

UNIVERSITY OF FLORIDA

Institute of Food and Agricultural Sciences

Reclaimed Water—A Sustainable Source for Florida's Growing Water Demands



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Water

- A major issue in Florida
- Extremely variable rainfall
- Range in central Florida = 32 to 76 inches
 - Floods followed by droughts
- Rapid population growth
 - Increasing demand on limited supplies
- Need for new water resources

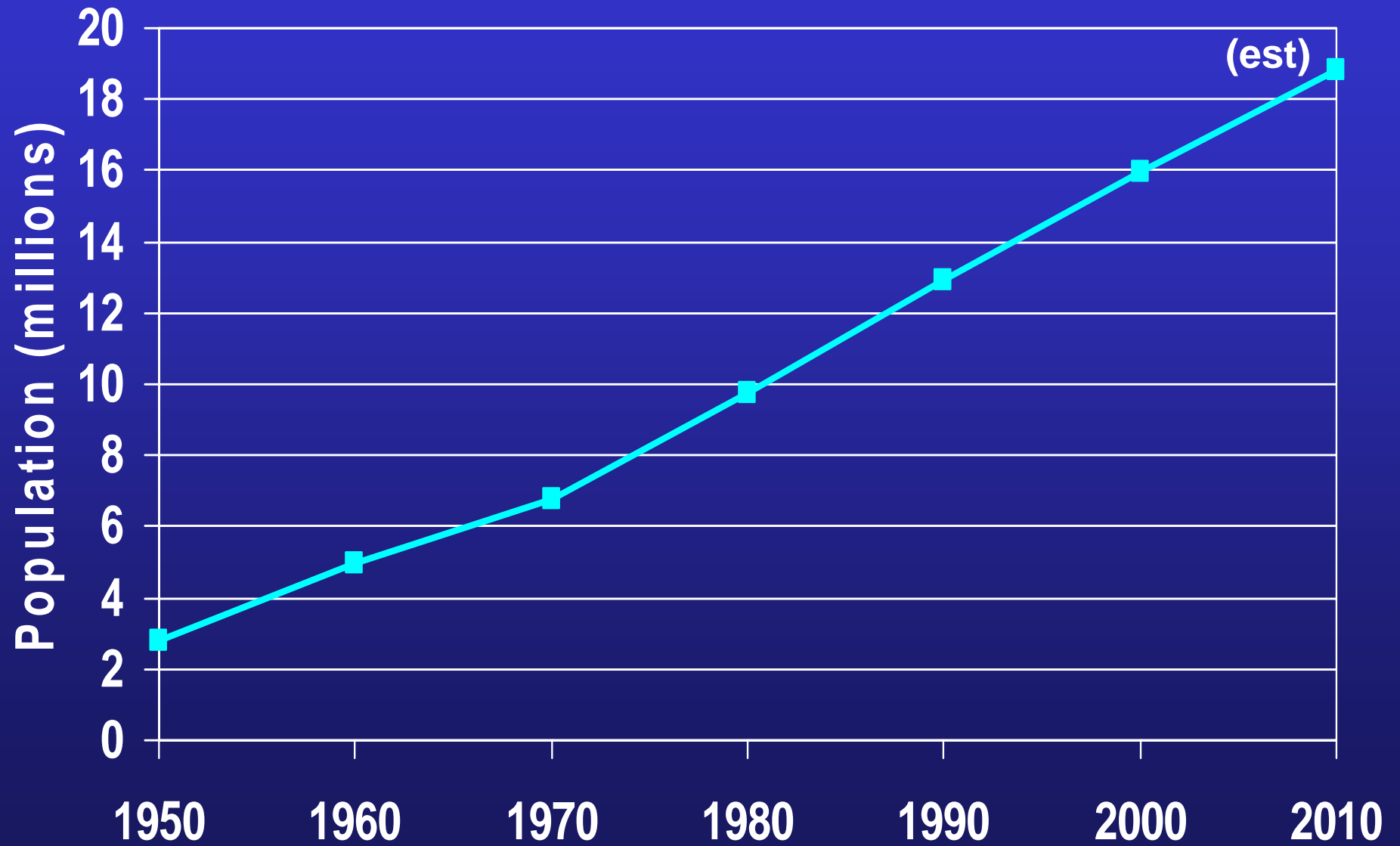
Water in Florida

- **Need for new water resources**
 - **Conservation**
 - **Reclaimed water**
 - **Desalination**
 - **Aquifer storage and recovery**
 - **Reservoirs**

Reclaimed Water ~ Why in Florida?

- **Rapid population growth ~ 17+ million in 2007**
- **4th largest state in population**
- **80% of population is within 20 miles of the coast**
- **Groundwater pumping near coast can lead to saltwater intrusion**

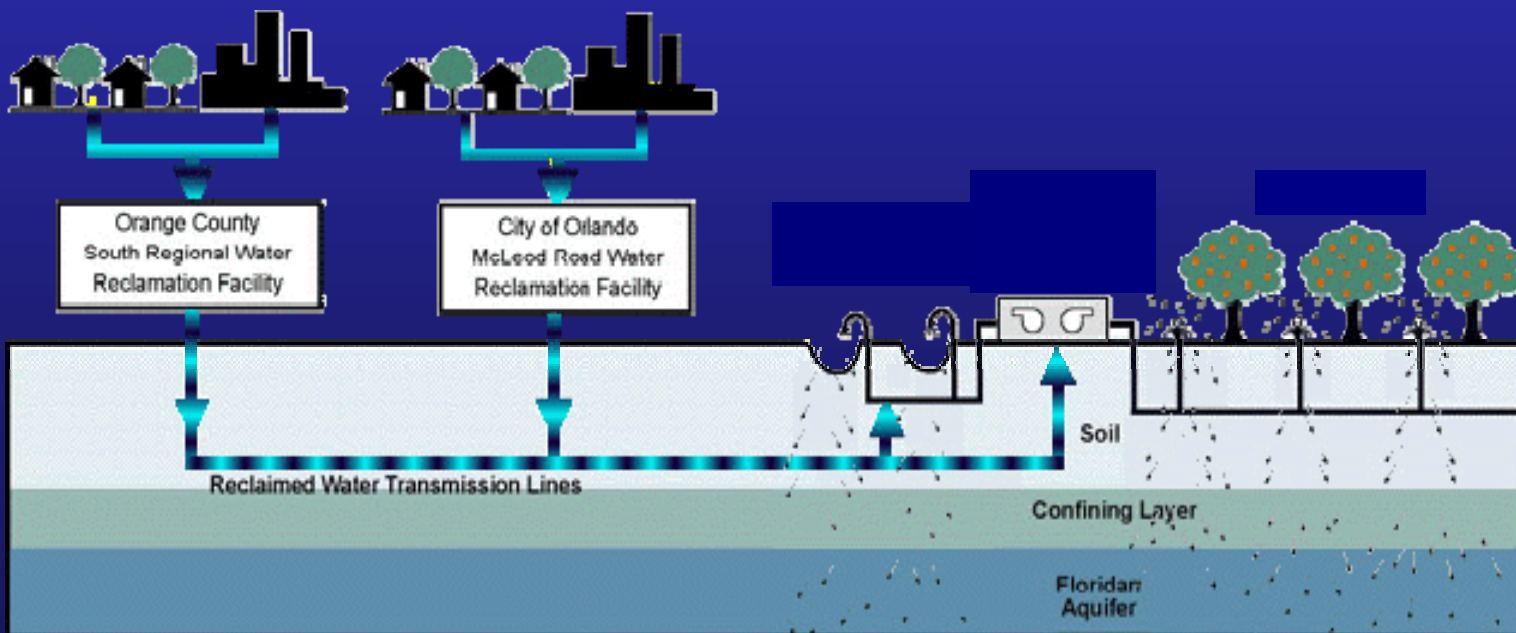
Florida Population





Wastewater

- Considered to be a disposal problem in 1980s
- Cities want to get rid of it on a regular basis
- With proper treatment, it can be a source of reclaimed water for crop irrigation



Reclaimed Water

- **A disposal problem?**
- **A potential resource?**

Reclaimed Water

- **Highly treated wastewater**
- **Can act as a good source of water for irrigation and other purposes**
- **Has been known about for many years**
- **Became more widely used in Florida in the 1980's and 1990's**
- **Florida is now one of the largest users of reclaimed water in the U.S.**

Reclaimed Water ~ Why in Florida?

- Florida's annual rainfall = 50+ inches
- Sandy soils – poor water holding capacity
- Summer rainy season, dry winter and spring
- Rain does not always come when you want it ~ Periodic droughts & forest fires

Groundwater Withdrawals – 1950-2000

- **Domestic – increased 15.5 times**
- **Irrigation – increased 20.7 times**

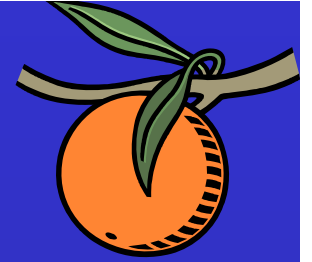
Wastewater Generation by Cities – 1950-2000

- **Increased 5 times**

Reclaimed Water ~ History

- **Disposal = Main goal in 1980's and early 90's**
- **Offered at no cost to growers to encourage use**
- **Gradual acceptance and increased usage in 1990's**
- **Drought in 2000 and 2001 created greater demand and wider acceptance**

Reclaimed Water



- Edible crops & golf courses ~ secondary effluent treatment, filtration, and high level disinfection (chlorination) required
- Edible crops irrigated with RW must be “cooked, peeled, or thermally processed”
- Salad crops (e.g. lettuce) that are eaten raw must use indirect (i.e. drip) irrigation—no direct contact of reclaimed water with crop



Reclaimed Water ~ History

- Use in Florida has increased greatly in past 20 years
- Several large projects started in Florida in the 1980's
 - Orlando Area - Water Conserv II – citrus, golf courses, residential
 - Tallahassee – field crops
 - St. Petersburg - residential





Perceived Concerns About Reclaimed Water

- Disease
- Virus
- Heavy Metals
- Food Safety
- Psychological Issues



Initial Concerns

- **Growers initially refused to accept the reclaimed water because of concerns over:**
 - **Disease**
 - **Flooding**
 - **Heavy Metals**
- **Image – the “Yuck” factor**
- **Quality standards established for RW**
- **Research started by University of Florida**



- **Set up to dispose of wastewater from Orlando and Orange County**
- **Provides high quality reclaimed water for crop irrigation**
- **Meets or exceeds drinking water standards for at least 10 elements**
- **Largest project in US for disposal of reclaimed water through agricultural irrigation and RIBs**

Conserv II water is chlorinated and has no color or odor. It meets or exceeds drinking water standards for the following elements:

Nitrate
Sodium
Chloride
Sulfate
Copper

Barium
Chromium
Selenium
Silver
Zinc



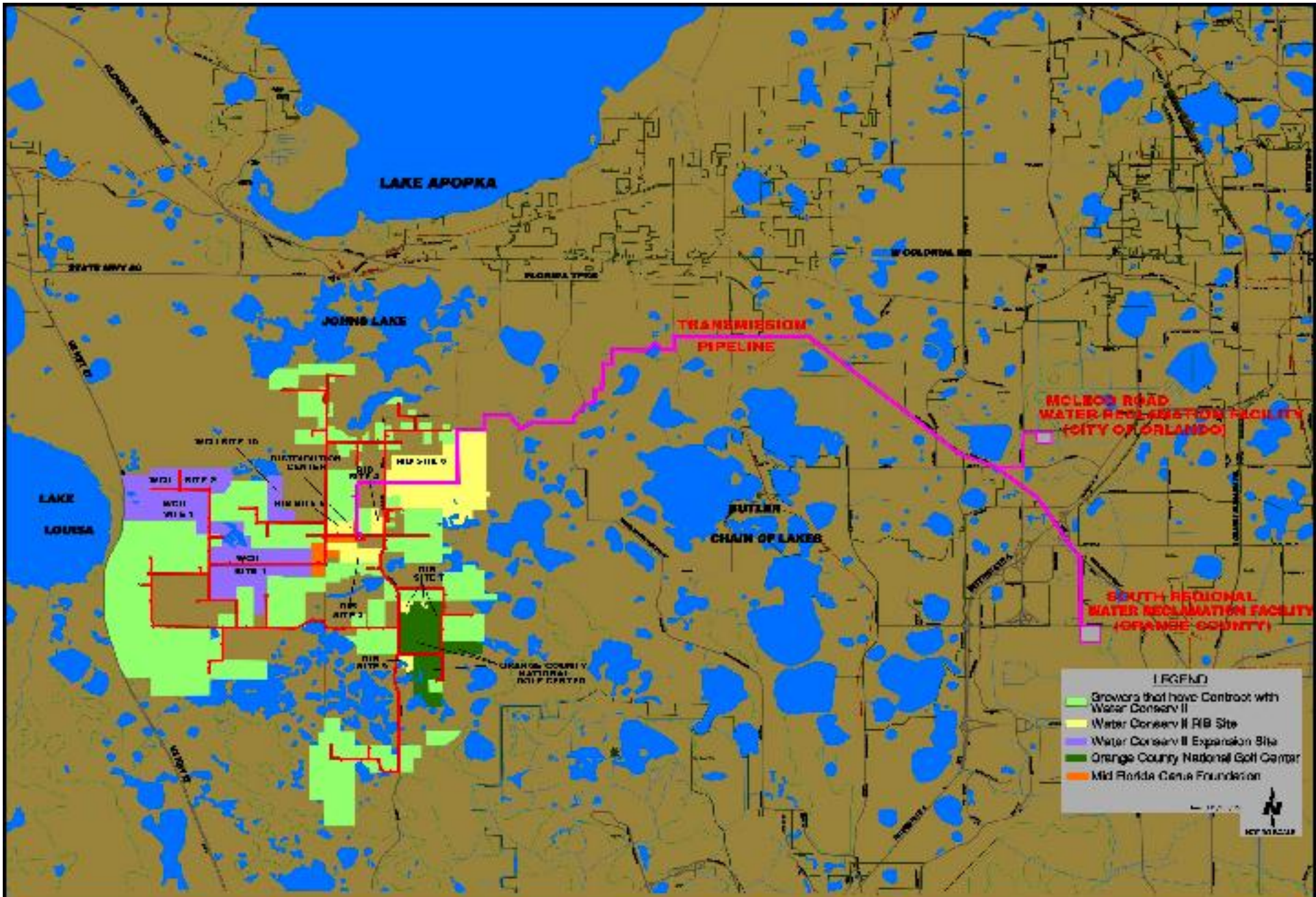
- **Delivers ~ 31 million gallons / day (mgd)
(113,500 m³ / day)**
- **Irrigates 3200 acres of agricultural crops-
primarily citrus**
- **Orange County National Golf Center - 54 holes**
- **12 nurseries and tree farms, two landfills**
- **100 acres of willows - Disney Animal Kingdom
browse farm**
- **Water comes initially from International Drive
tourist area, hotels, restaurants**











LEGEND

- Growers that have Contract with Water Conserv II
- Water Conserv II RIB Site
- Water Conserv II Expansion Site
- Orange County National Golf Center
- Mid Florida Canal Foundation

Scale: 1" = 1/2 Mile

North Arrow



**Water
Conserv II**
DISTRIBUTION CENTER
17498 McKinney Road

OPERATED BY
WOODARD & CURRAN, INC.





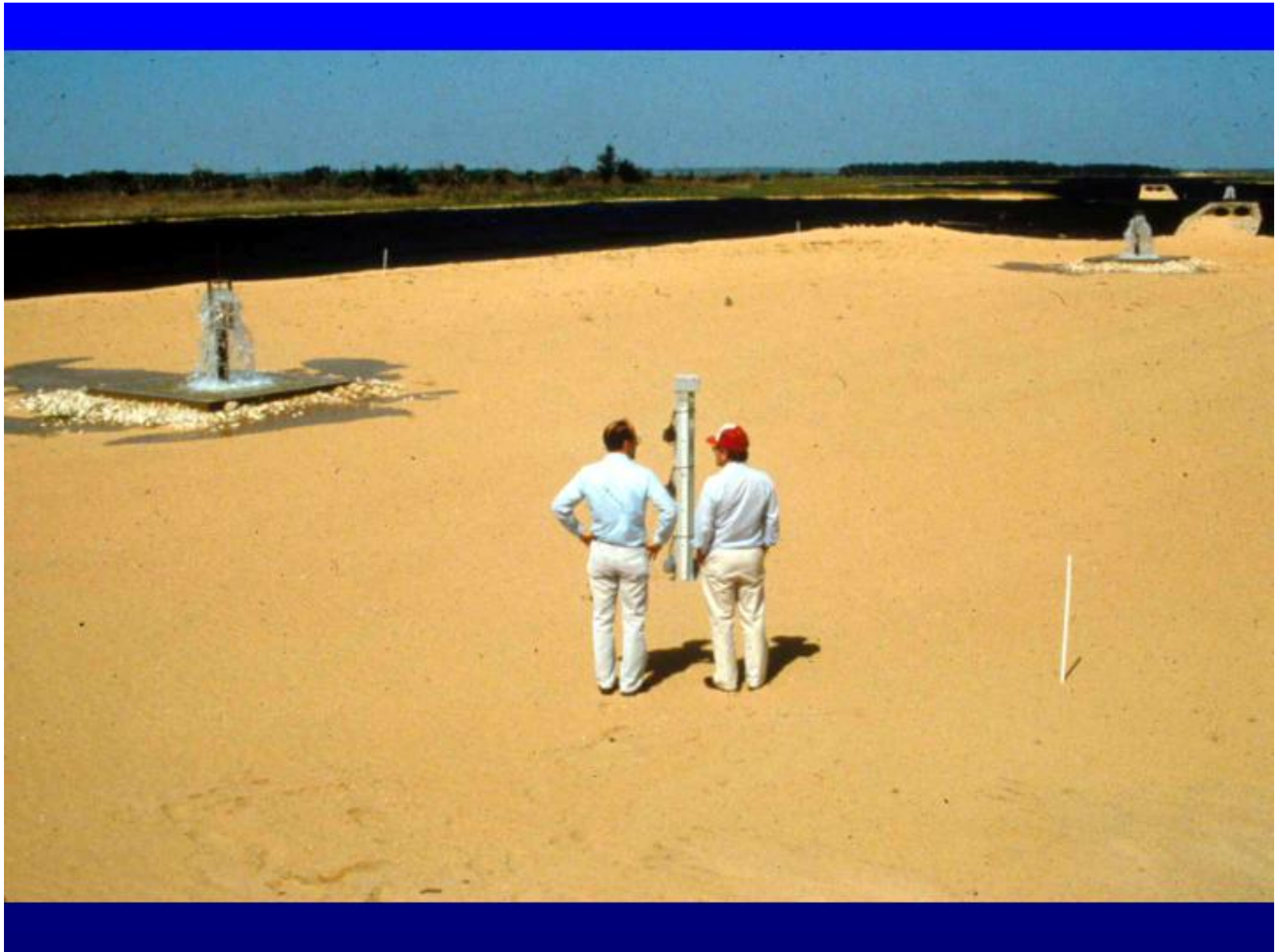






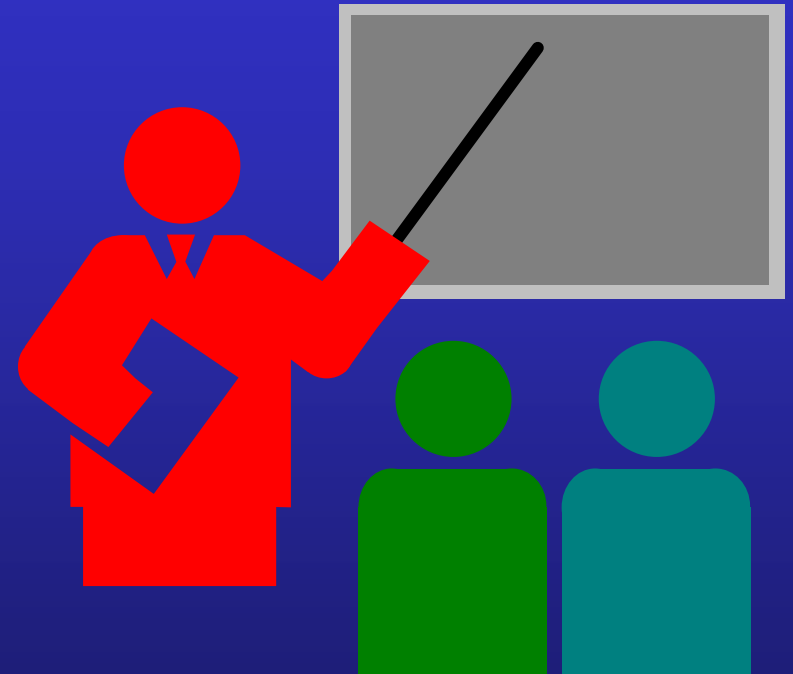






Research Results at Conserv II

- Trees grew best at highest irrigation rate
- No flooding damage (surprise)
- Disease problems (*Phytophthora*) = minor
- Fruit Yield: Best with highest irrigation rate



Advantages of Reclaimed Water

- City disposes of wastewater
- Fewer irrigation restrictions on growers
- Less agricultural pumping -
more aquifer recharge
- Citrus freeze protection
- Reliable source of irrigation water
- Cost savings to growers -
pumping and some fertilizer



Objectives

- Describe trends in reclaimed water usage in Florida
- Discuss changes in different sector use of reclaimed water



Florida Reuse Inventory

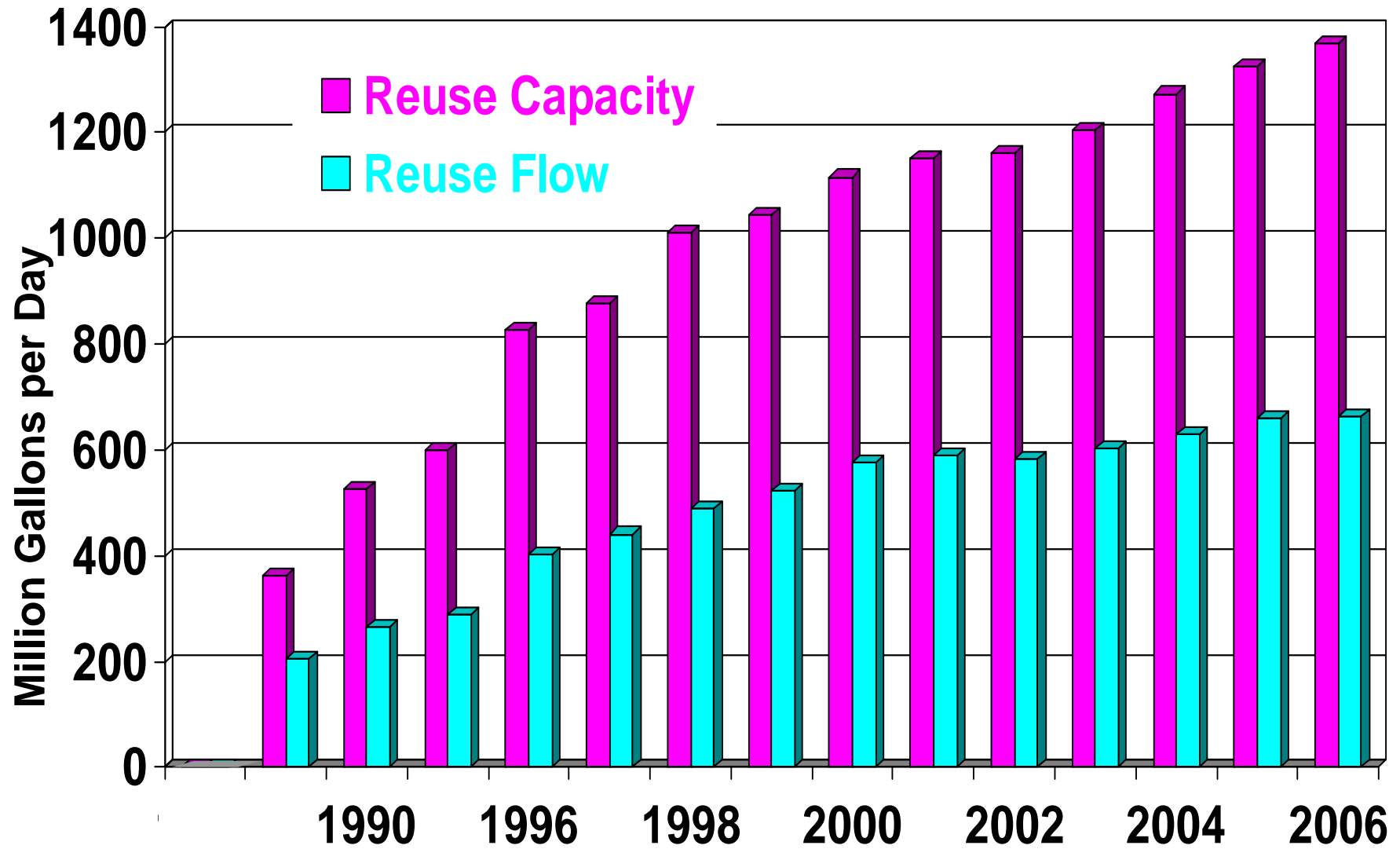


Fig. 1.

Change in reuse capacity and flow

Reclaimed Water

- Reuse capacity – Increased 277% (1986-2006)
- Reuse flow – Increased 221% (1986-2006)



Major Users of Reclaimed Water

- **Agriculture**
- **Golf courses**
- **Residential**
- **Other public access**
- **Ground water recharge**
- **Industrial**

Florida Reclaimed Water Use - Acres

◆ Golf Course

■ Residential

▲ Agriculture

■ Other Public Access

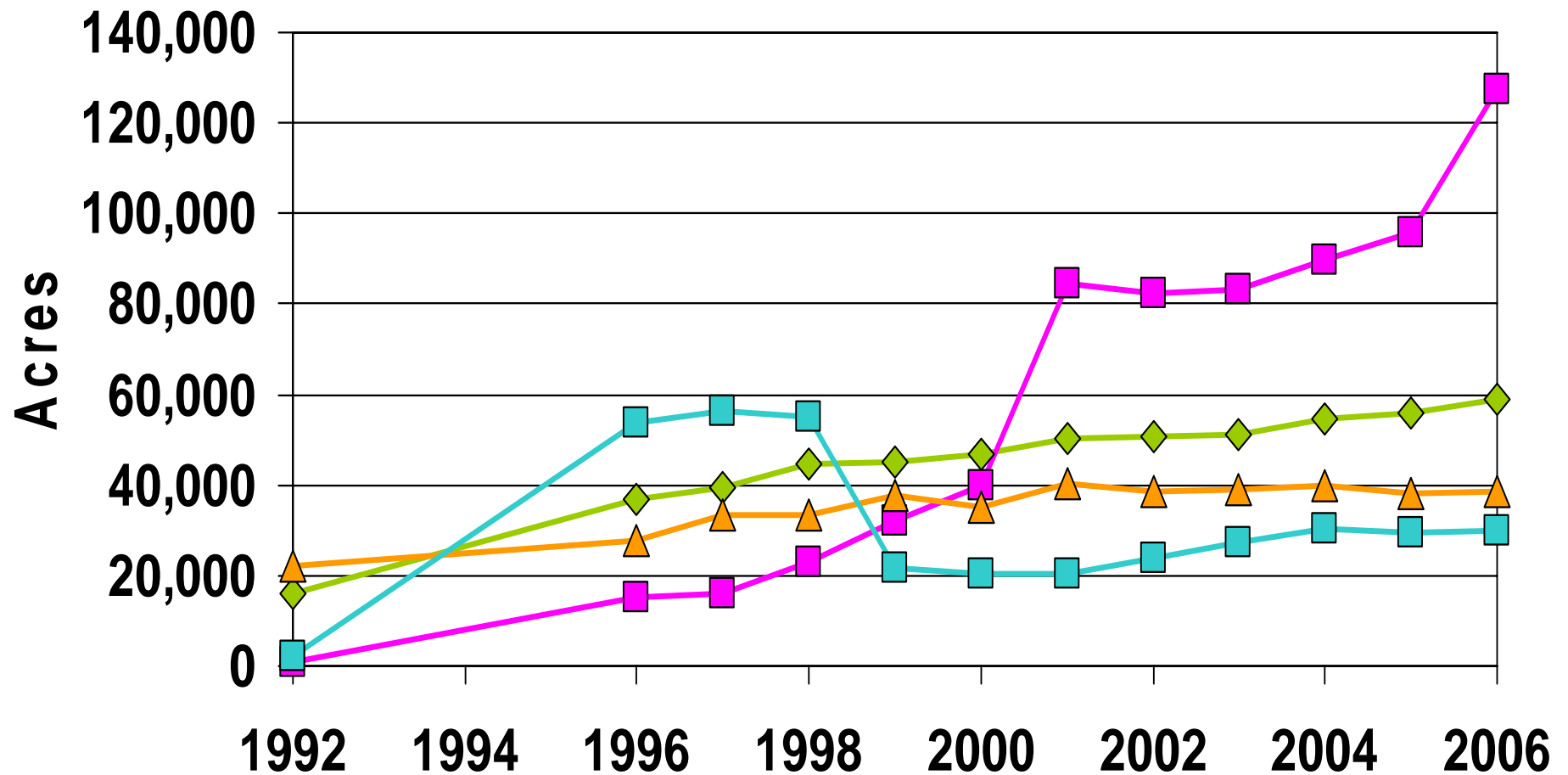


Fig. 3.

Florida Reclaimed Water Use - Flow

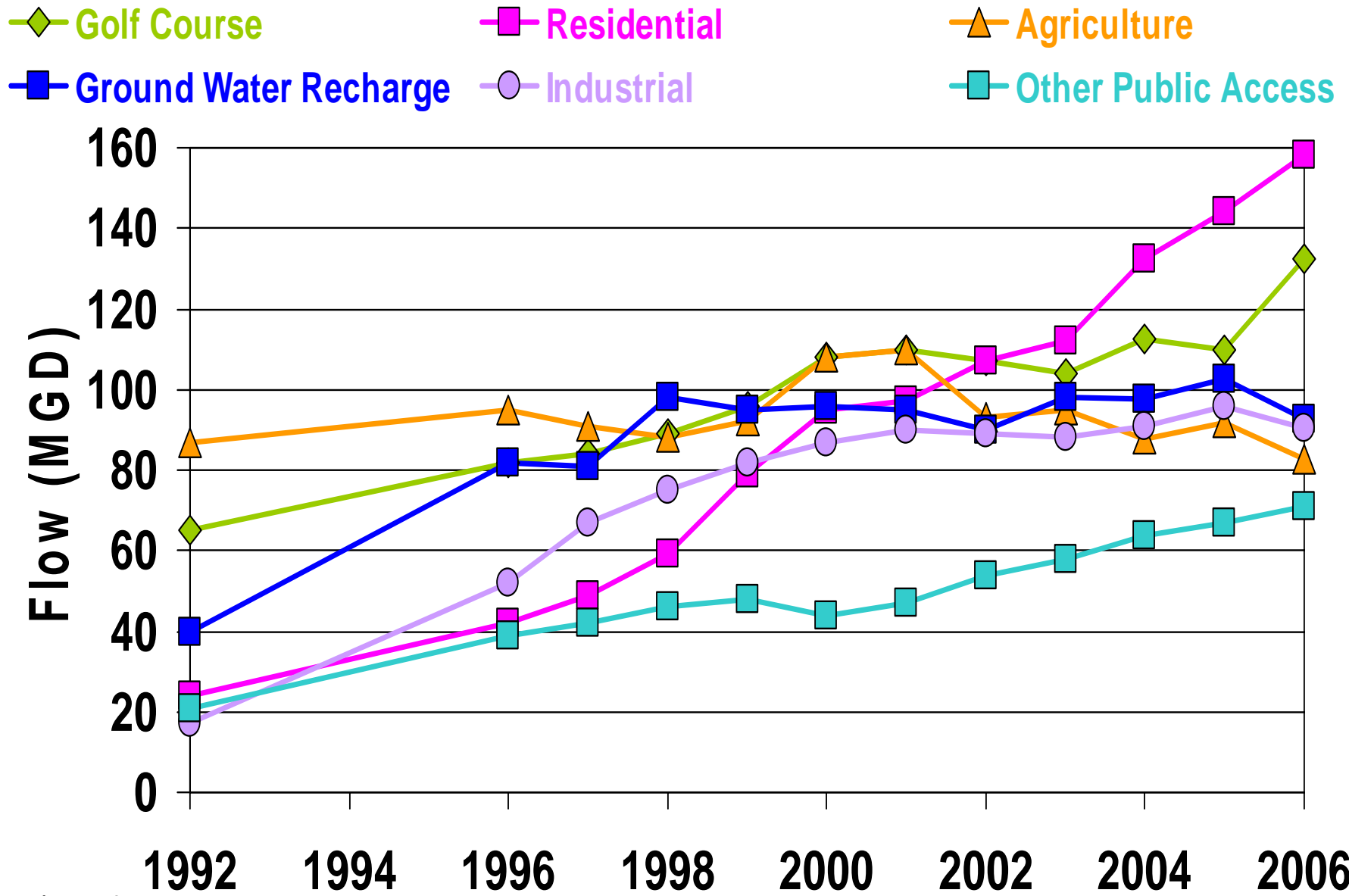


Fig. 4.

Florida Reclaimed Water Irrigation - Acres

◆ Edible Crops ■ Other Crops ▲ Agriculture Irrigation

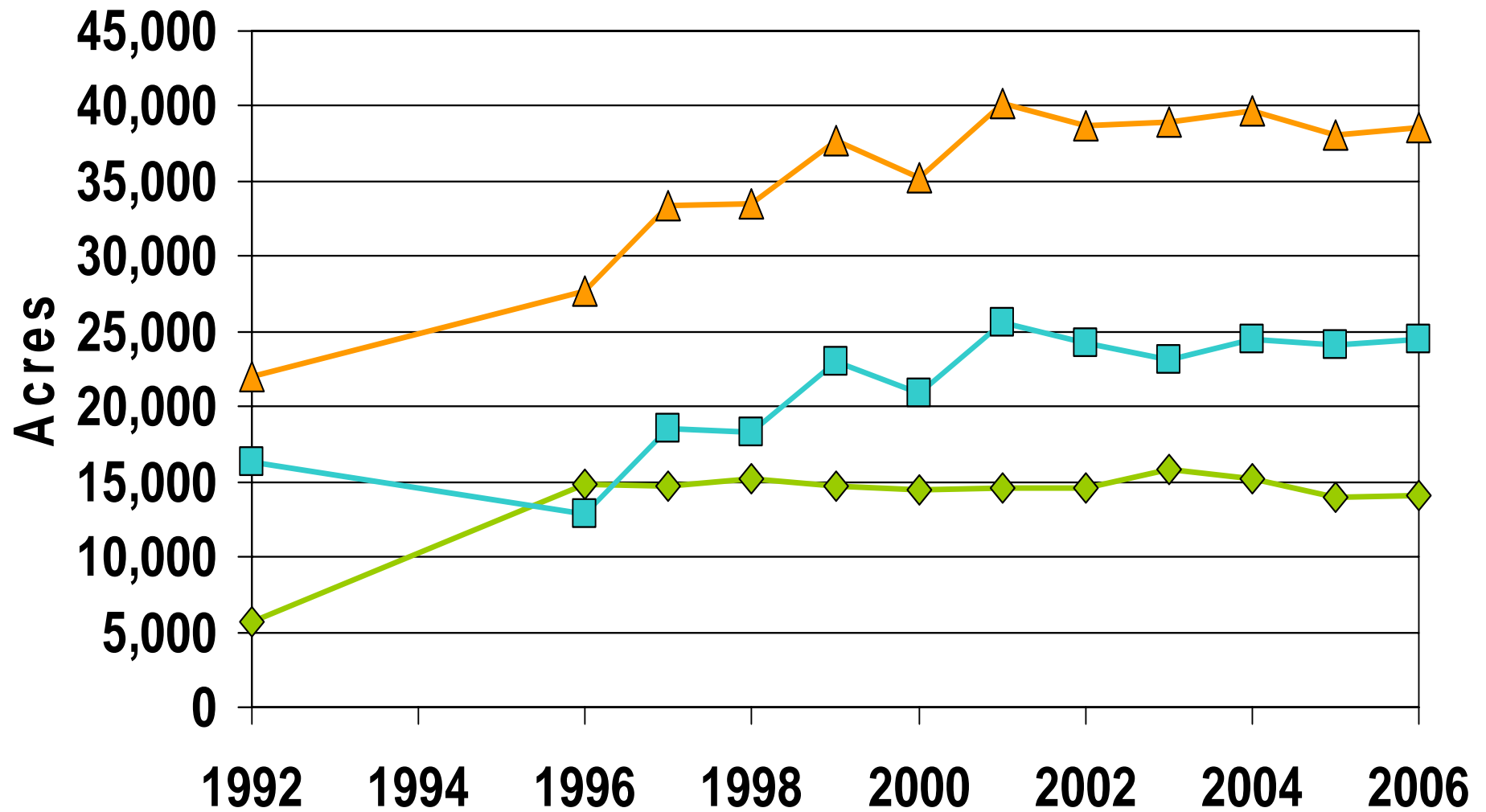
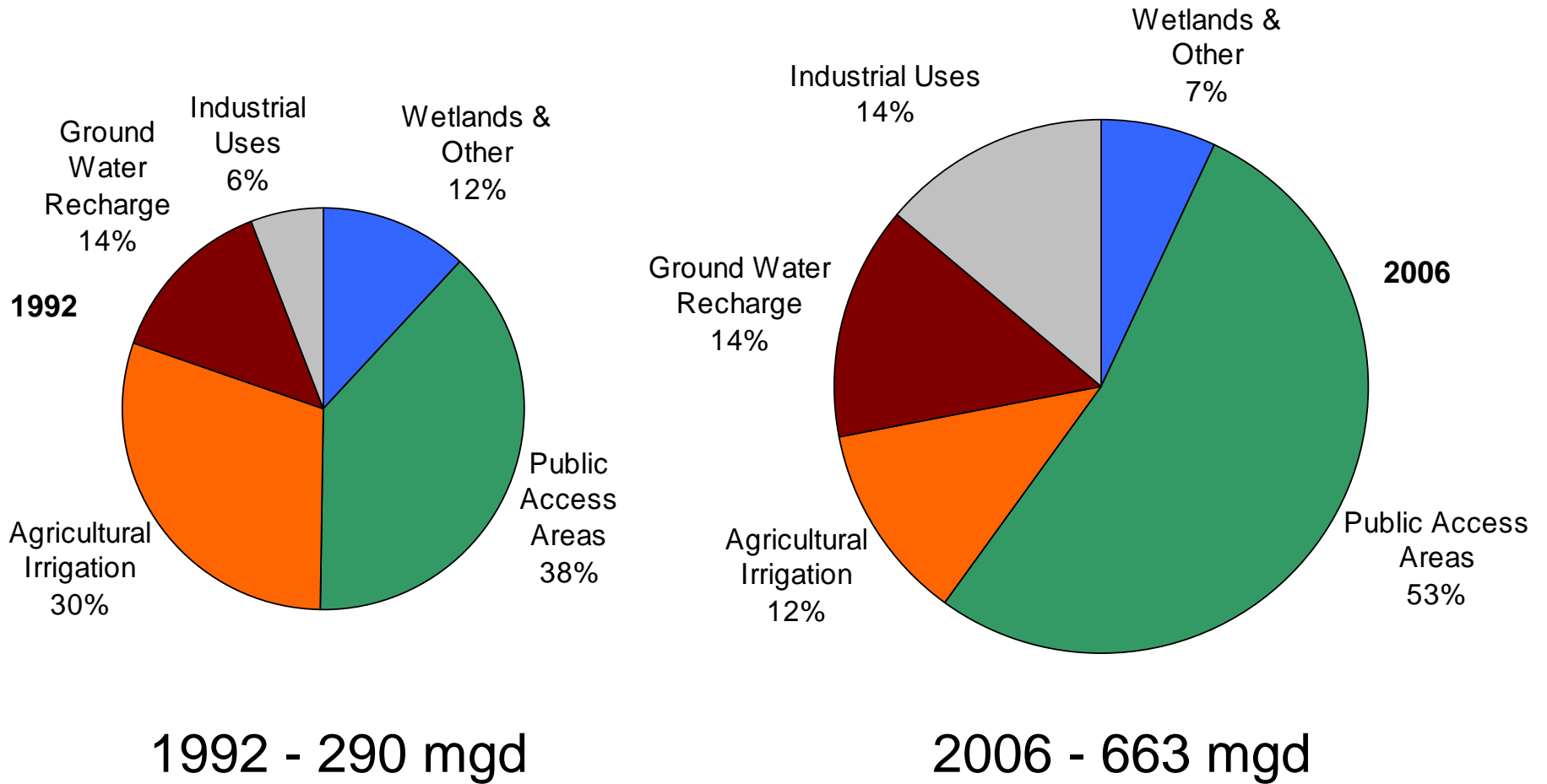


Fig. 2. **Change in agricultural reuse capacity and flow**

Agricultural Irrigation

- Agriculture was the largest user of RW in 1992, and was still a large user in 2006
- Agricultural use
 - Area increased 76% to 38,535 acres in 2006
- From 1996 to 2006, acreage of edible crops irrigated with RW remained relatively constant around 15,000 acres
- Ag irrigation flow dropped below most other users in 2004
- Competition from other users

Reclaimed Water 1992-2006



Reclaimed Water in Florida 1992-2006

	% Change	
	Flow (MGD)	Area (Acres)
Total Public Access	221	1026
Golf Course	90	263
Residential	560	12635
Other Public Access	238	1402
Agricultural Irrigation	-5	76
Edible Crops	-26	149
Other Crops	-0-	50
Ground Water Recharge	132	189
Industrial	432	n/a

Other Uses

- **Golf course irrigation**
 - Next largest user of RW in 1992
 - Flow increased 90% to 123 mgd
 - Acreage increased 263% to 58,899 acres
- **Other users**
 - Residential flow increased 560% to 158 mgd
 - Industrial flow increased 432% to 90 mgd
 - Ground water recharge increased 132% to 93 mgd



- **Major increase in residential land irrigation of over 10,000% to 127,352 acres = impressive**
- **Public has come to accept reclaimed water as an alternate irrigation source**



Attitudes towards Reclaimed Water

- **Early 1980's ~ RW = *Disposal Problem***
 - Use lowest cost method for disposal (dump into nearby river, lake, ocean, or spray field)
 - Concerns over heavy metals, salts, odor, disease organisms
 - Given away for free to encourage use
- **Safe use was demonstrated -- agricultural and urban acceptance increased**
- **Droughts in 2000, 2001, & 2007 created greater acceptance**

- **Some early Conserv II contracts expired in 2006**
- **Safety of reclaimed water in Florida has now been established**
- **Reclaimed water now accepted by most Floridians**
- **Other entities are willing to pay for reclaimed water**

- **Other interests - started competing with agriculture for use of this water**
- **Cities are now consider charging agriculture for this water**
- **Growers = unhappy about paying for a product which had been free**
- **Balancing act:**
 - **Supply and Demand**
 - **Disposal vs. beneficial use**

- **Economic and political forces will determine how reclaimed water will be distributed**
- **Reclaimed water still has to be disposed of in rainy periods, but shortages have developed during droughts**
- **Agriculture may have to pay for reclaimed water, use less water, or develop other water sources**

Reclaimed Water

- For reclaimed water to continue to be successfully used, quality must be maintained
- Particular elements to watch
 - Sodium
 - Chloride
 - Boron

Summary

- In less than 20 years, reclaimed water has changed from an urban disposal problem to a commodity of some value
- Flow to residential, golf course, ground water recharge & industrial users surpassed agriculture in 2004
- Florida agriculture, which used to benefit from free reclaimed water, may not be willing to pay for this water



- Agriculture initially will be charged \$0.11 per 1000 gallons (~ \$3.00/acre inch) at Conserv II
- Price will rise to \$0.19 per 1000 gallons (~ \$5.16/acre inch)
- Growers have to decide if it is more cost effective to pay for RW or reactivate old wells
- Fuel pumping costs





Challenges to Reclaimed Water Use for Irrigation

- “Yuck” factor – choice of words is critical – “Toilet to Tap”
- Retrofit cities with a second set of pipes -- Cost
- Psychological – perceived health risk, but no adverse health effects seen



Reclaimed Water

- Is currently used in Florida for irrigation, groundwater recharge, industrial, wetlands, and other uses
- RW = intended for irrigation, but it meets most drinking water standards. Highly tested water
- Will RW be used for drinking water?
 - Depends on population growth and development of other water supplies
 - California example-indirect potable reuse

Summary

- Image of reclaimed water has changed greatly in 20 years
- Used to be disposal problem
- Now a product in demand
- Florida agriculture helped reclaimed water gain acceptance
- Now agriculture may have to pay for reclaimed water





- **Is Reclaimed Water the Wave of the Future in Florida?**
- **Answer is YES**





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The Old Story



Irrigation Water Standards

- Bacteriological Indicators - fecal coliform
- Reclaimed water has tougher standards for fecal coliform than irrigation water
 - RW = <2.2 per 100 ml
 - Class III surface water = 200 per 100 ml
- Reclaimed water is frequently tested to meet particular standards (most tested of all irrigation waters)
- Most other irrigation water has little or no testing
- (Which water would you want used for irrigation of edible crops?)

Water Quality (mg/L)

	Drinking Water (MCL)	Conserv II (MACL)	Conserv II (typical)
Nitrate	10	10	6.1 – 7
Phosphorus	---	10	1.1
Potassium	---	30	11.5
Calcium	---	200	42
Magnesium	---	25	8.5
Chloride	250	100	75 – 100
Sodium	160	70	50 – 70
Sulfate	250	100	29 – 55
pH	6.5 – 8.5	6.5 – 8.4	7.1 – 7.2

Water Quality (mg/L)

	Drinking Water (MCL)	Conserv II (MACL)	Conserv II (typical)
Boron	---	1.0	< 0.25
Cadmium	0.005	0.01	< 0.002
Copper	1	0.2	0.002 – 0.05
Iron	0.3	5.0	0.01 – 0.37
Lead	0.015	0.1	< 0.003
Arsenic	0.05	0.10	< 0.005
Zinc	5	1.0	0.04 – 0.06
Chromium	0.1	0.01	< 0.005
Mercury	0.002	0.01	< 0.0002
Nickel	0.1	0.2	< 0.03
Silver	0.1	0.05	< 0.041

Reuse Flow and Flow Ratio

County	Total Flow (mgd)	Reuse Flow (mgd)	Flow Ratio
Alachua	19.50	13.69	0.70
Broward	211.68	12.58	0.06
Collier	28.95	23.59	0.81
Duval	91.48	5.87	0.06
Hillsborough	96.47	32.25	0.33
Lake	12.90	12.90	1.00

Reuse Flow and Flow Ratio

County	Total Flow (mgd)	Reuse Flow (mgd)	Flow Ratio
Leon	20.30	20.30	1.00
Miami-Dade	298.69	20.60	0.07
Orange	86.49	86.05	0.99
Palm Beach	125.92	35.81	0.28
Pinellas	106.29	56.67	0.53
Polk	33.57	30.05	0.90

Irrigation Water Standards

- Bacteriological Indicators - fecal coliform
- Reclaimed water has tougher standards for fecal coliform than irrigation water
 - RW = <2.2 per 100 ml
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- Reclaimed water is frequently tested to meet particular standards (most tested of all irrigation waters)
- Most other irrigation water has little or no testing
- (Which water would you want used for irrigation of edible crops?)

Options Initially Considered for Wastewater Disposal

- 1- Pipeline ~ 68 miles long to carry wastewater to Atlantic Ocean
- 2- Establish “Groundwater Conservation Program” – inject RW meeting drinking water standards into the Floridan aquifer
- 3- Purchase large tracts of land for rapid infiltration basins (RIBs)
- 4- Increase treatment level to convert wastewater to meet RW standards. Growers would apply RW to citrus groves
- 5- Inject wastewater into deep wells over 3000 feet deep using high pressure

Reuse Terms

- **“Reclaimed water” = water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility**
- **“Reuse” = deliberate application of reclaimed water for a beneficial purpose**

Florida Reclaimed Water Use - Acres

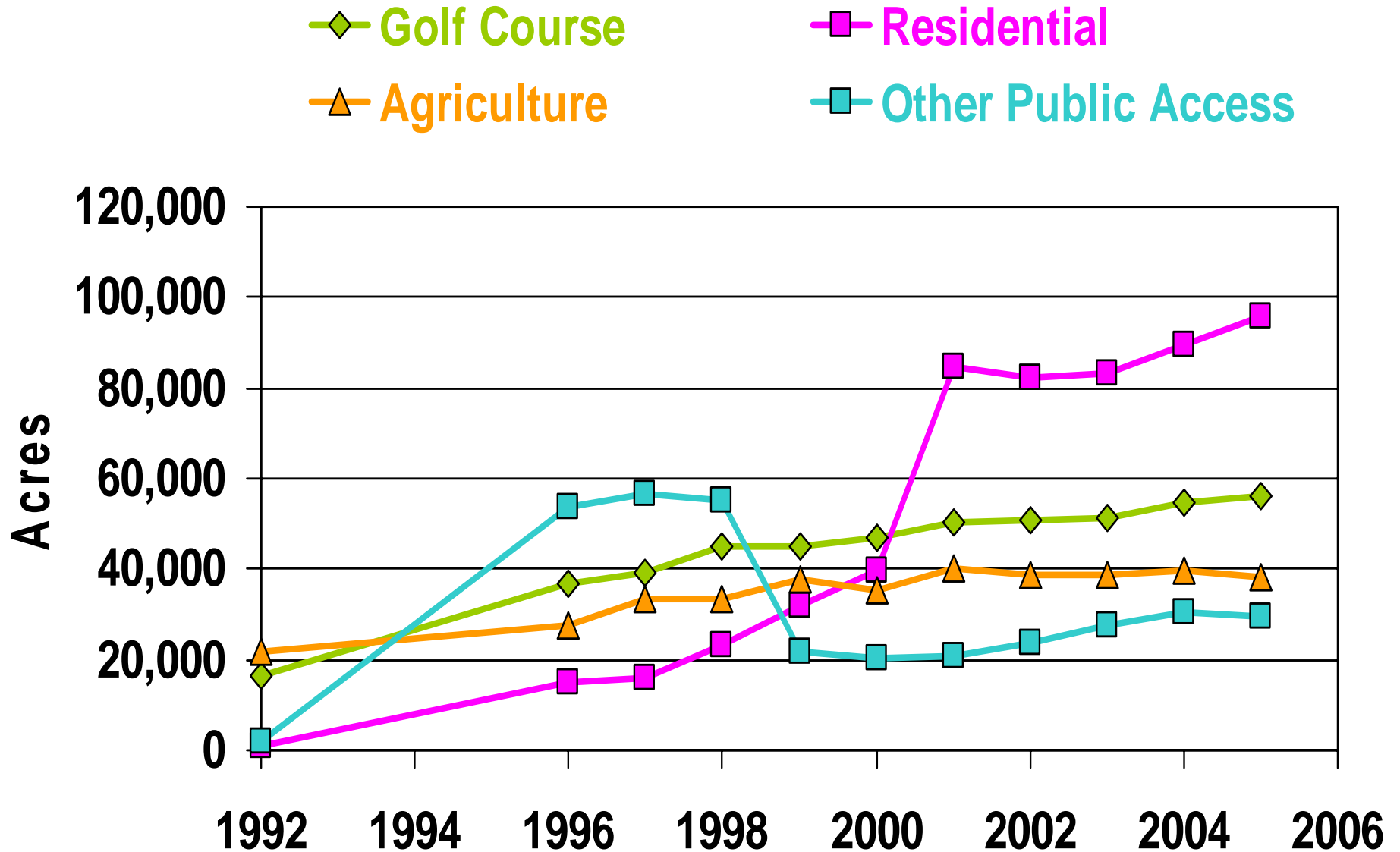


Fig. 3.

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◆ Edible Crops ■ Other Crops ▲ Agriculture Irrigation

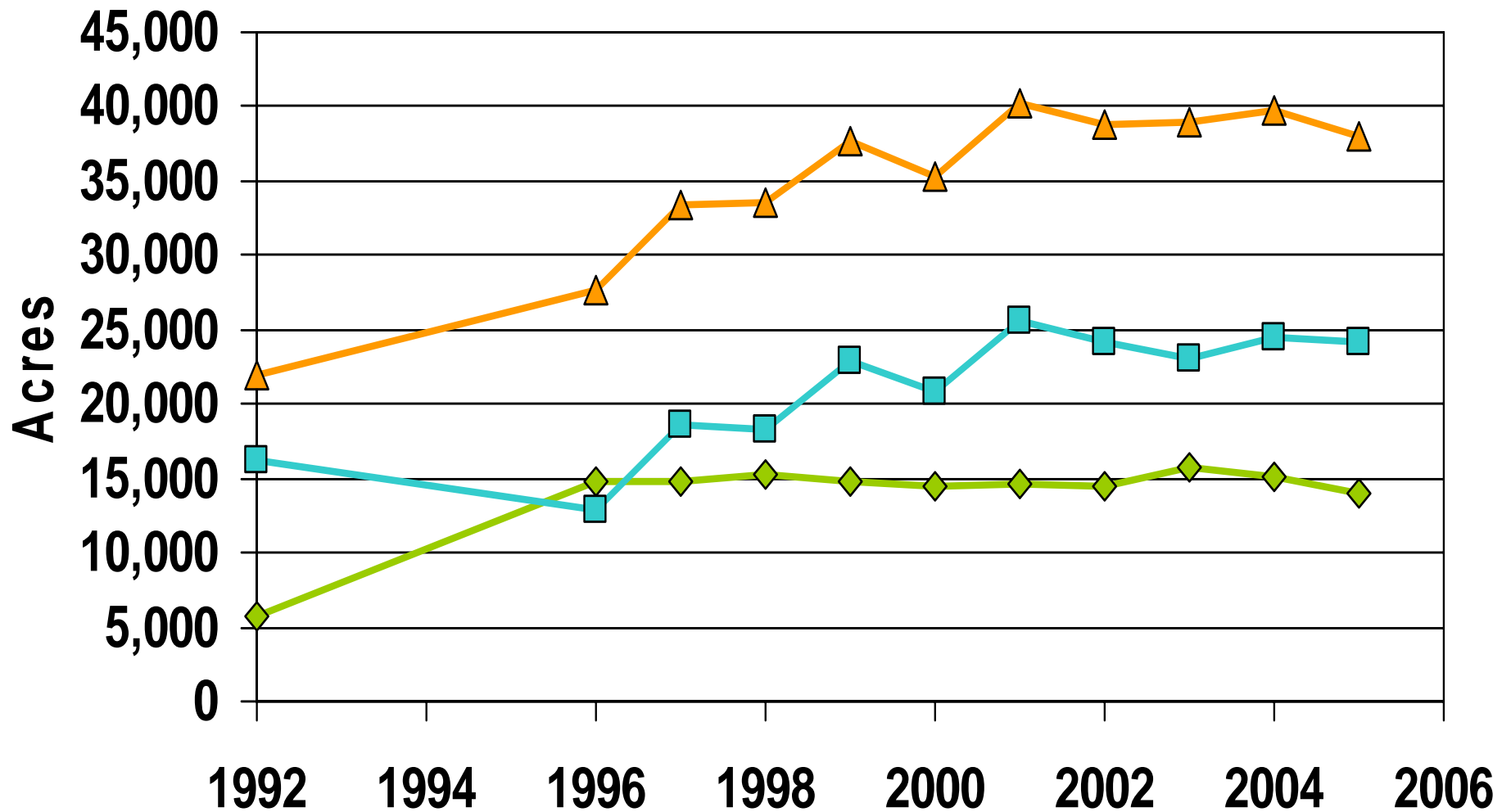
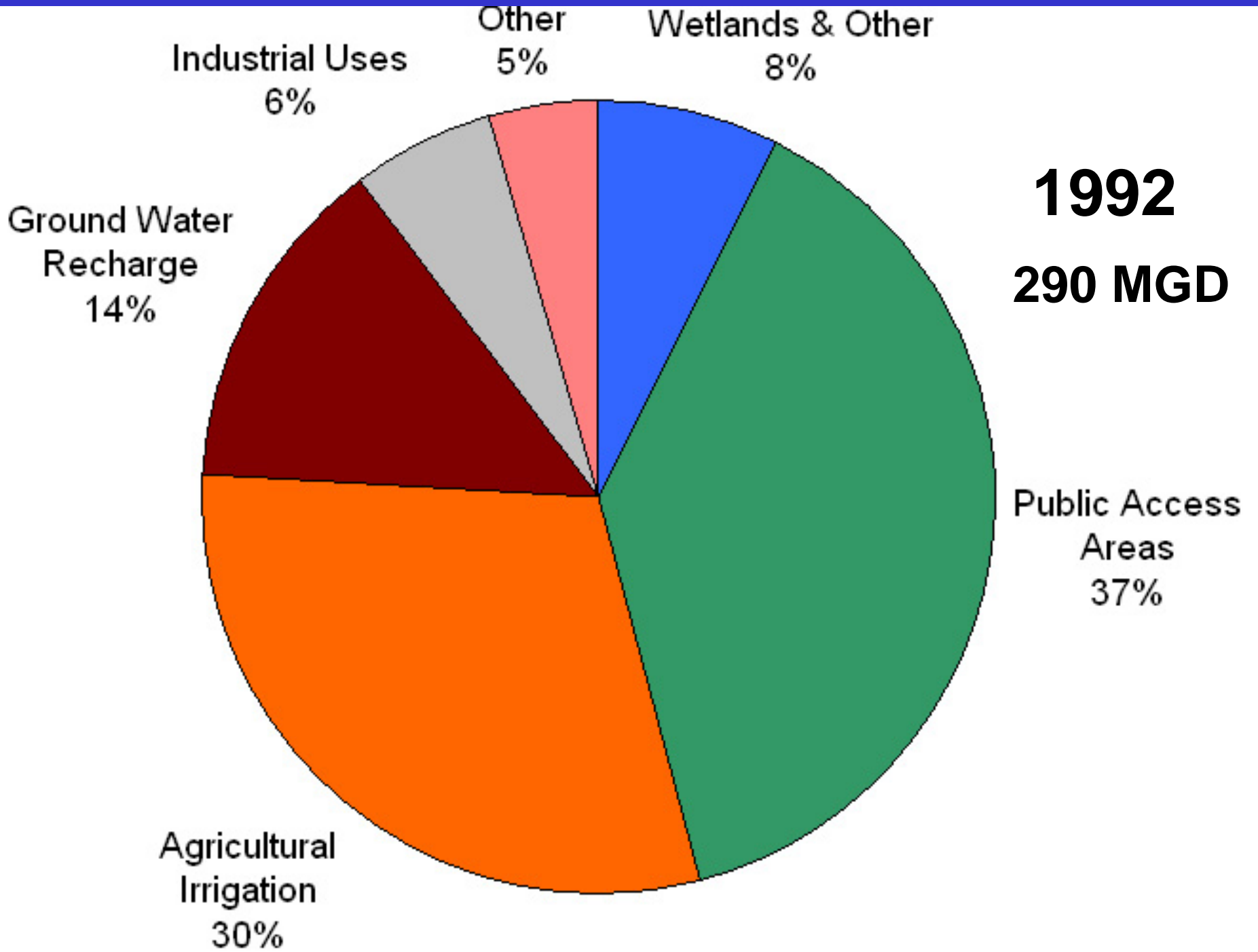


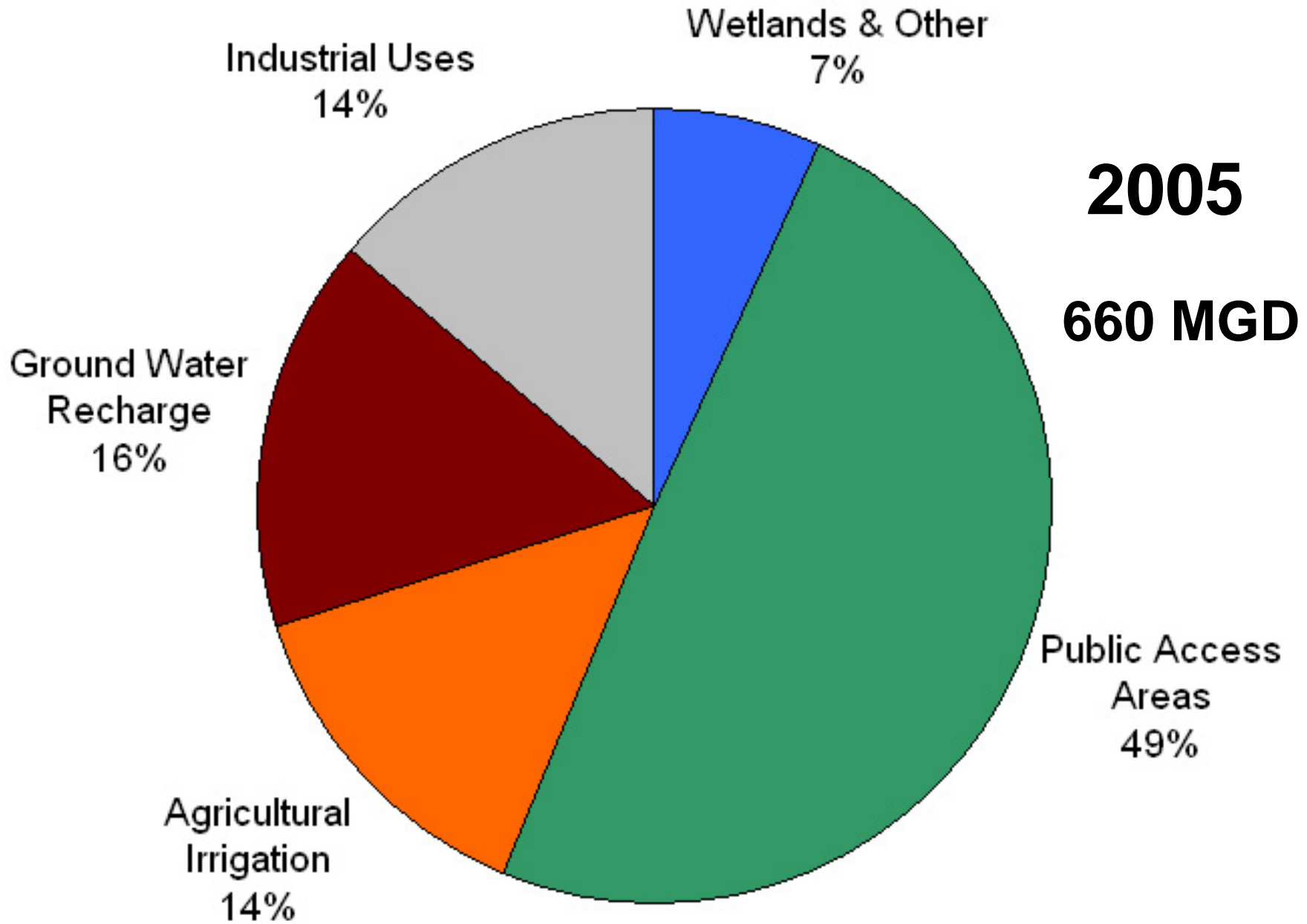
Fig. 2. **Change in agricultural reuse capacity and flow**

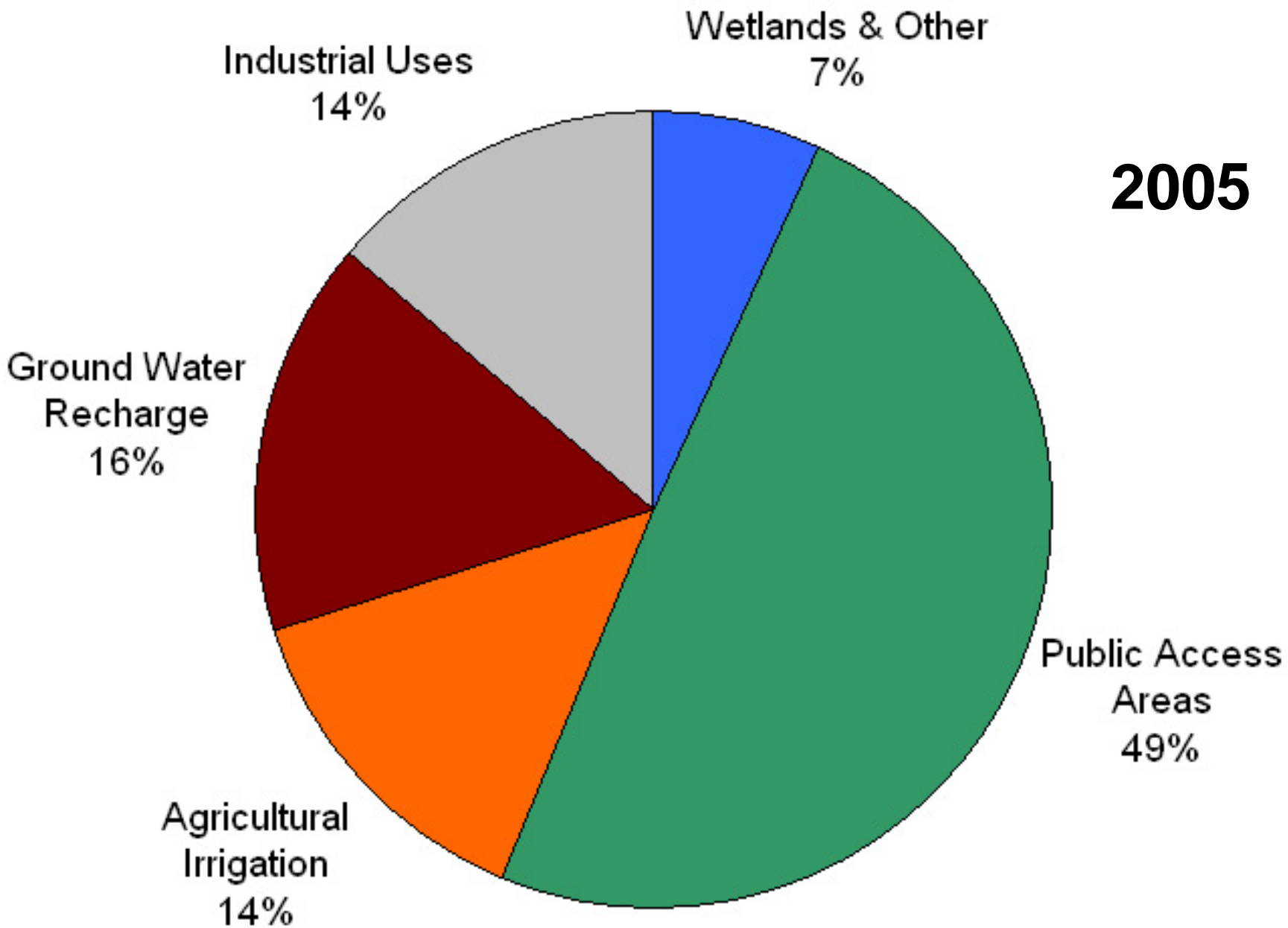


1992

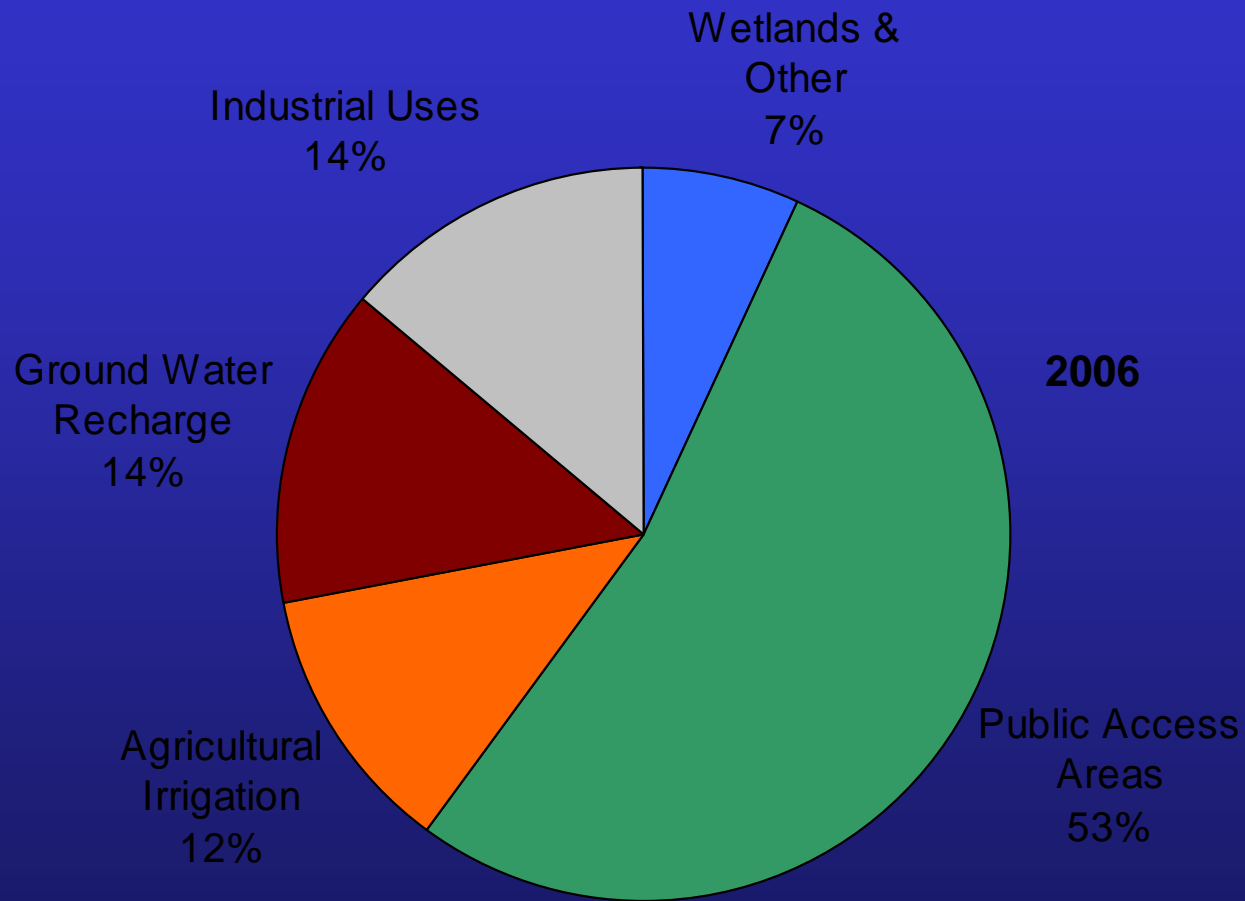
290 MGD

Public Access
Areas
37%





Reclaimed Water 2006



2006 - 663 mgd



Objectives

- **To determine the effects of reclaimed water on citrus tree performance**
- **To determine the effects of high irrigation rates (up to 100 acre inches per year) on tree growth and yield**
- **Disposal of reclaimed water**

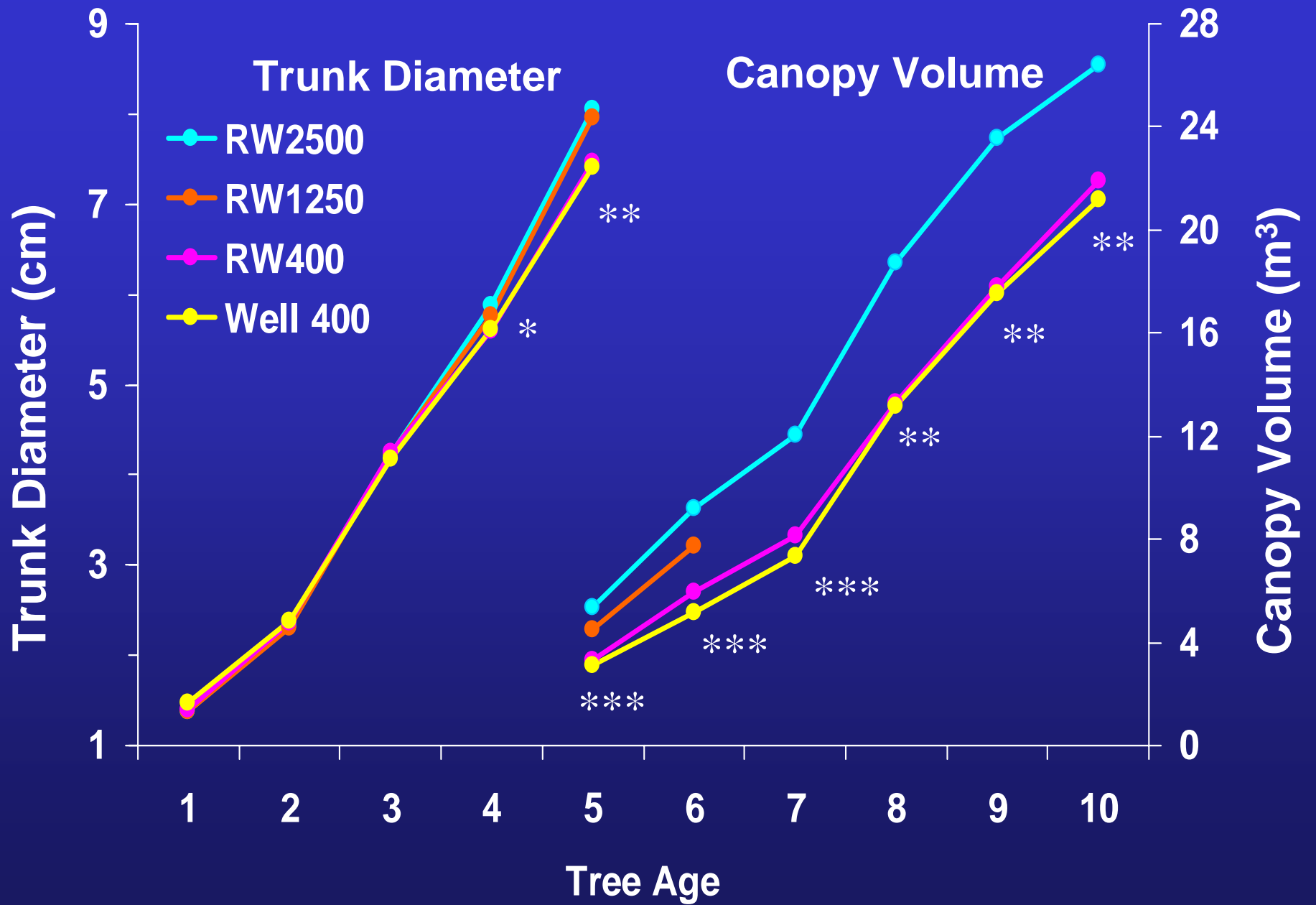
Irrigation Treatments

Irrigation	Scion	Rootstock
Well 16"	Hamlin	Carrizo
RW 16"	Orlando	Cleopatra
RW 50"		Sour
RW 100"		Swingle

Tree Spacing = 10 ft x 20 ft

24 – Trees / Plot

4 Replications



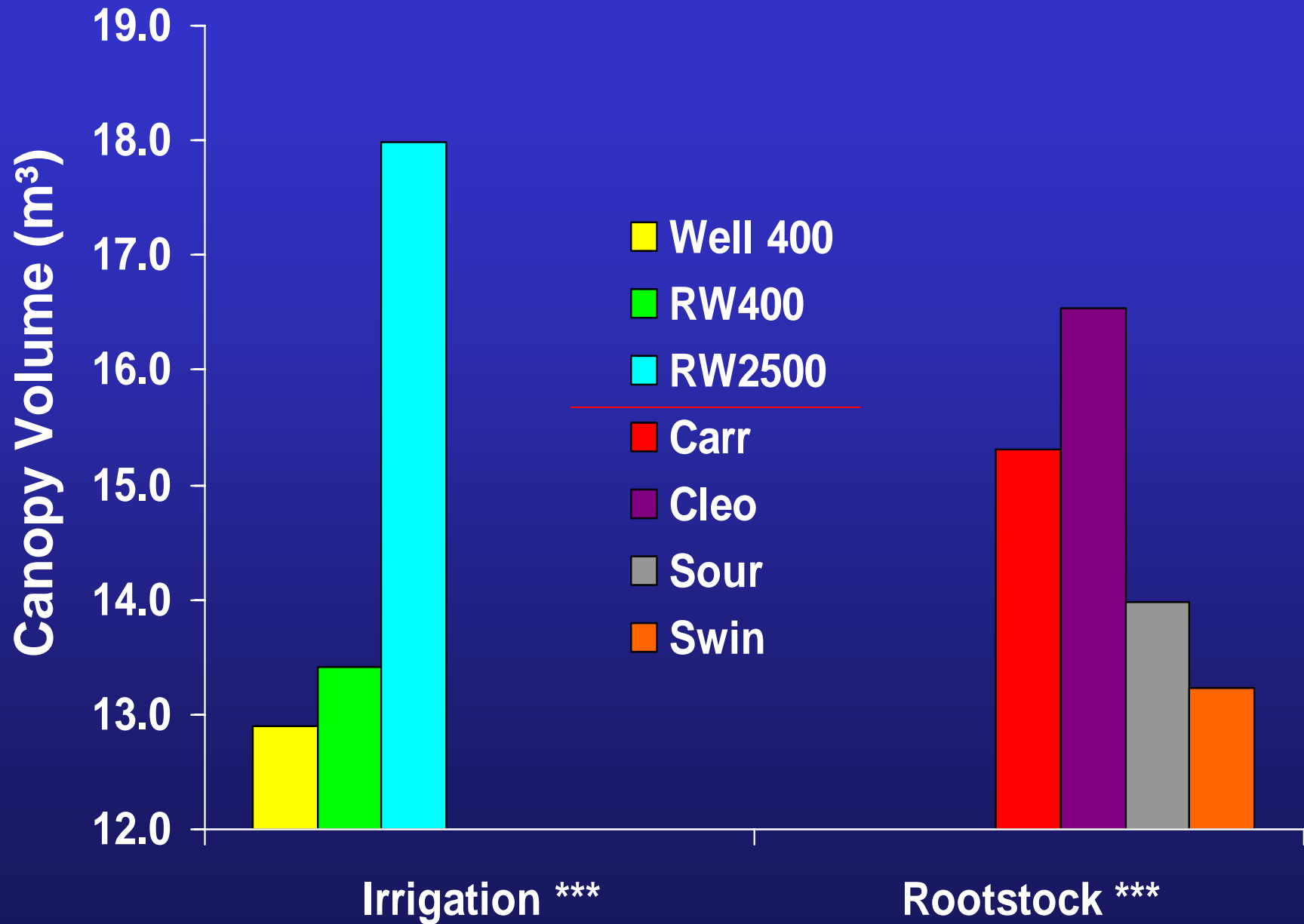


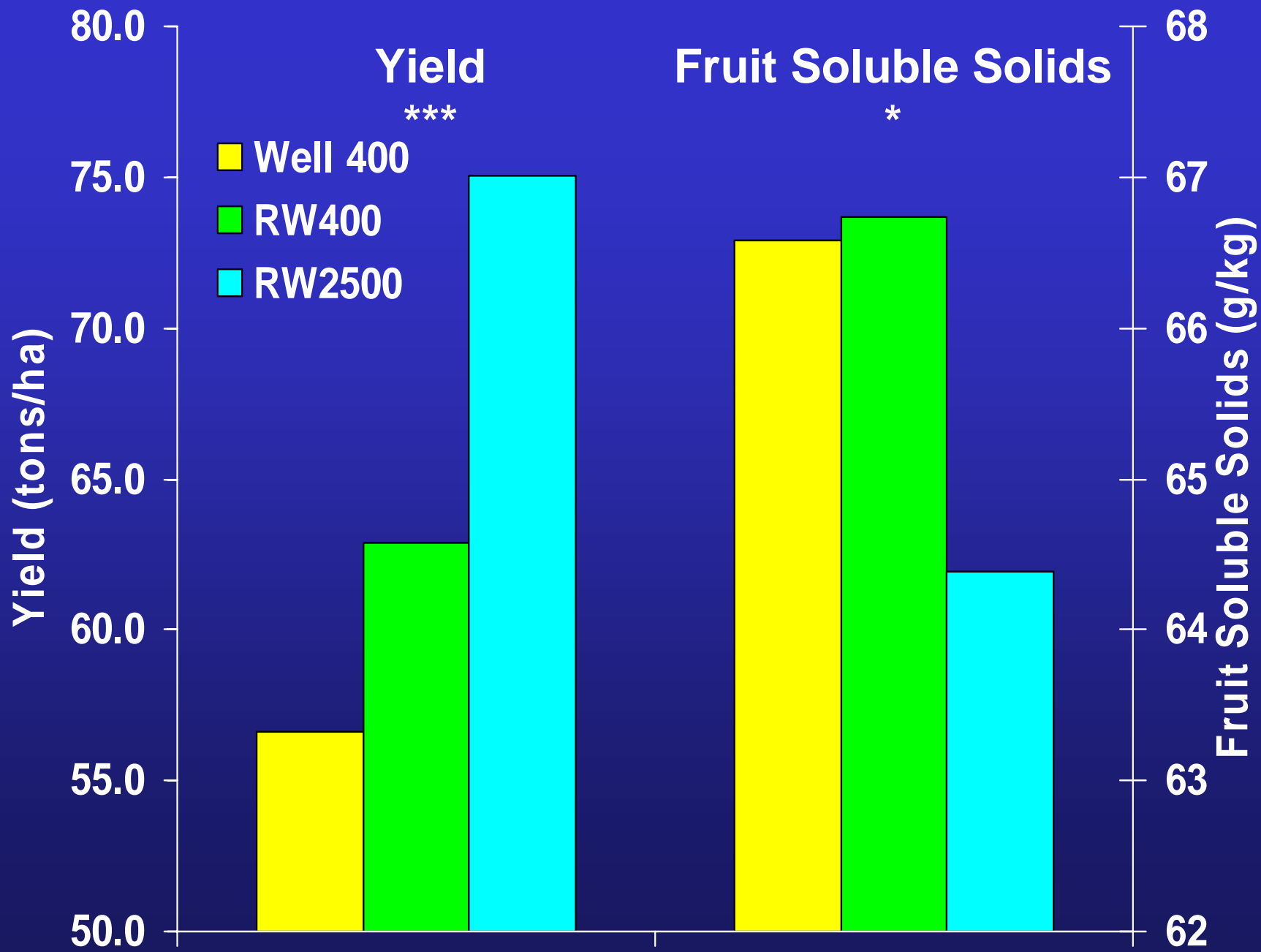






Canopy Volume (Year 10)

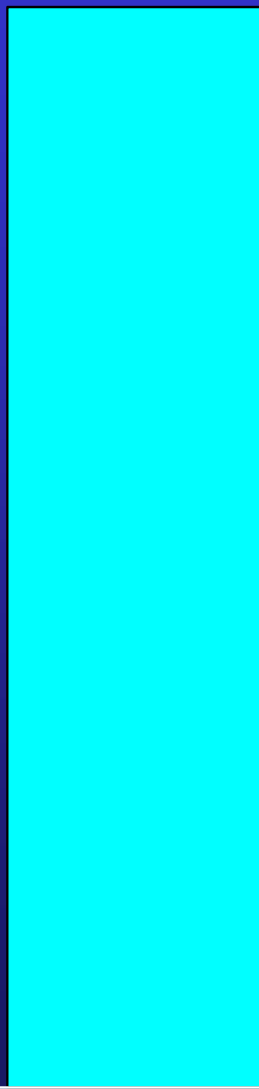
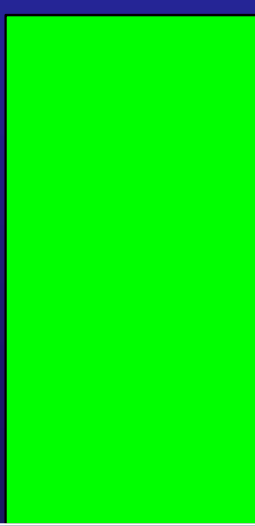




Processing Soluble Solids Tons/ha

Soluble Solids (tons/ha)

- Well 400
- RW400
- RW2500



3.6

3.8

4.0

4.2

4.4

4.6

4.8

5.0

Response to Irrigation

- Higher irrigation rate promoted greater canopy growth and fruit yield
- Soluble solids diluted slightly by the higher irrigation rate
- Increased fruit yield compensated for dilution effect
- Total solids / acre increased by higher irrigation rate

Reclaimed Water ~ Conserv II

- **Growers initially refused to take reclaimed water from city**
- **Concerns about**
 - **Possible Flooding**
 - **Heavy Metals**
 - **Health & Safety**
 - **Image (“Yuck Factor”)**



Florida Reclaimed Water Irrigation – Flow (MGD)

◆ Edible Crops ■ Other Crops ▲ Agriculture Irrigation

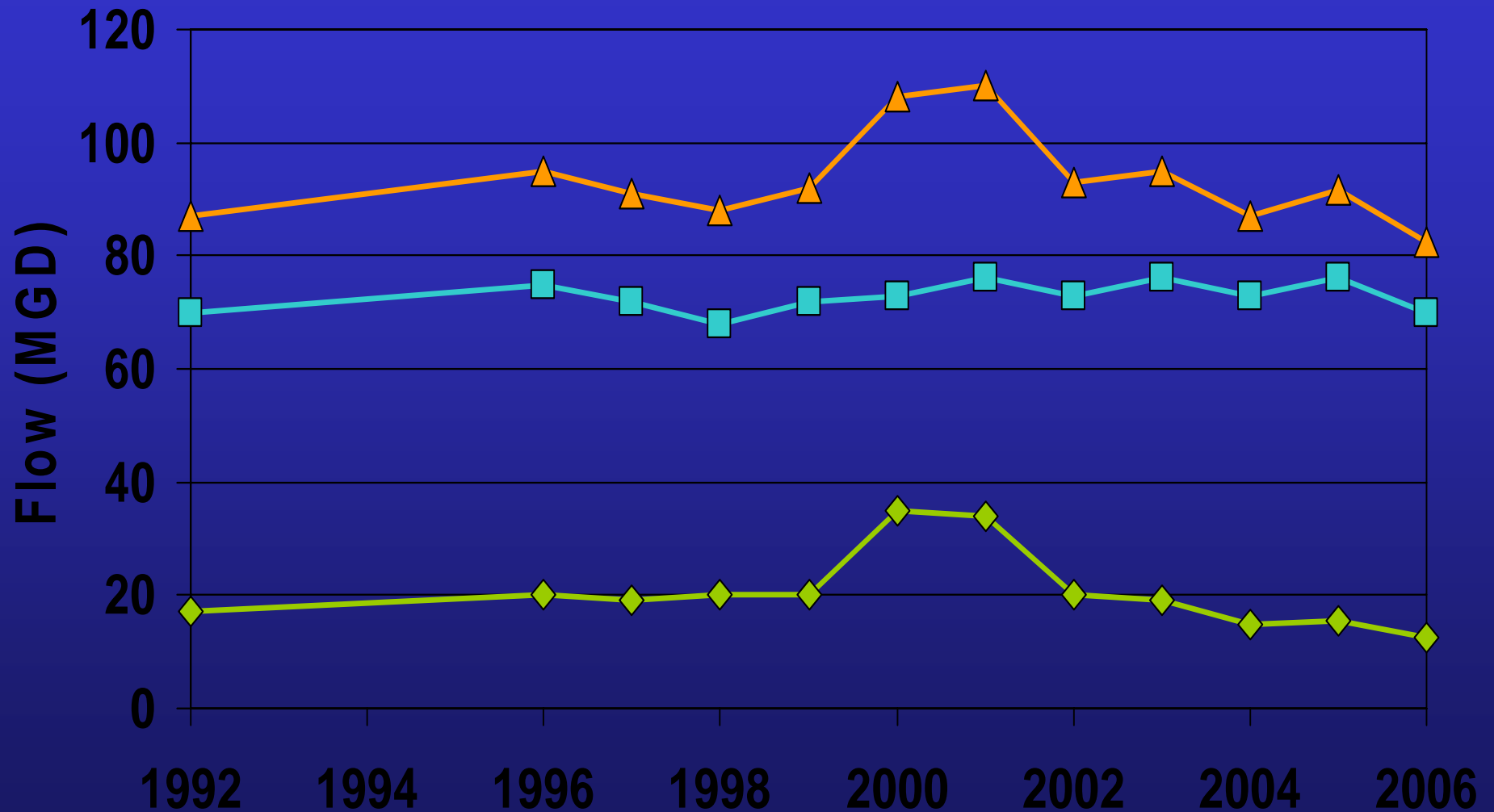


Fig. 3. Change in agricultural reuse capacity and flow