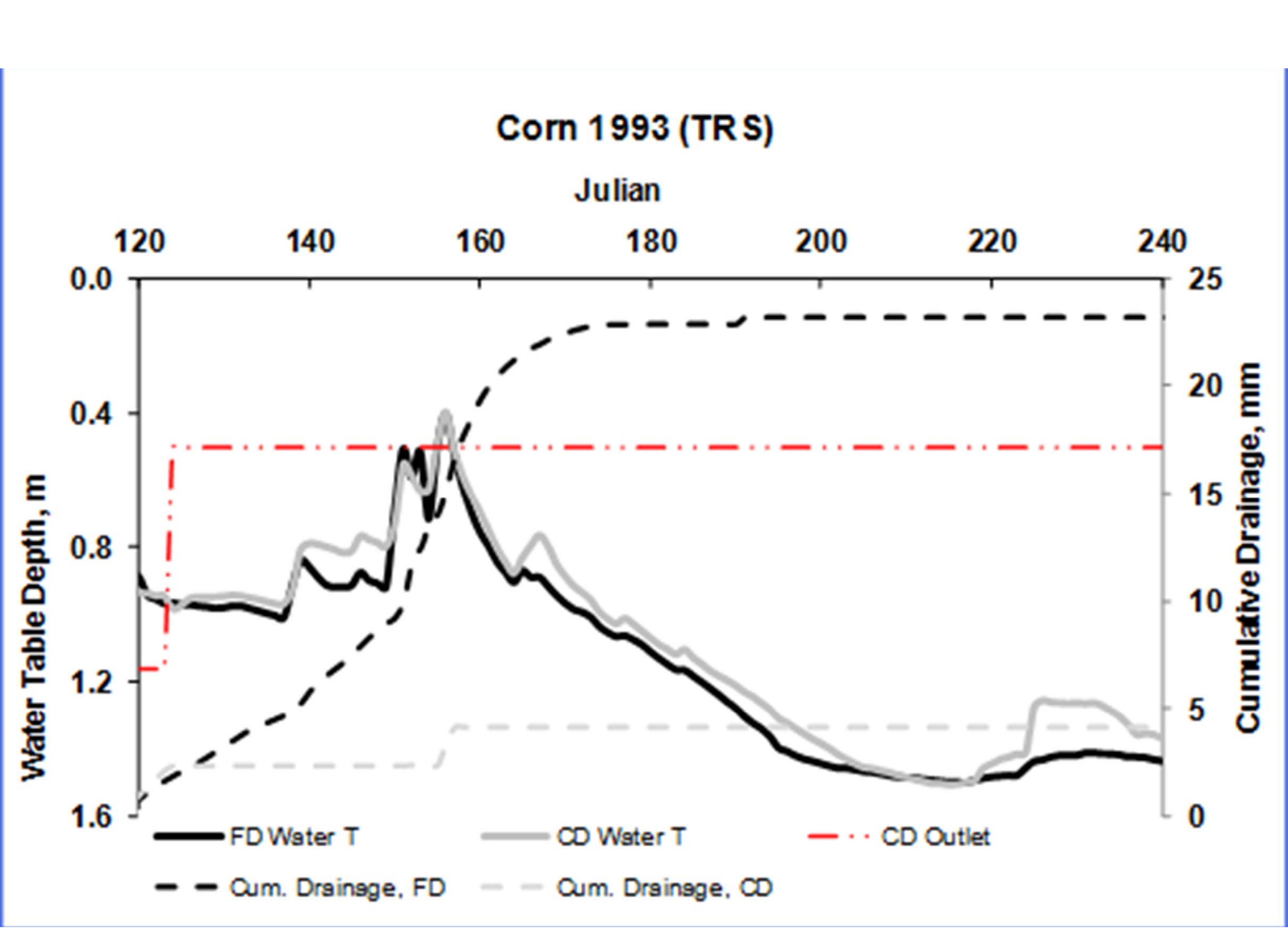
Effect of DWM on Corn Yield (Bu/Ac), Plymouth, North Carolina



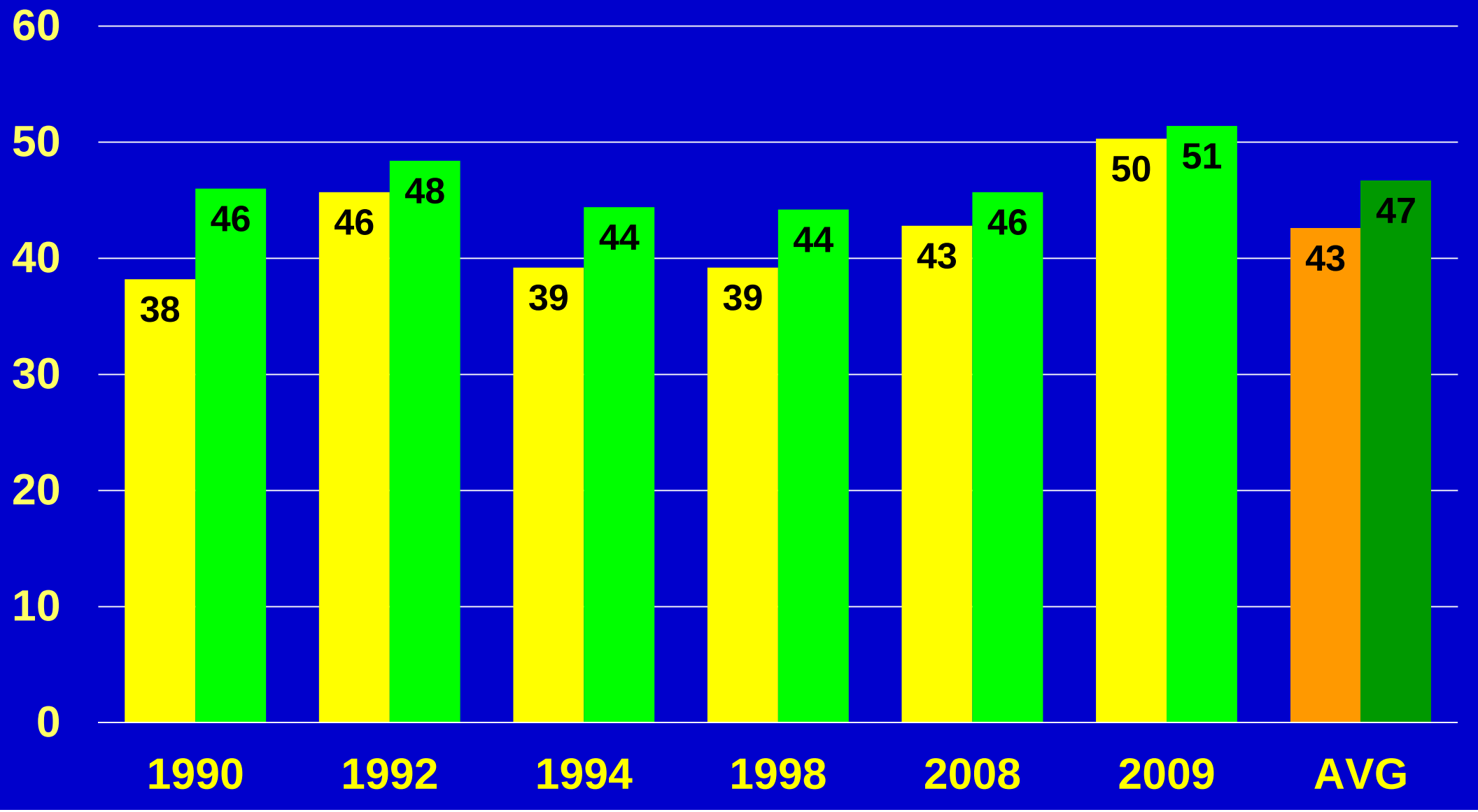

Percent Increase in Corn Yield Due to DWM in North Carolina
25
20
15
10
5
0
6.1
21.1
11.7
4.9
3.9
22.9
6.9
11.1*
Year
1991
1993
2007
2008
2009
2010
2011
Avg

Effect of DWM on Corn Yield (Bu/Ac), Plymouth, North Carolina

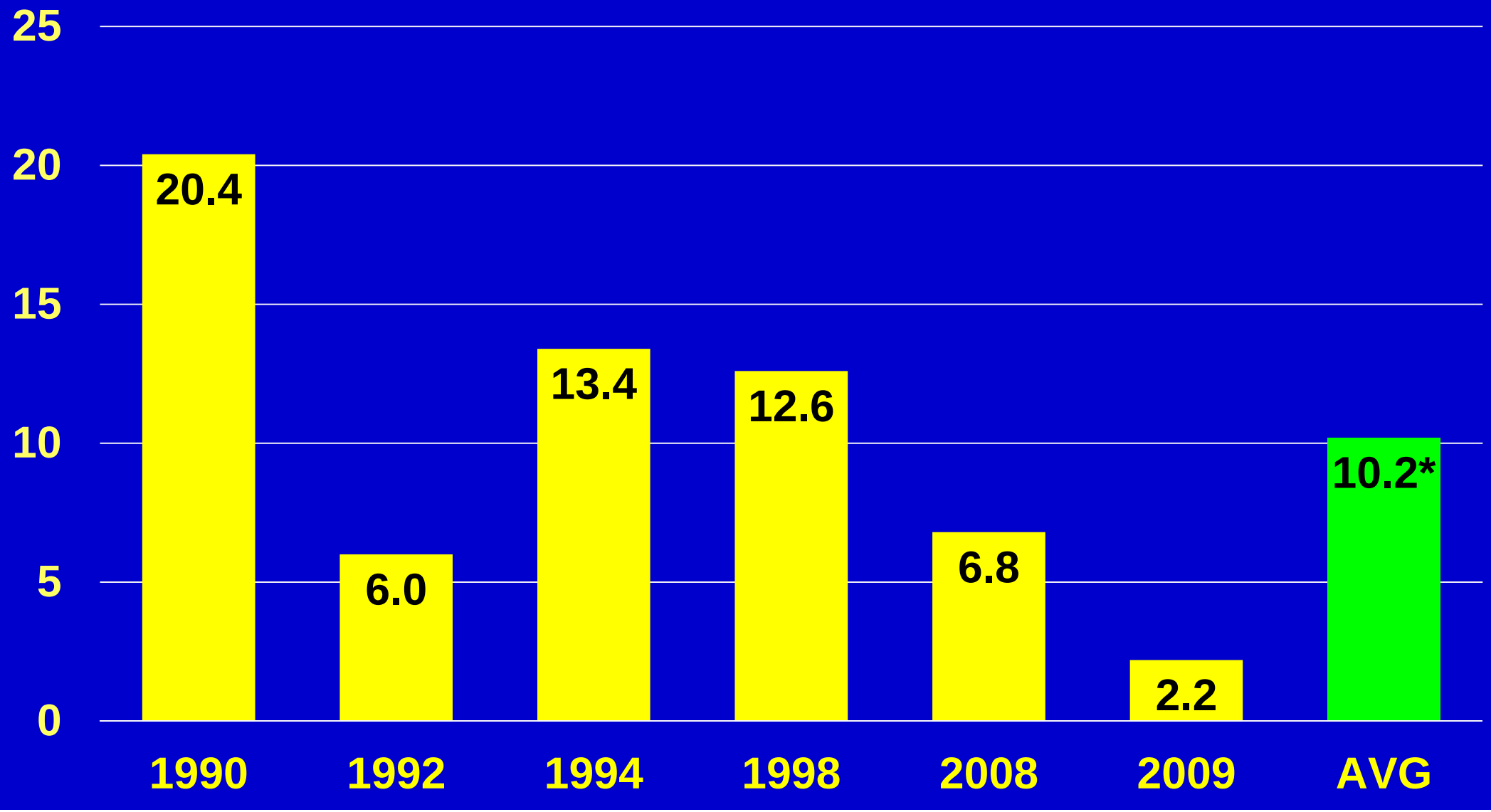



Corn 1993 (TRS)
Julian
120
140
160
180
200
220
240
0.0
0.4
0.8
1.2
1.6
Water Table Depth, m
25
20
15
10
5
0
Cumulative Drainage, mm
FD Water T
CD Water T
CD Outlet
Cum. Drainage, FD
Cum. Drainage, CD

Effect of DWM on Soybean Yield
Plymouth, North Carolina



Percent Increase in Soybean Yield Due to DWM in North Carolina



Summary: Effects of DWM on Crop Yields, Published in Refereed Journals

Location	Reference	Years	# Sites	Crop	% Increase
Illinois	Cooke & Verma (2012)	2	4	Corn & Soybean	No Effect
Indiana	Delbecq et al. (2012)	5	2	Corn	6 - 10
Iowa	Jaynes et al. (2012)	2	1	Corn	No Effect
		2	1	Soybean	8
	Helmers et al. (2012)	4	1	Corn	-3
		4	1	Soybean	No Effect
N. Carolina	Poole et al. (2013)	6	2	Corn	11
		5	2	Soybean	10
Ohio	Ghane et al. (2012)	1-2	7	Corn	1-17
		1-2	7	Soybean	1-7
Ontario	Drury et al. (2008)	2	1	Corn & Soybean	No Effect
Sweden	Wesstrom et al. (2007)	4	1	Cereals	2-18

Summary: Published Results of Effects of DWM on Nitrogen Losses in Drainage Waters

Location	Reference	Number Sites	Site years	% Reduction N Loss
North Carolina	Gilliam et al., 1979	2	6	50-85
	Evans et al., 1989	3	6	18-56
Ontario	Lalonde et al., 1996	2	4	69-82
	Tan et al., 1998	1	2	19
	Drury et al., 2008	1	4	44
Sweden	Wesstrom et al., 2007	1	4	80
Ohio	Fausey, 2005	1	5	46
Iowa	Jaynes et al., 2012	1	4	46
	Helmers et al., 2012	1	4	21
Indiana	Adenya et al., 2012	2	4	18-23
Illinois	Cooke and Verma, 2012	4	8	51-79
Summary		19	51	43 (18-80)

Effect DWM on Crop Yields and N Losses

Journal of Soil and Water Conservation,
Vol. 67(6): 167-172, Dec., 2012.

Summary: Impacts of DWM

- **DWM Conserves Water and Increases Crop Yields. Amount of increase depends on soils, weather, and drainage system design.**

- **DWM Substantially Reduces N Losses in Drainage Waters. This provides important water quality and environmental benefits.**

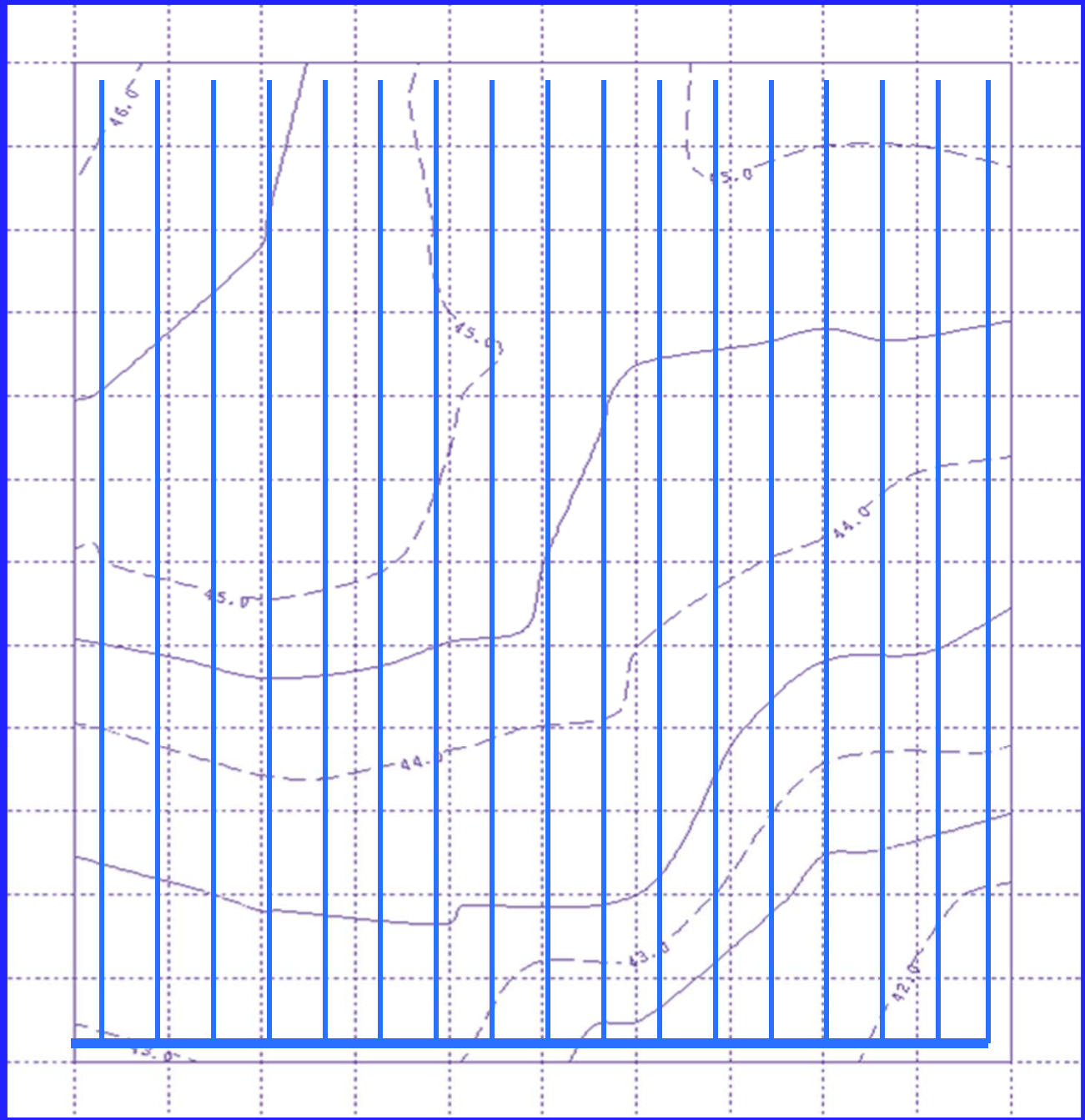
The Time Is NOW!

Needs

- **Drainage Systems on 40-50 Million Acres installed in the 1950s-1970s will be replaced over the next two decades.**
- **Installation of subsurface drainage is at an all time high due to high commodity prices and recognition of importance of drainage to yields.**
- **Conventional drainage systems without DWM will increase total N loads in streams and rivers.**
- **As more intensive drainage systems are installed, the yield benefit for DWM will increase—but only if the systems are designed to accommodate DWM**

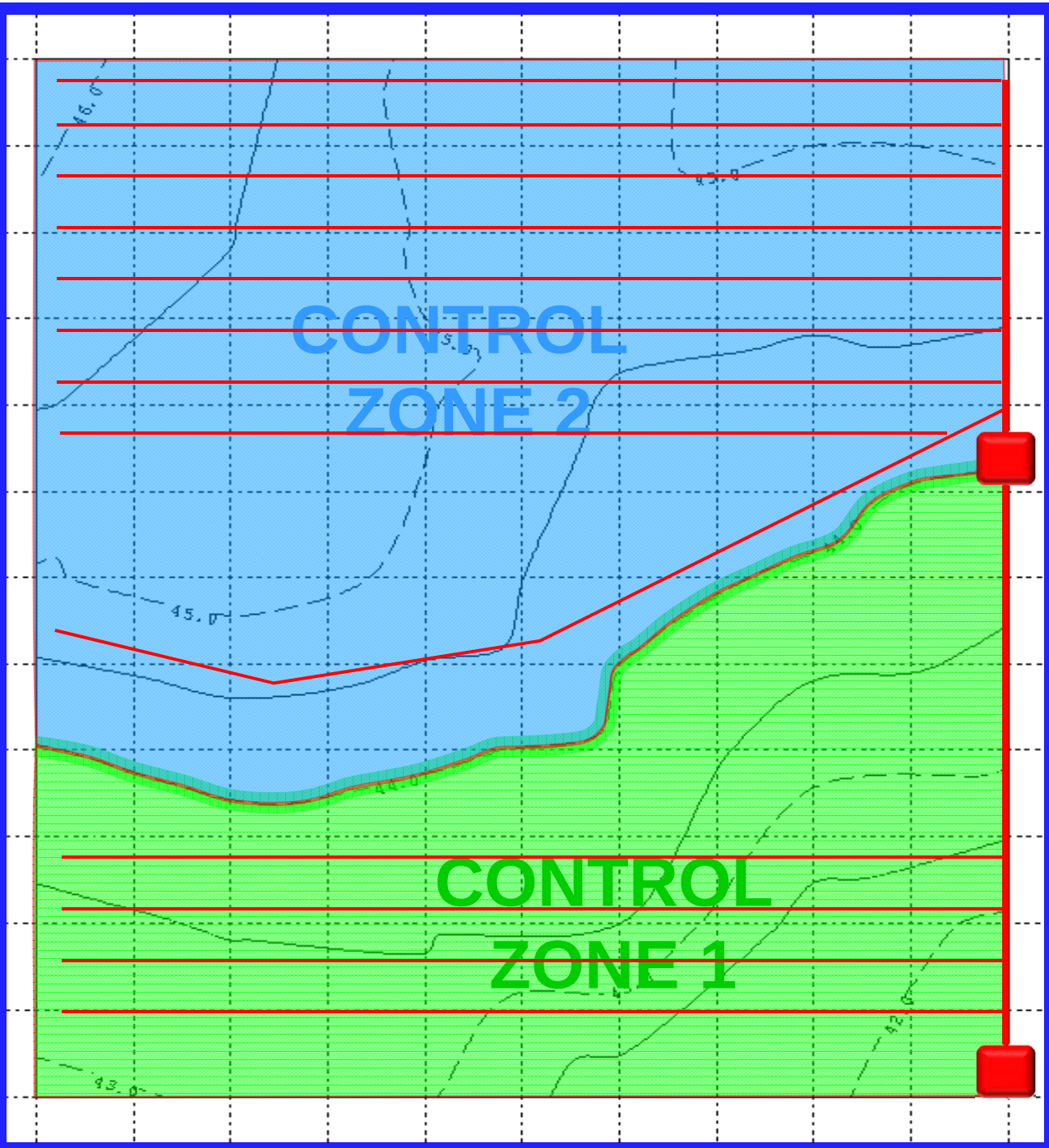
Designing For DWM Zones

(Dr. Gary Sands, UM)



Designing For DWM Zones

(Dr. Gary Sands, UM)



The Time is NOW!

Opportunity

- We know that DWM can be used to conserve water, increase yields, and substantially reduce N loads. More …
- New technology is available and more being developed to automatically and remotely control DWM structures.
- NRCS has made DWM a National Priority.
- USDA programs are in place to assist with the cost of installation and initial operation.
- TSPs are being trained to provide design and management services for DWM.
- Methods have been developed to determine effects of DWM on annual N loads for purposes of N trading or

Conclusions

- DWM conserves water, increases yields, and reduces N loads to surface waters.
- Nutrient trading or other performance based incentive programs are needed to promote the widespread application of DWM.
- The Time is NOW!

END

NC STATE UNIVERSITY
Bio&Ag
ENGINEERING

Golden Rule of Drainage

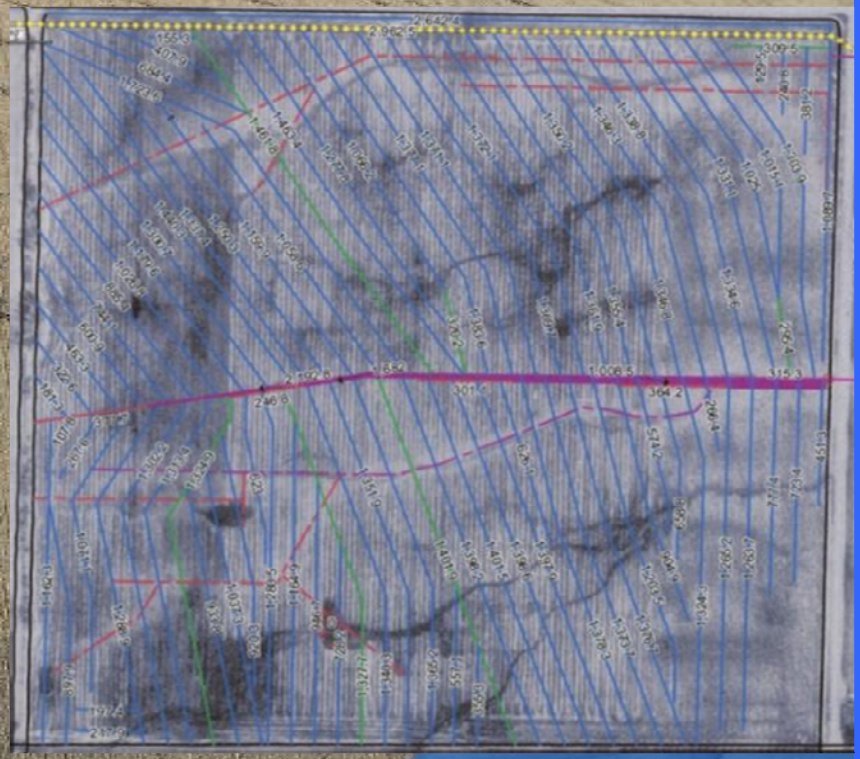
Drain only the amount of water necessary for agricultural production. Drainage in excess of this minimum amount removes water that could be used by the crop and may have detrimental environmental impacts downstream.

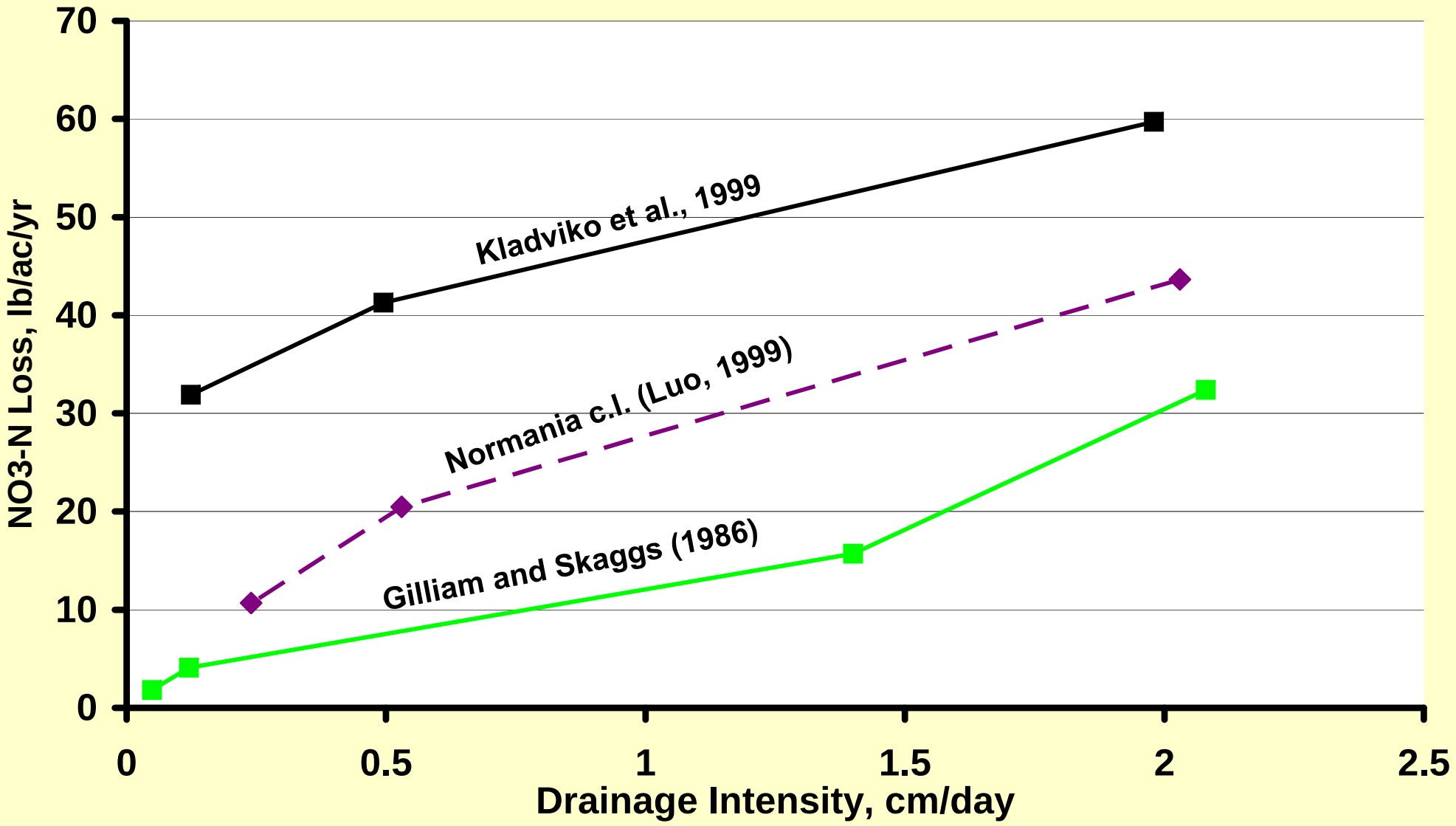
NC STATE UNIVERSITY
Bio&Ag ENGINEERING

- **As more intensive drainage systems are installed, the yield benefit for DWM will increase—but only if the systems are designed to accommodate DWM.**

DWM Designs are the Key

(Dr. Gary Sands, UM)





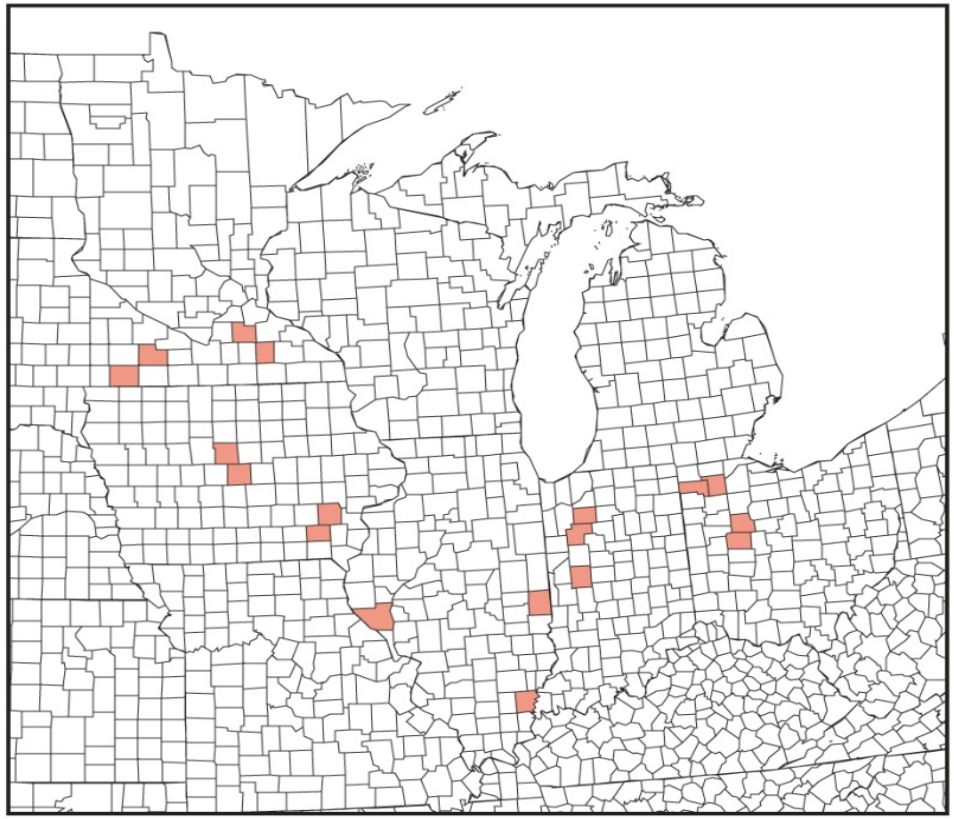
NC STATE UNIVERSITY Bio&Ag ENGINEERING

Reference	Location	Soil	Area (ha)	Drain Spacing (m)	Drain Depth (m)	Control Depth* (m)	Percent Reduction Drainage	N Loss
Gilliam et al. (1979)	N. Carolina	Portsmouth sl	5 to 16	30 & 80	1.2	0.3-0.5	50	50
	N. Carolina	Goldsboro sl	3	30	1	0.3	85	85
Evans et al. (1989)	N. Carolina	Ballahack sl	4	18	1	0.6	56	56
	N. Carolina	Wasda muck	4	100	1.2	0.6	51	56
	N. Carolina	Wasda muck	4	18	1	0.6	17	18
Lalonde et al. (1996)	Ontario	Bainesville sil	0.63	18.3	1	0.75	49	69
						0.5	80	82
Tan et al.(1998)	Ontario	Brookston cl	2.2	9.3	0.65	0.3	20	19
Gaynor et al., 2002	Ontario	Brookston cl	0.1	7.5	0.6	0.3	16**	***
Drury et al., 2008	Ontario	Brookston cl	0.1	7.5	0.6	0.3	29****	31 - 44*****
Wesstrom et al. (2007)	Sweden	Loamy Sand	0.2	10	1	0.2-0.4	80	80
Fausey (2005)	Ohio	Hoytville sic	0.07	6	0.8	0.3	41	46
Jaynes (2011)	Iowa	Kossuth/Ottosen	0.46	36	1.2	0.6	18	21

* Controll typically removed during seedbed preparation, planting, and harvesting periods.
**CD reduced subsurface drainage by 35%, increased surface runoff by 28% & reduced total outflow by 16%
***Nitrogen results not reported, effects of pesticide loss are reported
****CD reduced subsurface drainage by 29%, increased surface runoff by 38% & reduced total outflow by 11%
***** CD reduced N loss by 44% for recommended N application rates and by 31% for elevated N rates

NC STATE UNIVERSITY
Bio&Ag ENGINEERING

Five-State CIG Plot Locations



NC STATE UNIVERSITY
Bio&Ag ENGINEERING

RESULTS (5 State CIG)

- **Drainage Water Management reduced drainage outflow and nitrate loads by an average of 35 %**
- **No significant differences in nitrate concentrations were observed**

(From NRCS Summary of Results of CIG, 2011)

NC STATE UNIVERSITY Bio&Ag ENGINEERING

- **Point 5. Field monitoring and experiments on a wide range of soils and climates have shown that DWM reduces N losses to surface waters**
- **Most results in range of 18 to 60% reduction**
- **Some results show reduction >80% (Beware!)**

NC STATE UNIVERSITY
Bio&Ag
ENGINEERING

Potential Effect of DWM in the Midwest on N Load to Gulf of Mexico

- **83,000 metric ton N per Year**
- Based on 4.8 million ha of drained corn land suitable for DWM in Midwest (Jaynes et al., 2010)

NC STATE UNIVERSITY
Bio&Ag ENGINEERING

RESULTS – Yields (5 State CIG)

- Crop yields (corn and soybean) were increased by a maximum of 20 percent, and decreased by as much as 12 percent
- 60 percent of annual comparisons had increased yields, and 40 percent had decreased yields
- Five-State average yield increase = 1.3 percent

(From NRCS Summary of results of CIG, 2011)

NC STATE UNIVERSITY Bio&Ag ENGINEERING

- **Point 6. Effects of DWM on crop yield and on N losses to surface waters depends on Drainage Intensity, Soils, and Climate.**
- **Point 7. DWM as normally practiced is NOT an irrigation system. It will not provide drought protection in dry years.**
- **Point 8. DWM will conserve water and increase yields, but, in most cases, its impact on yields will not provide sufficient incentive to promote its sustained application.**

NC STATE UNIVERSITY
Bio&Ag ENGINEERING

STATUS CONTROLLED DRAINAGE IN N.C. (~1996)

Total Acreage in Controlled Drainage

Ag. Lands	420,000
Forest Lands	200,000

Reduced N Outflows >4,000,000 lbs/year

STATUS CONTROLLED DRAINAGE IN N.C. (2011)

Moderately Well Managed	150,000 Ac
Poorly or Weakly Managed	150,000 Ac

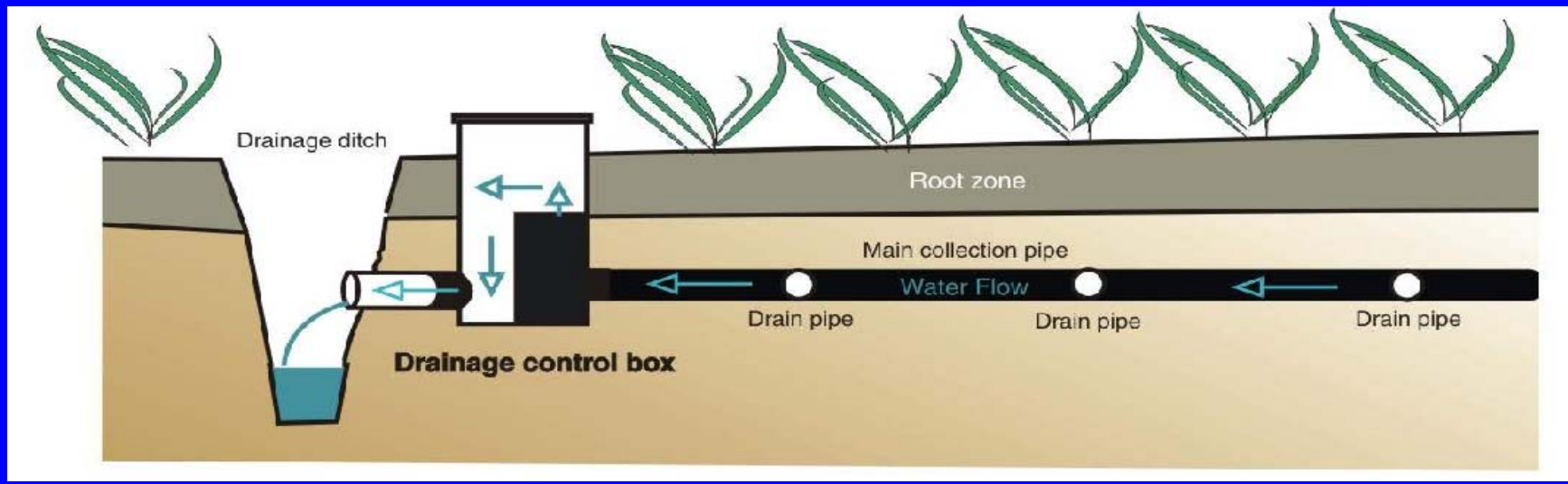
Reduced N Outflows >2,000,000 lbs/year

NC STATE UNIVERSITY Bio&Ag ENGINEERING

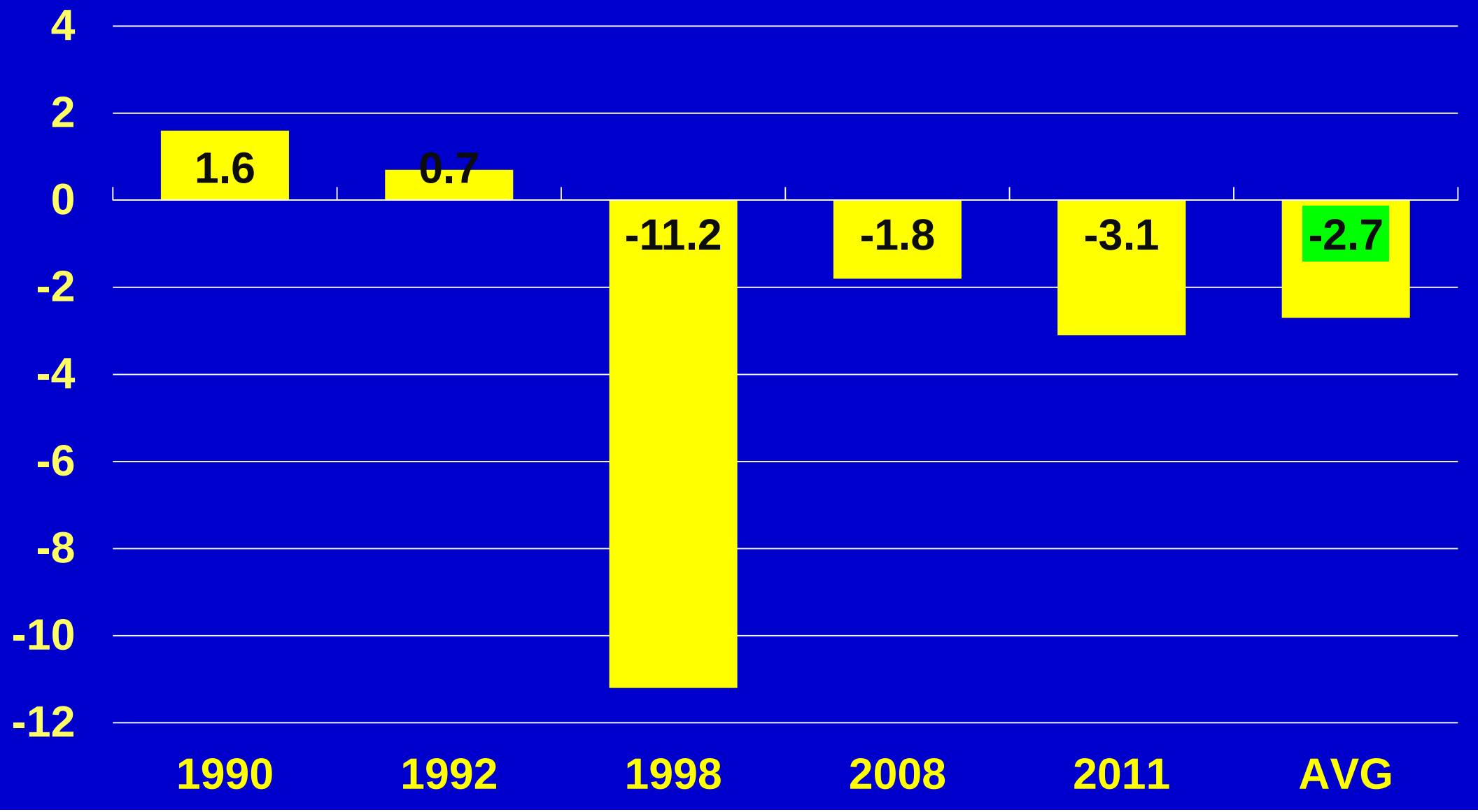
NC STATE UNIVERSITY
&Ag
INEERING

Journal of Soil and Water Conservation, Vol. 30(6), Dec.,2012

Drainage Water Management (DWM) can be used to reduce drainage during periods it is not needed



Percent Increase in Wheat Yield Due to DWM in North Carolina



Drainage and Water Conservation

- Drained lands frequently have yield losses due to drought conditions (too little water).
- The same drainage intensity is not needed all of the time.
- Excessive drainage, or drainage during periods when it is not needed increases nitrogen losses to in drainage water and causes water quality problems downstream.

NC STATE UNIVERSITY
Bio&Ag ENGINEERING