Ground Water Availability and Resource Protection

February 2009

Why Are We Discussing Groundwater?

- Sole Source Aquifer - no significant fresh water streams or rivers
- Limited resource - recharge occurs in a “Spine Area”
- Fresh ground water is restricted to depths less than 350 feet
- Multiple contamination threats - to the water table from land use activities and to the confined aquifers from over pumping
- Most likely cause for a loss of fresh ground water is salt water intrusion due to over pumping
- Salt water intrusion has already occurred in limited areas of the Shore

What is an Aquifer

- Any coarse grained material (sand, gravel) that can supply sufficient water for a beneficial use

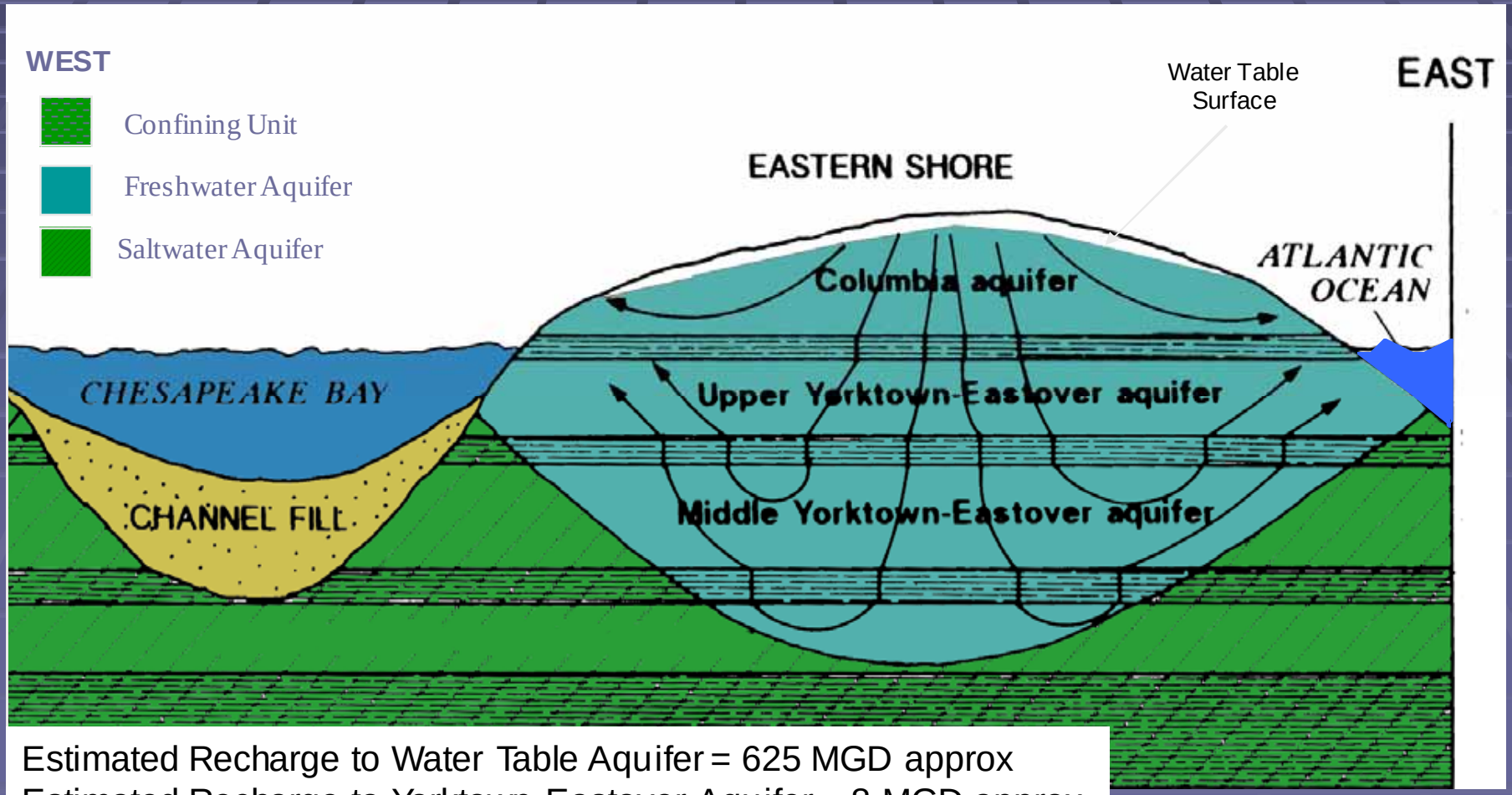
What is a Confining Unit

- Any fine grained material (silt, clay) that can significantly restrict vertical movement of groundwater such that the resulting groundwater is under pressure.

Water Table –vs- Confined Aquifer

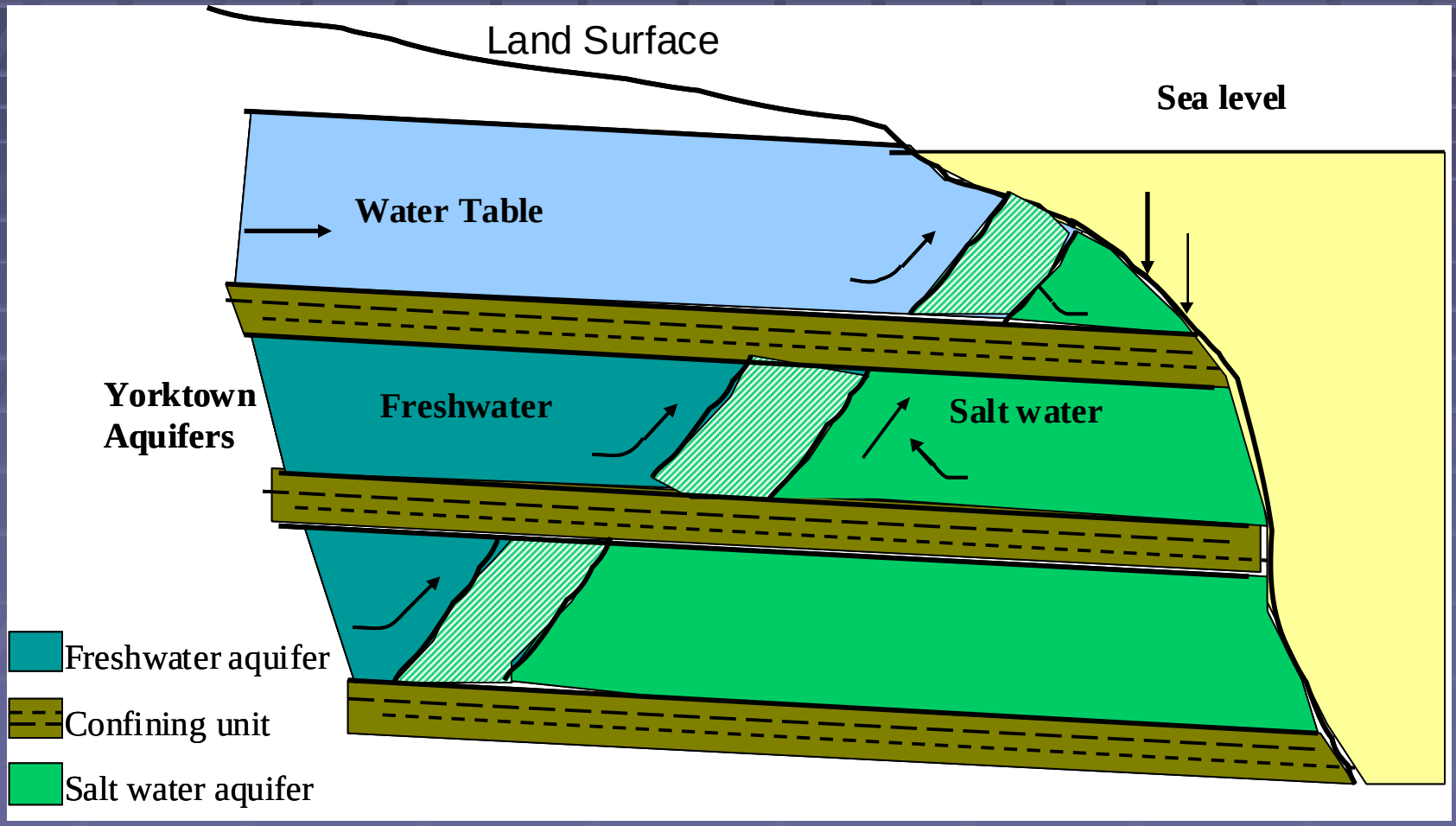
- Water Table
  - Water is not “under pressure”
  - Well yield is lower than comparable confined aquifers
  - Replenished (recharged) directly by precipitation
  - More vulnerable to contamination from surface activities
- Confined aquifer
  - Water is under pressure, confined by an overlying layer(s) of silt and clay
  - Replenished from vertical flow through the confining unit (recharge is much lower than a water table aquifer)
  - More vulnerable to saltwater intrusion

Schematic Cross-Section of Freshwater Lens

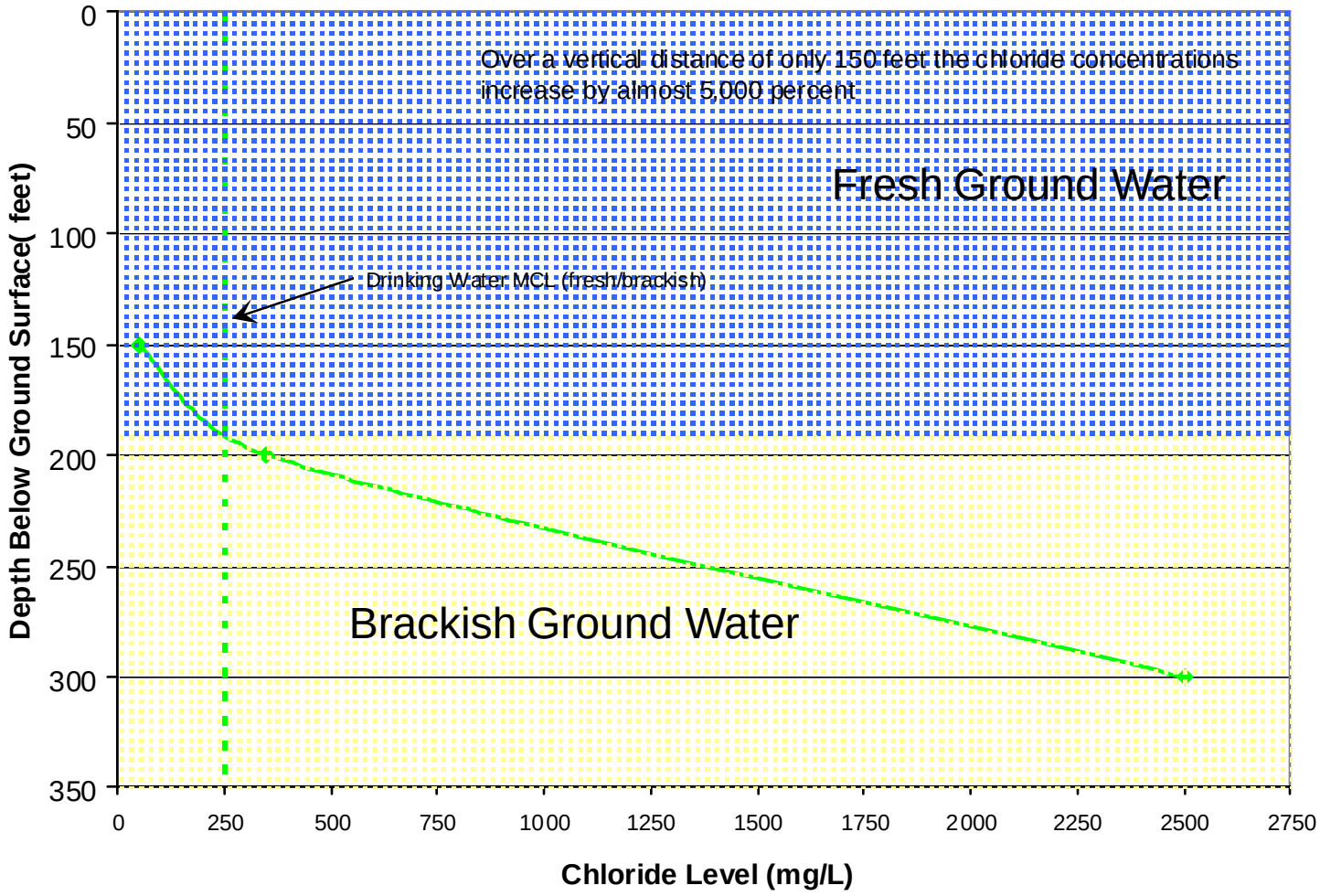


Estimated Recharge to Water Table Aquifer = 625 MGD approx
Estimated Recharge to Yorktown-Eastover Aquifer = 8 MGD approx

Schematic Cross-Section of Freshwater/Saltwater Interface



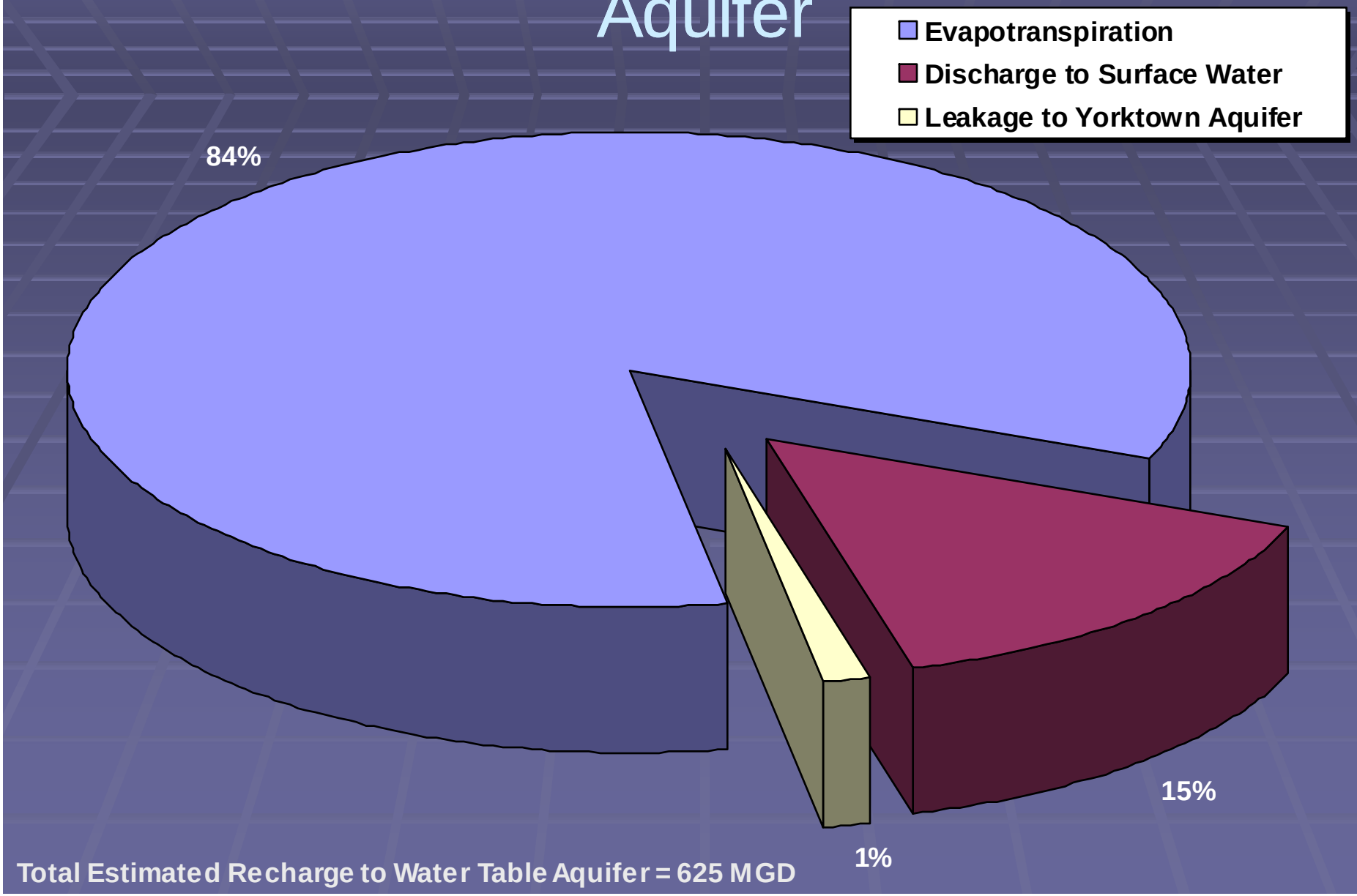
Chloride Increase With Depth Upshur Neck Seaside Example



Recharge to the Aquifers

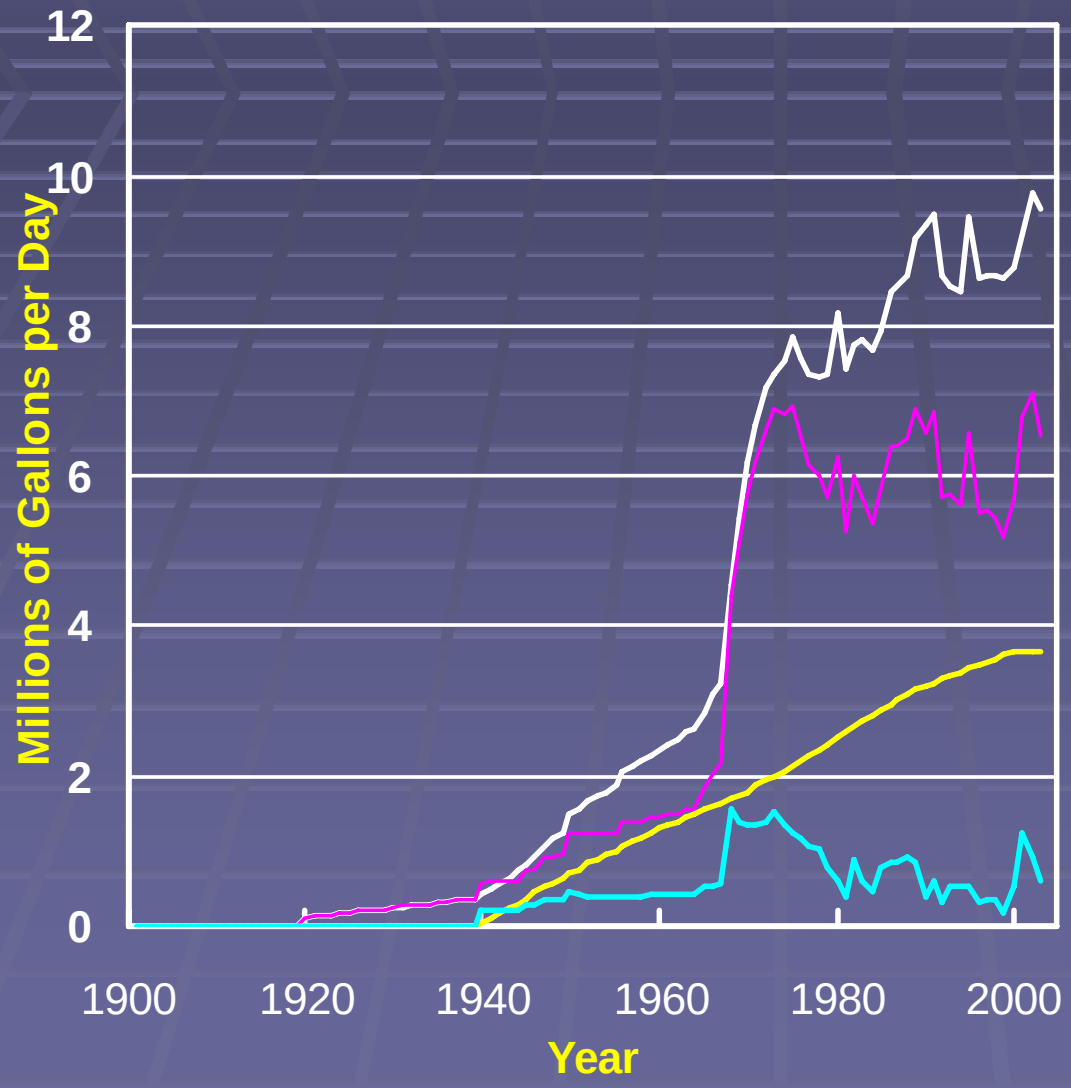
- Recharge from precipitation sustains the fresh water lens
- Approximately 44 inches of rain fall on the Eastern Shore in an normal year
- About 5 to 6 inches per year recharge the water table aquifer
- About 0.05 inches per year recharge the confined aquifer

Water Budget for the Water Table Aquifer



Total Estimated Recharge to Water Table Aquifer = 625 MGD

Total Water Budget in the Confined Aquifer



Water Leaking through upper confining unit

Public/Industrial pumping

Domestic pumping

Water released from storage

Public/Industrial pumping
+ domestic pumping

Is equal to

Water Leaking through upper confining unit
+ water released from storage

Historical Water Use

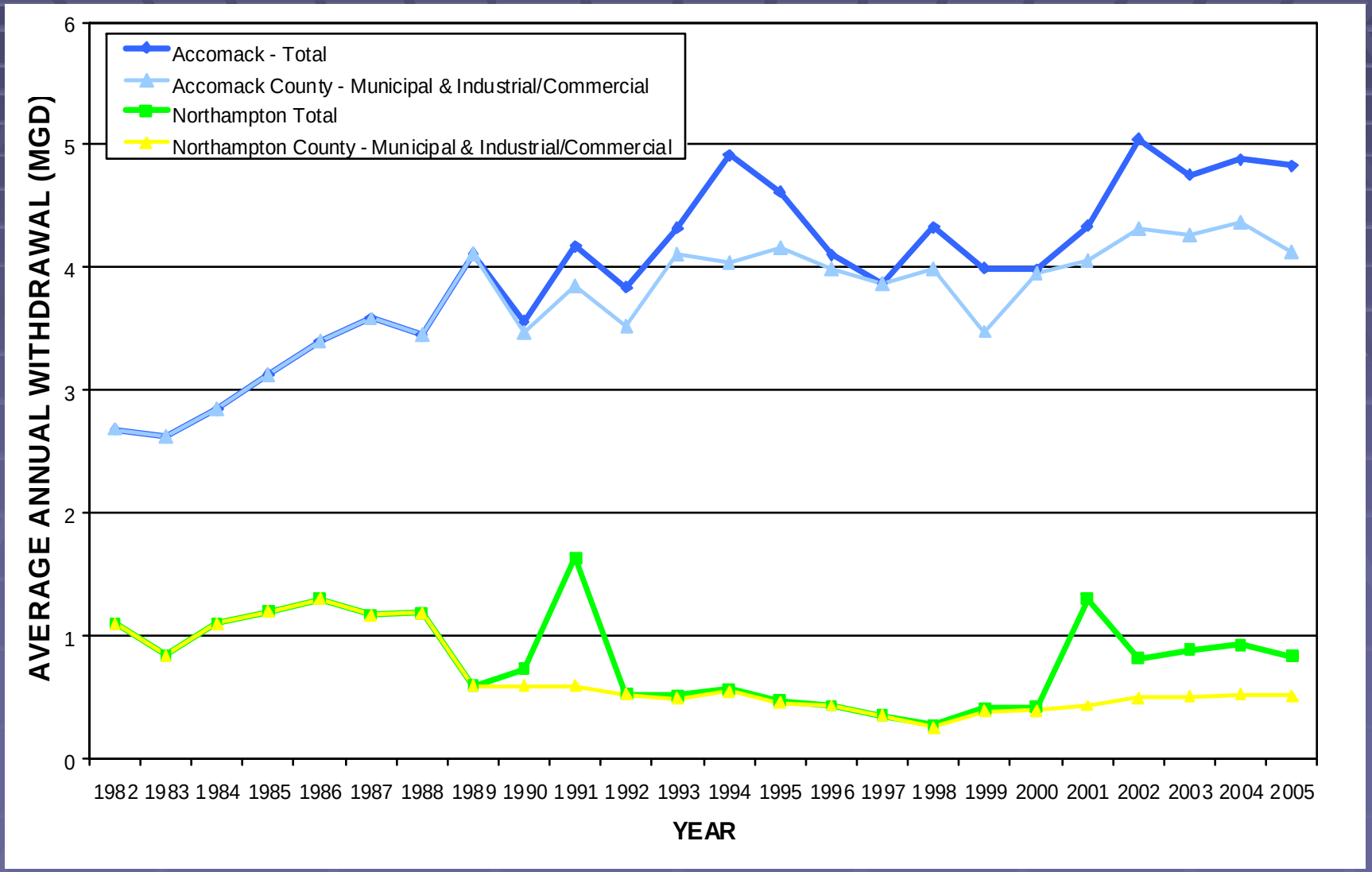
- VDEQ maintains records of water use for all Permitted Withdrawals (withdrawals greater than 300,000 gal/month).
- Records for agricultural withdrawals to date are inconsistent and under represents actual use.
- No use records are maintained for private wells or small water systems.

Historical Water Use

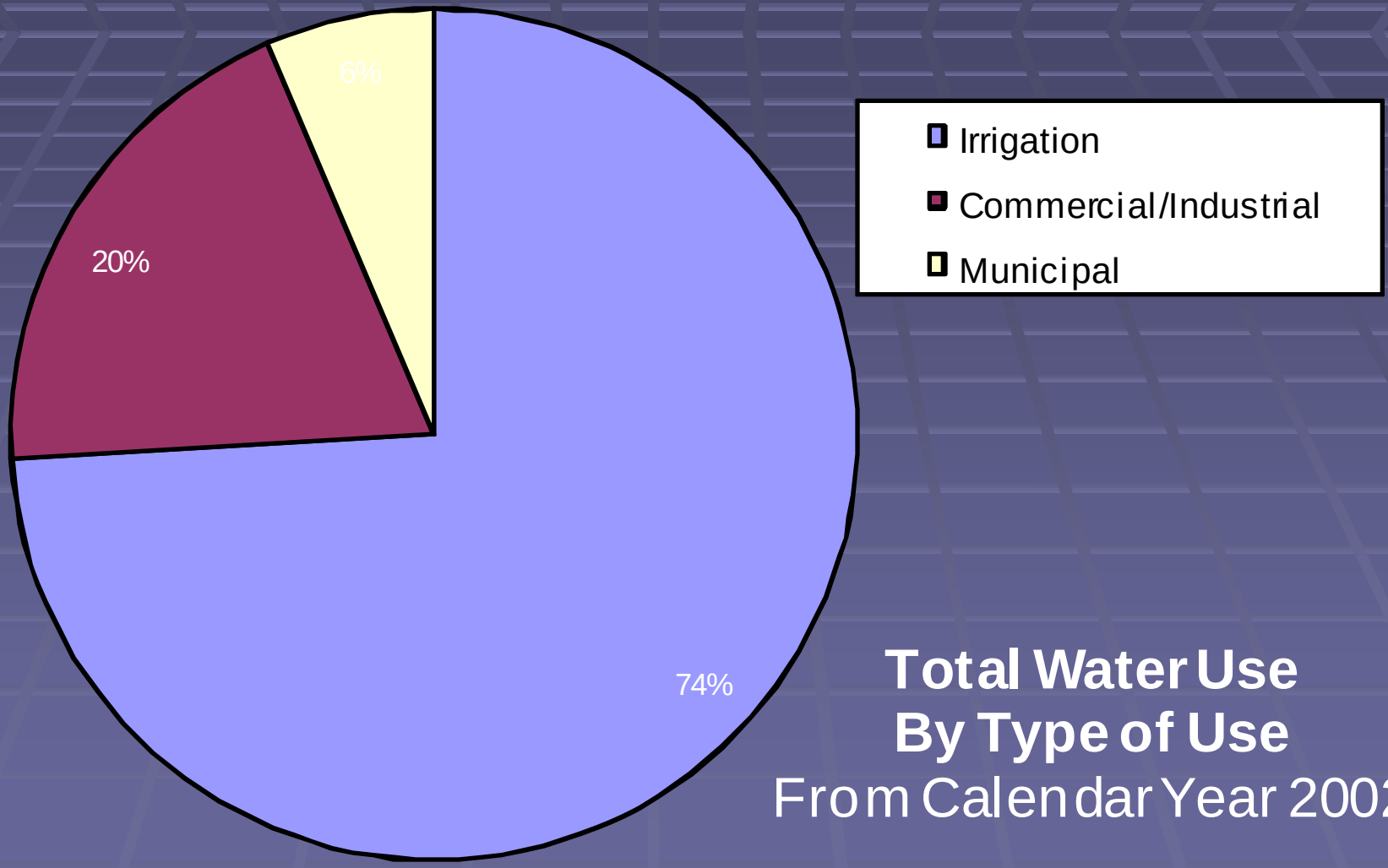
Source	Year	Irrigation	Commercial/Industrial	Municipal	Total
Groundwater Wells	2001	1.14	3.39	1.11	5.64
	2002	1.03	3.63	1.19	5.86
	2003	0.83	3.62	1.16	5.61
	2004	0.89	3.66	1.19	5.74
	2005	0.81	3.51	1.09	5.41
	2006	0.16	3.56	1.15	4.88
	Average	**0.81**	**3.56**	**1.15**	**5.52**
"Groundwater" Ponds	2001	8.30	0.00	0.00	8.30
	2002	9.42	0.00	0.00	9.42
	2003	8.97	0.00	0.00	8.97
	2004	5.87	0.00	0.00	5.87
	2005	2.95	0.00	0.00	2.95
	2006	5.74	0.00	0.00	5.74
	Average	**6.87**	**0.00**	**0.00**	**6.87**
Surface Water	2001	3.51	0	0	3.51
	2002	3.34	0	0	3.34
	2003	1.93	0	0	1.95
	2004	2.28	0	0	2.29
	2005	3.18	0	0	3.20
	2006	3.64	0	0	3.64
	Average	**2.98**	**0**	**0**	**2.99**
Water Use Total	2001	12.95	3.39	1.11	17.45
	2002	13.79	3.63	1.19	18.61
	2003	11.73	3.63	1.16	16.52
	2004	9.04	3.67	1.19	13.91
	2005	6.93	3.53	1.09	11.55
	2006	9.54	3.56	1.15	14.25
	Average	**10.66**	**3.57**	**1.15**	**15.38**

Notes: Commercial/Industrial and Municipal Use for 2006 estimated as average of past use
"Groundwater" Ponds category corresponds to "Type = GW" and "Source = Pond" in database
Maximum use (highlighted year - 2002) corresponds to extreme drought in August-September

Permitted Groundwater Withdrawals

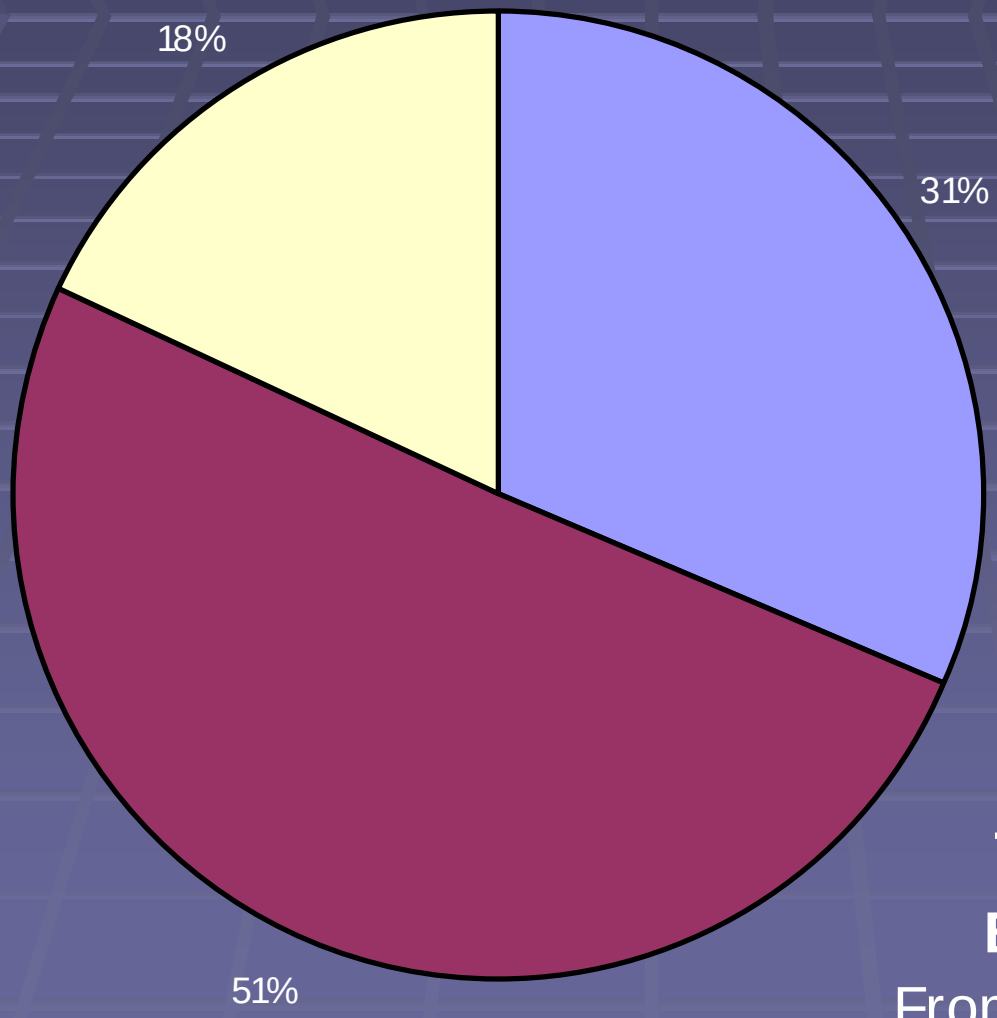


Surface & Groundwater Use



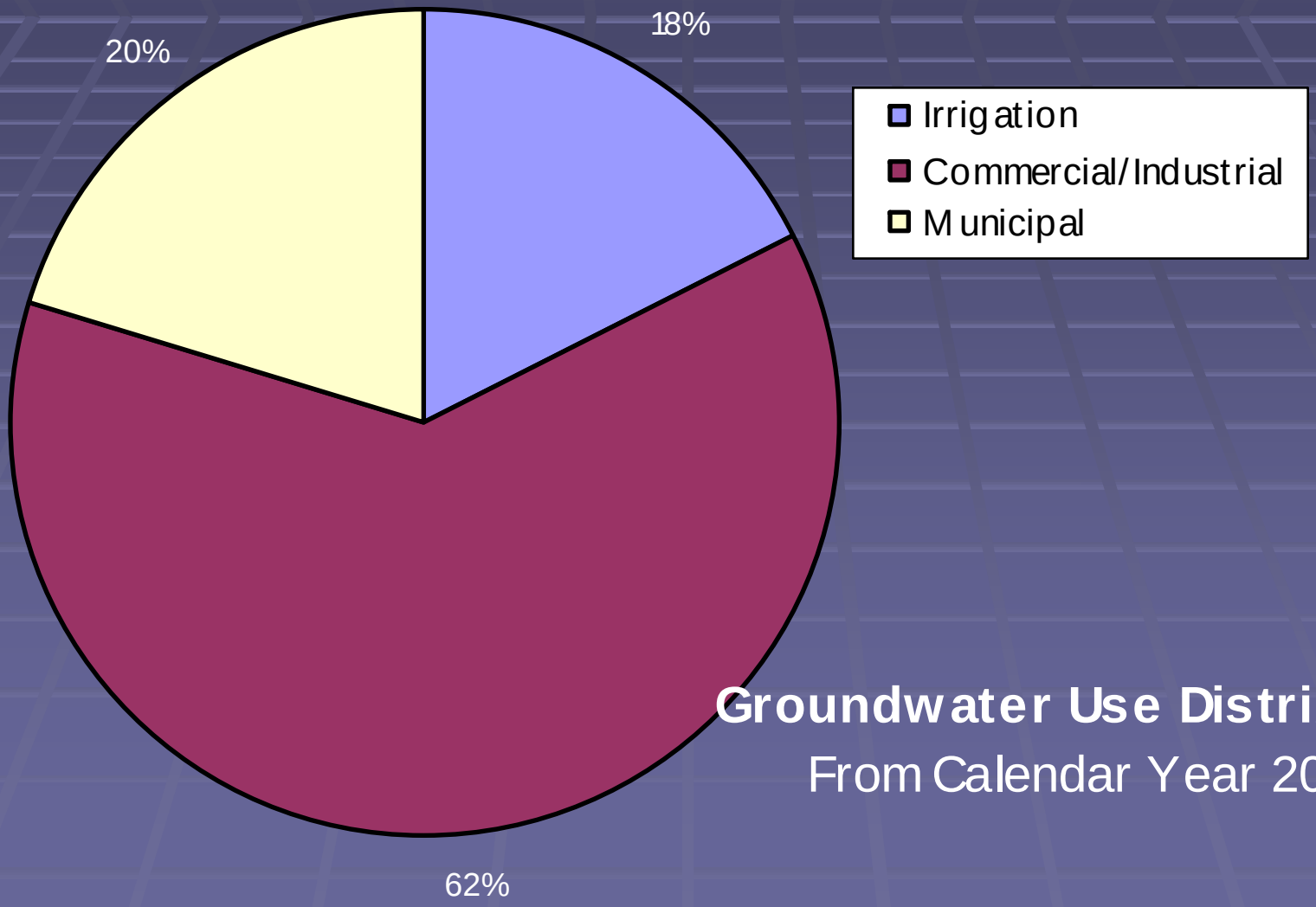
Total Water Use
By Type of Use
From Calendar Year 2002

Water Use by Source



Total Water Use
By Source Water
From Calendar Year 2002

Types of Groundwater Use



Groundwater Use Distribution
From Calendar Year 2002

How Do We Determine Impacts to the Groundwater System

- Direct Measurements
  - Pumping records
  - Groundwater levels
  - Water quality change over time
- Models
  - Groundwater flow (water level)
  - Water quality (salt water intrusion)

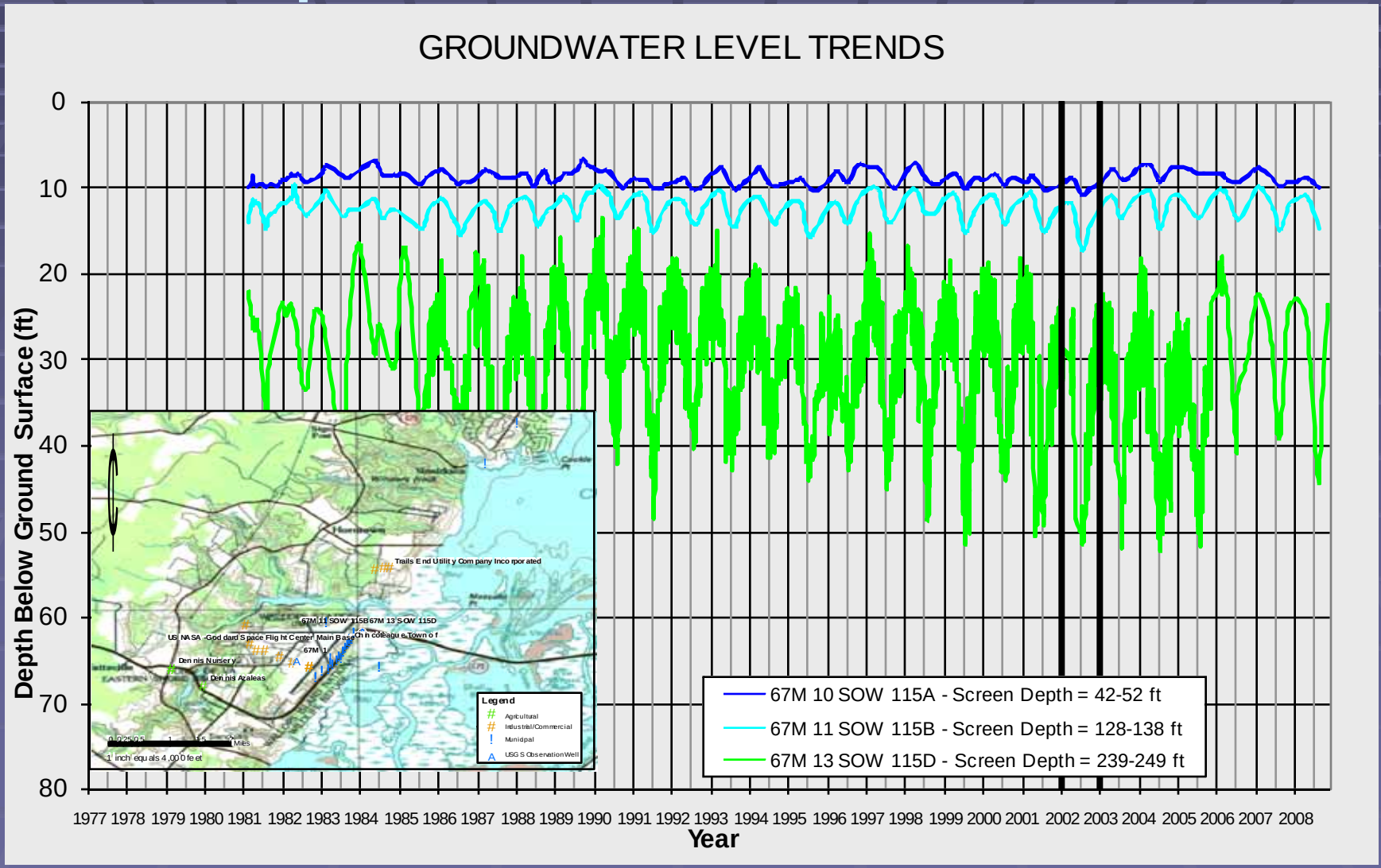
Why Measure Ground Water Levels?

- Ground water use:
  - Lowers ground water levels, reducing available water to other ground water users
  - Reduces the size of the freshwater lens
- Impact of ground water use can be evaluated:
  - Indirectly using models
  - Measured directly from pumping wells and observation wells

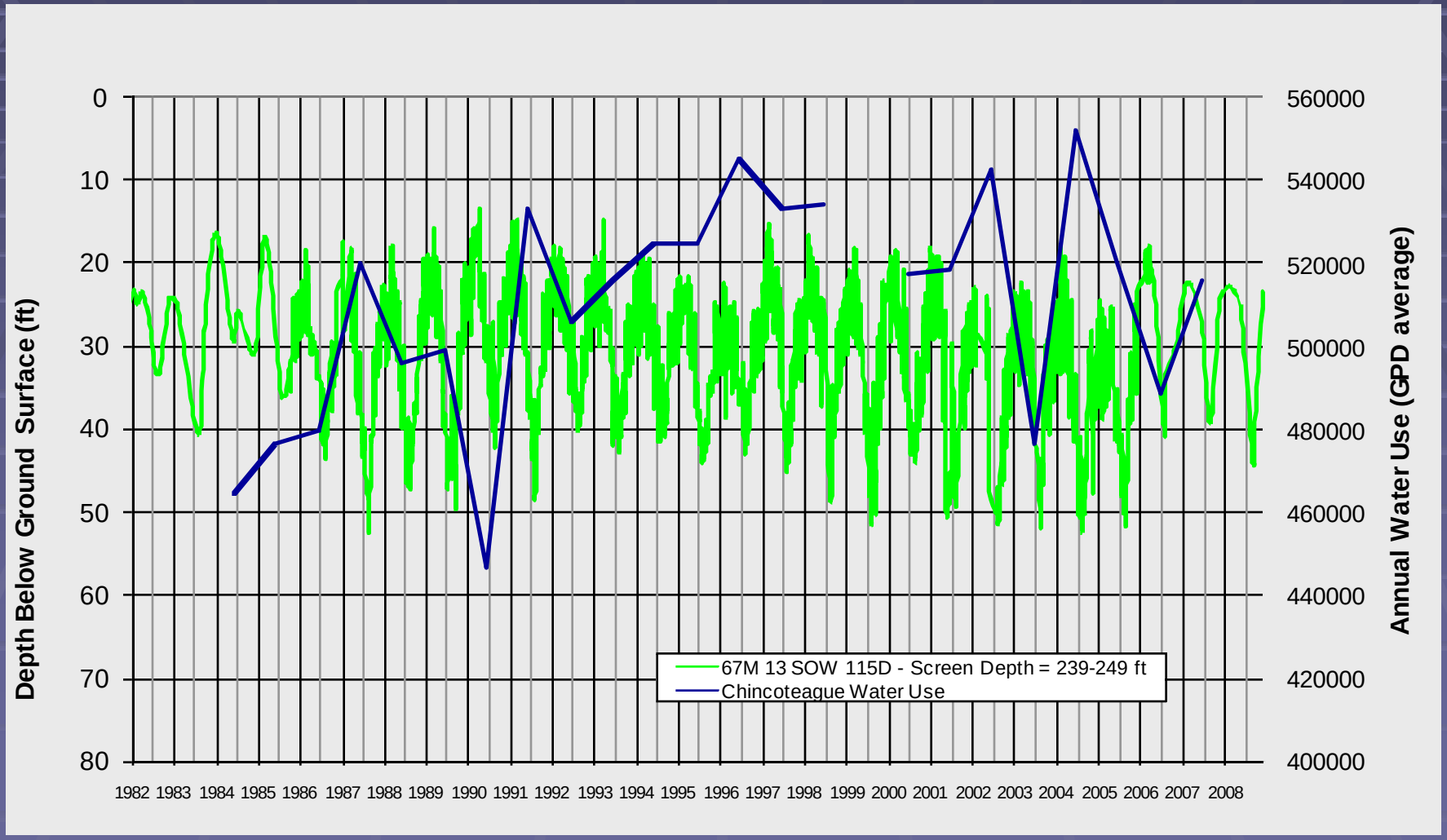
Use of Ground Water Level Measurements

- Are exact measurements from individual locations
- Limited by screen interval and spatial distribution
- Excellent for tracking long term water level trends
- Cannot predict future trends
- Limited use for estimating water levels between monitoring locations

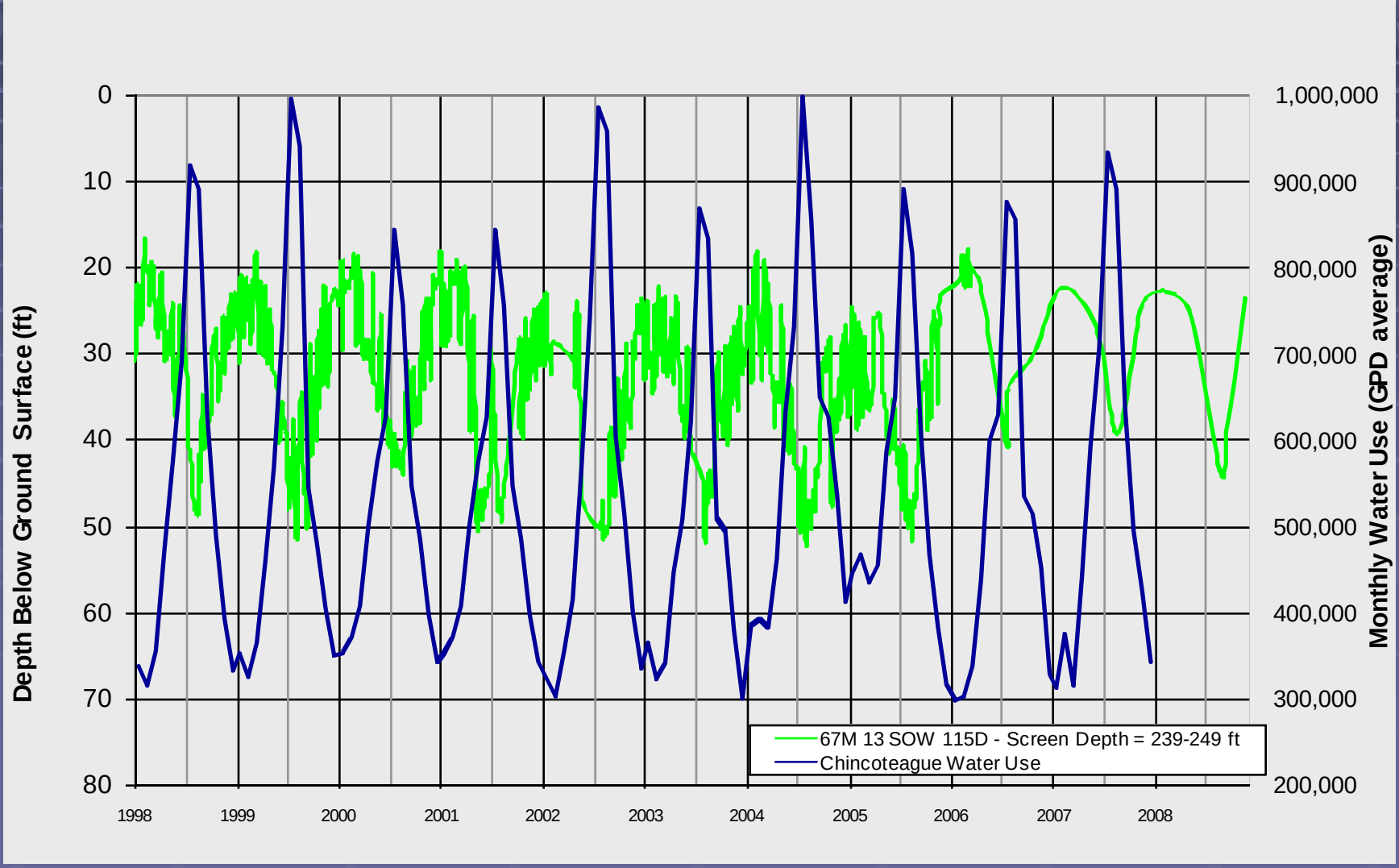
Long Term Drawdown and Episodic Withdrawals



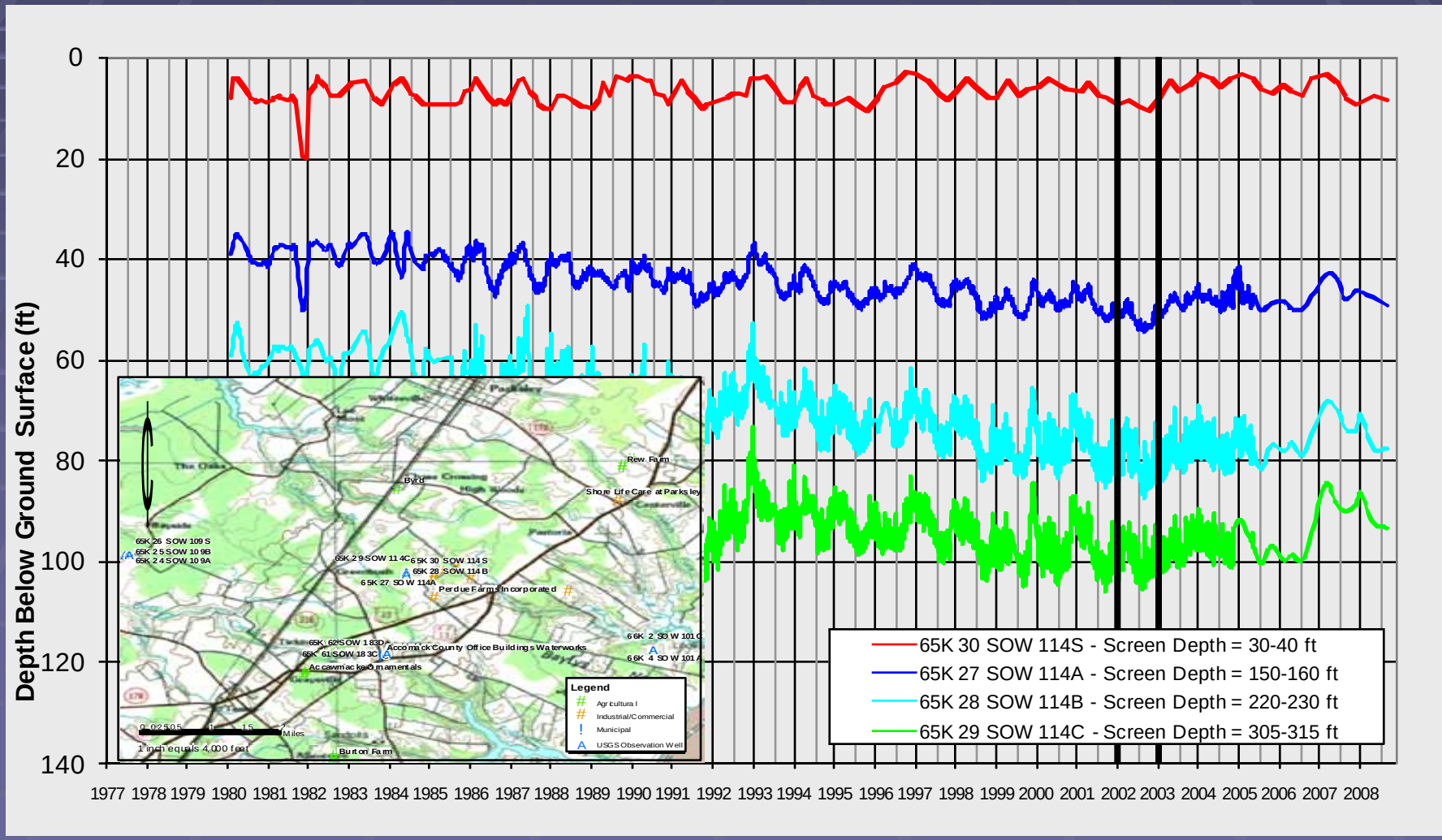
Water Level Change and Annual Use



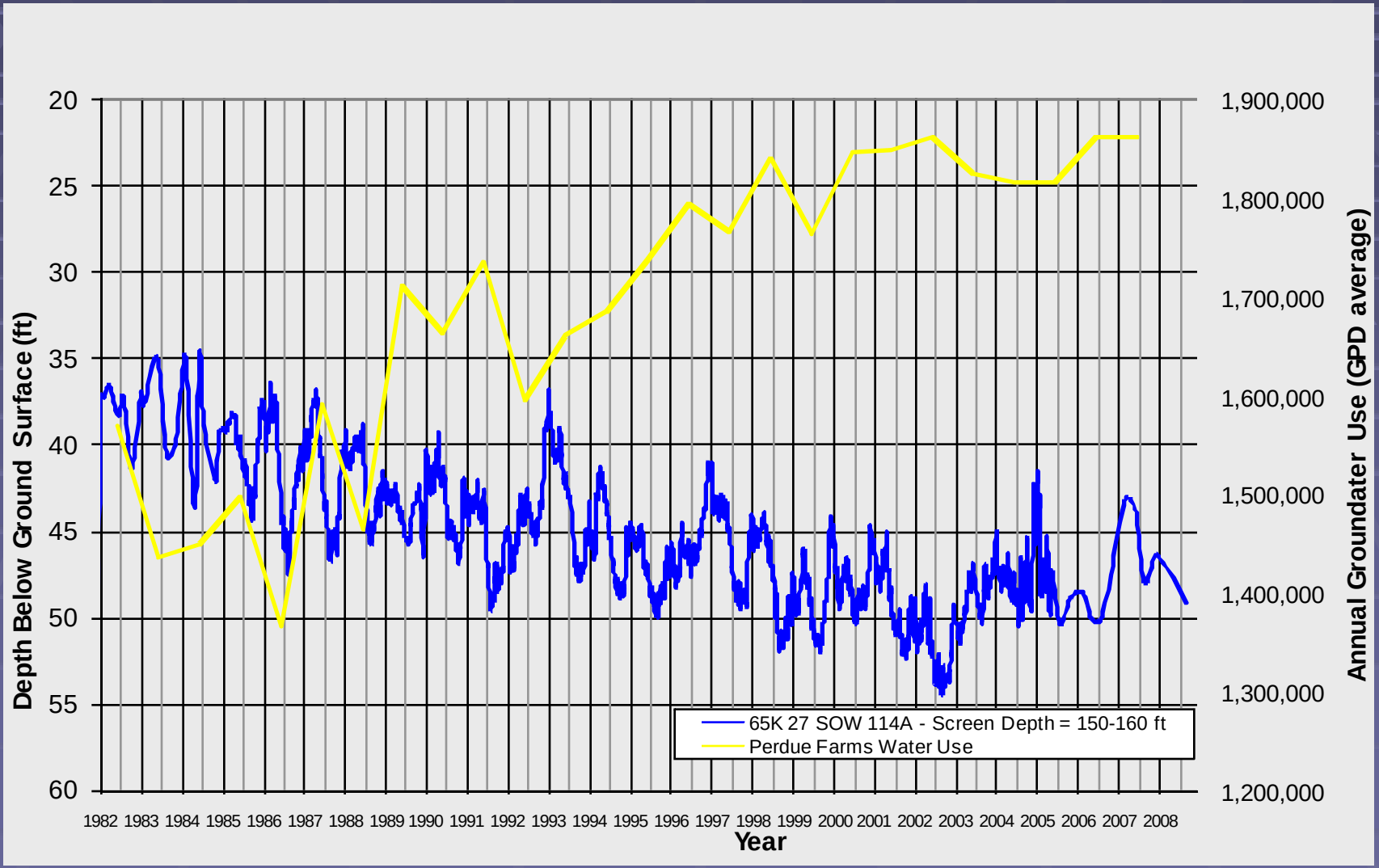
Water Level Change and Monthly Use



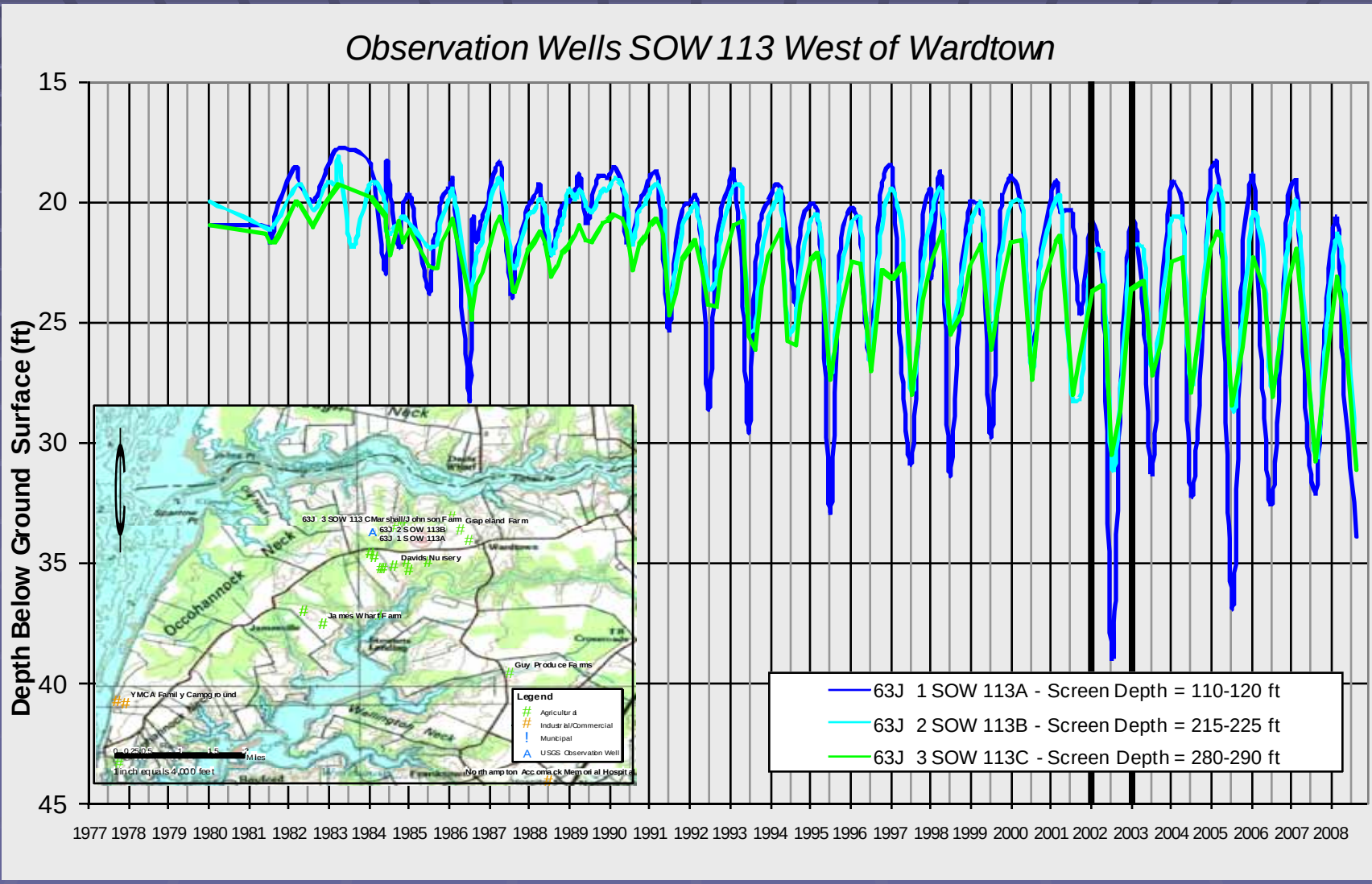
Ground Water Levels Near Perdue Foods



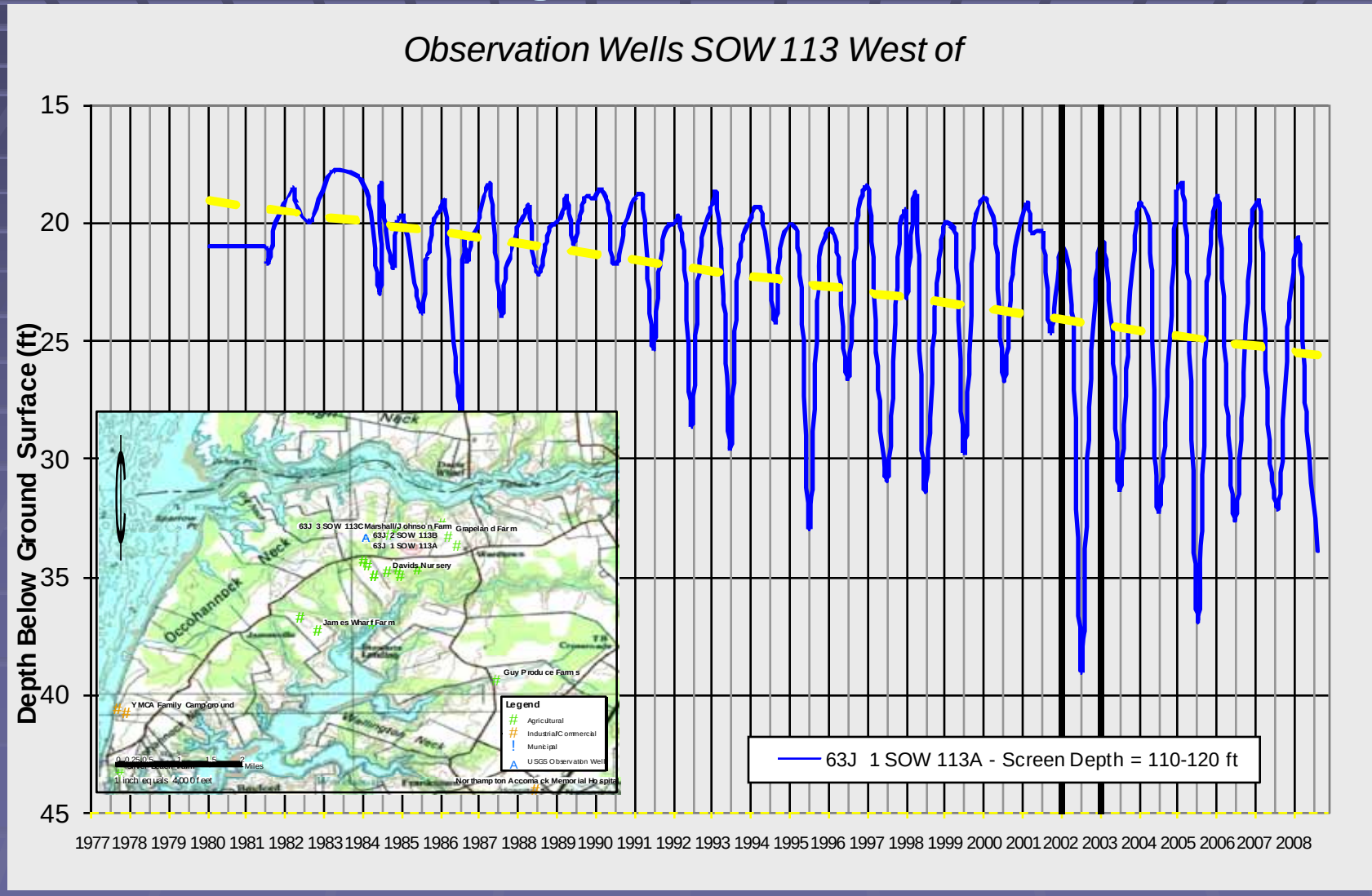
Water Level Change and Annual Use Near Perdue Farms



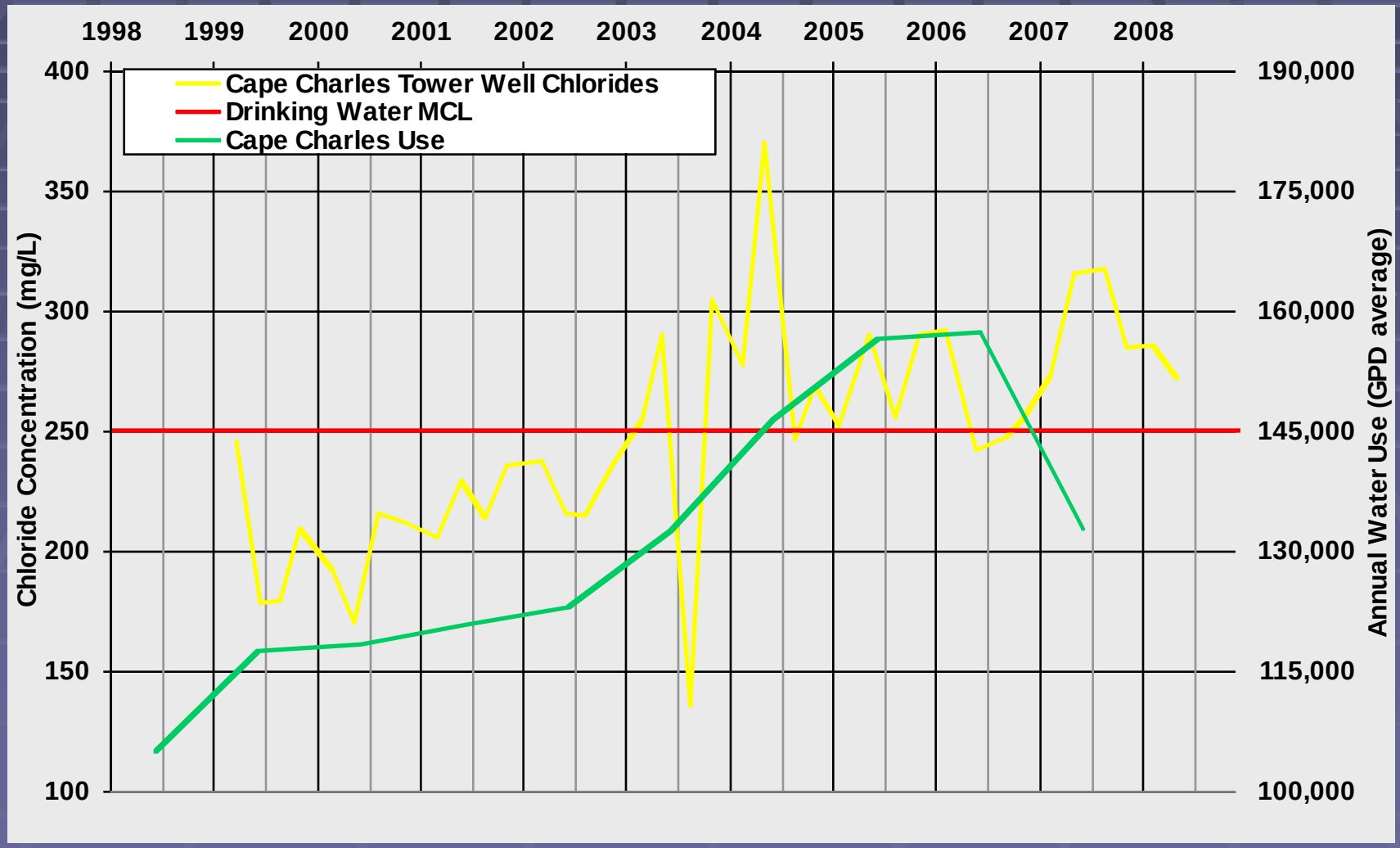
Effect of Irrigation Use



Long Term Decline from Irrigation Use



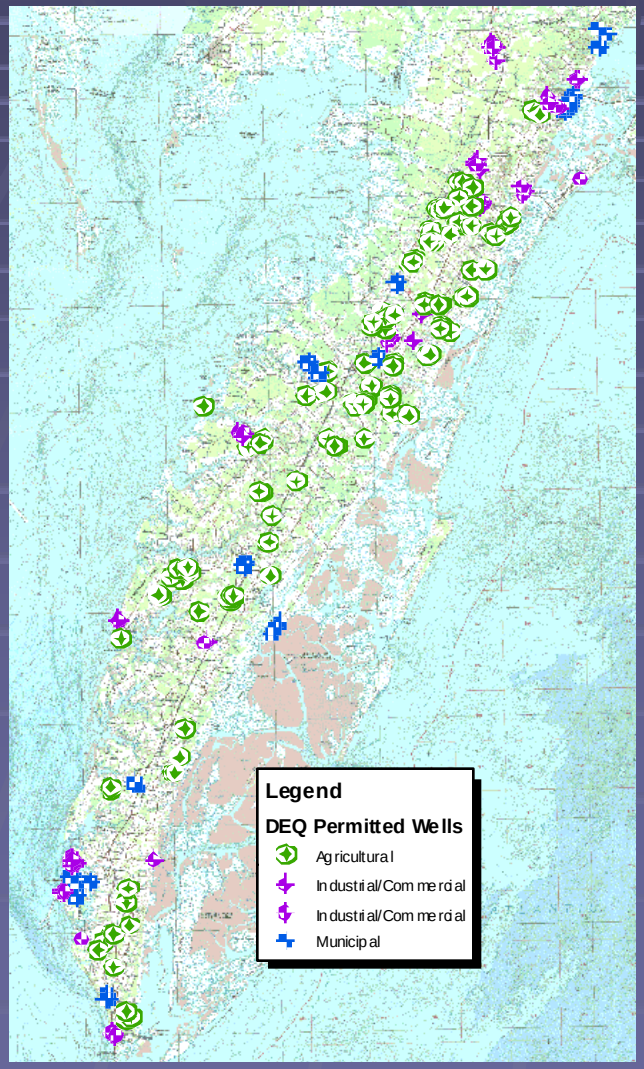
Ground Water Use and Water Quality Trends

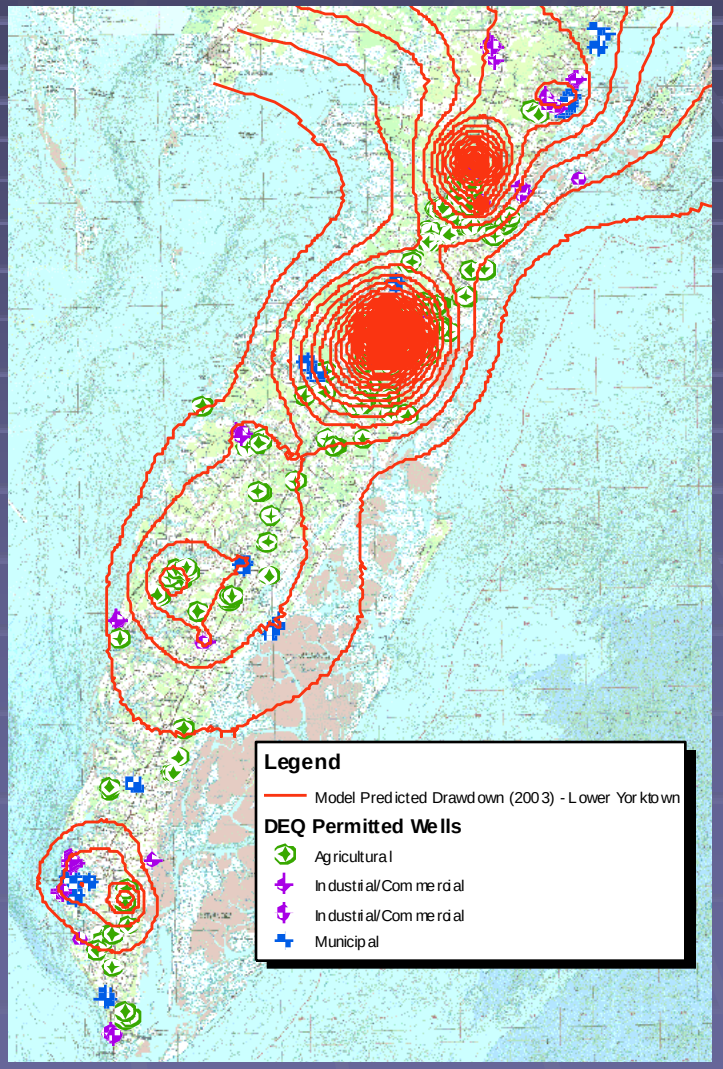


Use of Ground Water Models

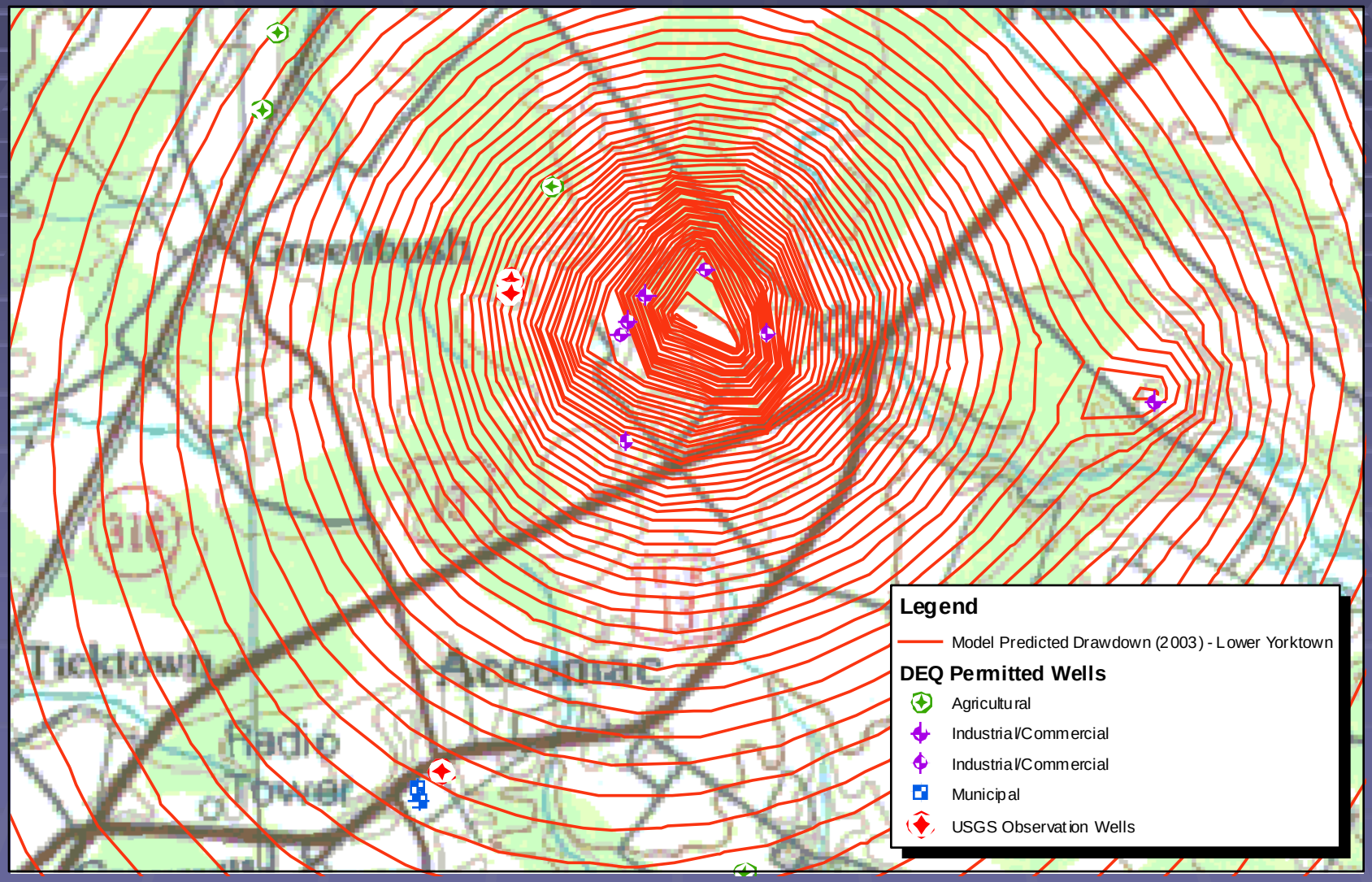
- Models:
  - Estimates ground water levels based on generalization of critical aquifer properties
  - Cannot be as exact as physical measurements
  - Can estimate water levels and water quality in areas where wells are absent
  - Can estimate water levels and water quality trends in the future

Model Predicted Drawdown In the Lower Yorktown Aquifer





Estimates Drawdown and Water Quality Effects Where No Observation Wells are Present



Available Water Evaluations

- A variety of approaches have been taken to quantify available water on the Eastern Shore.
- Primary limitation to developing one number is the solution is “non-unique”, dependant on many factors.

Spine Recharge Area Method

- Estimated 11-MGD recharge rate to Yorktown-Eastover aquifer for the entire Eastern Shore of Virginia. The majority of this recharge occurs in Accomack County.
- This method likely underestimates recharge amount:
  - Does not consider lateral flow from Maryland
  - Does not adjust recharge rate with increased use (pumping "induces" recharge to the Yorktown-Eastover aquifer).

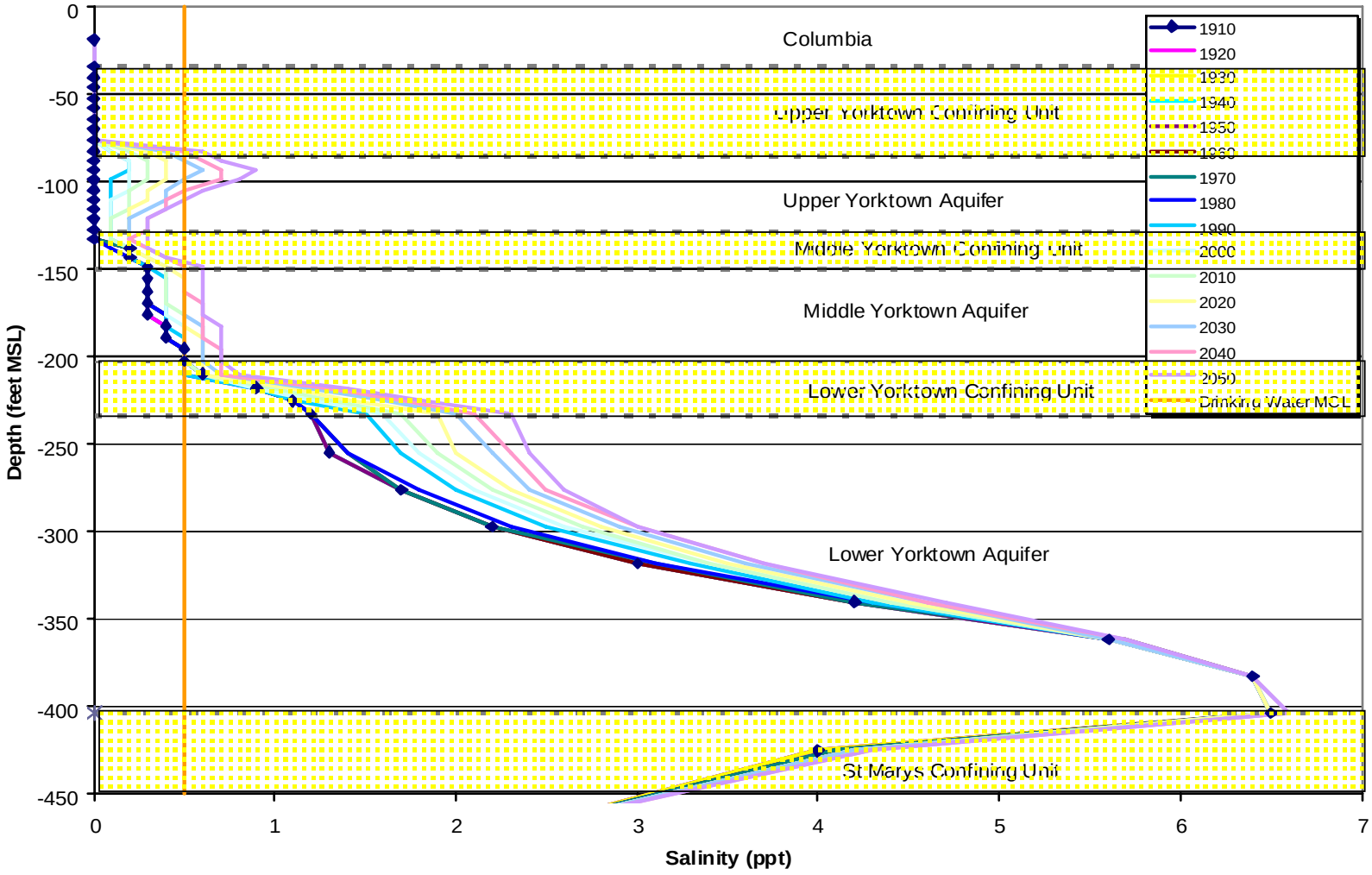
Local Development Area Approach

- All major public / industrial / municipal / agricultural use should be regulated by DEQ.
- The most significant non-permitted use are developments relying on individual private wells.
- Using the USGS Sharp-interface saltwater intrusion model under various development conditions (number of lots, lot size, lot density, aquifer used) predict likelihood that significant saltwater intrusion will occur under buildout for coastal areas and “spine recharge” areas.
- Limitation - this approach does not take into account other near-by users or site specific conditions.

A New Tool: USGS SEAWAT Model

- Beta Version
- Major Enhancements
  - Increased resolution:
    - minimum horizontal size 1,000x1,000 Feet – from original 1-mile
    - Vertical layers increased from original 4 to 46.
  - Functional Water Table
  - Increased lateral extent into Maryland
  - Ability to simulate gradational increase in saltwater
- Calibrated from 1920 through 2003 at 20 observation points

Town of Cape Charles
Model Predicted Water Quality



Summary

- Ground water is the sole source of water on the Eastern Shore and is available as a fresh water lens.
- Any ground water withdrawal reduces the size of the lens, thus reducing the amount of fresh water available for use.
- Current ground water use has not decreased the size of the freshwater lens to the extent that fresh water is unavailable over significant areas.
- Saltwater intrusion has occurred in limited areas on the Shore.
- Significant saltwater intrusion will occur in coastal areas and along the spine near high pumping areas if current ground water withdrawals increase substantially (2 to 3x the current maximum monthly use).
- Areas where fresh ground water is most abundant is near the spine recharge area.
- Availability of fresh water near the coast is largely site specific.

Reducing Saltwater Intrusion

- The most effective method is maximizing use of the water table aquifer.
- Localized saltwater intrusion is greatly reduced by concentrating new water supply near the Spine Recharge area.
- Encouraging reuse can reduce water consumption and/or increase recharge to the aquifer.
- Reducing total water consumption reduces overall demand. This is most critical in coastal areas where localized saltwater intrusion is more likely to occur. Some examples:
  - Low flow/Ultra low flow plumbing
  - Xeriscape Landscaping
  - Maintaining green space that does not require irrigation (cluster development, etc)
  - LIDD Stormwater controls that increase recharge

The Eastern Shore of Virginia Groundwater Committee has initiated a major revision and update of the Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia using a Sustainable Development Approach

Groundwater Supply and Protection Revision

- Original Plan finalized May 1992
  - Structured around "Wellhead Protection"
  - Generally approached issues separately
  - Focus on identifying resources, use, potential contaminant threats
  - Only considered the fresh water portions of the Yorktown-Eastover Aquifer
- New approach is based on Sustainable Use and is more systematic than the original Wellhead Protection Plan
  - Sustainable development is defined as:
    - ***"…the development that meets the needs of the present without compromising the ability of future generations to meet their own needs."***
    - ***And meets the following conditions:***
      - ***1. " Renewable resources such as fish, soil, and groundwater must be used no faster than the rate at which they regenerate."***
      - ***2. "Pollution and wastes must be emitted no faster than natural systems can absorb them, recycle them, or render them harmless."***

Focus Issues for Sustainability Effort

- Stakeholders needs and requirements
- Source, quantity, quantity of available water resources
- Threats to water supply
- New and emerging technologies and processes
- Cost constraints

Identify Stakeholders

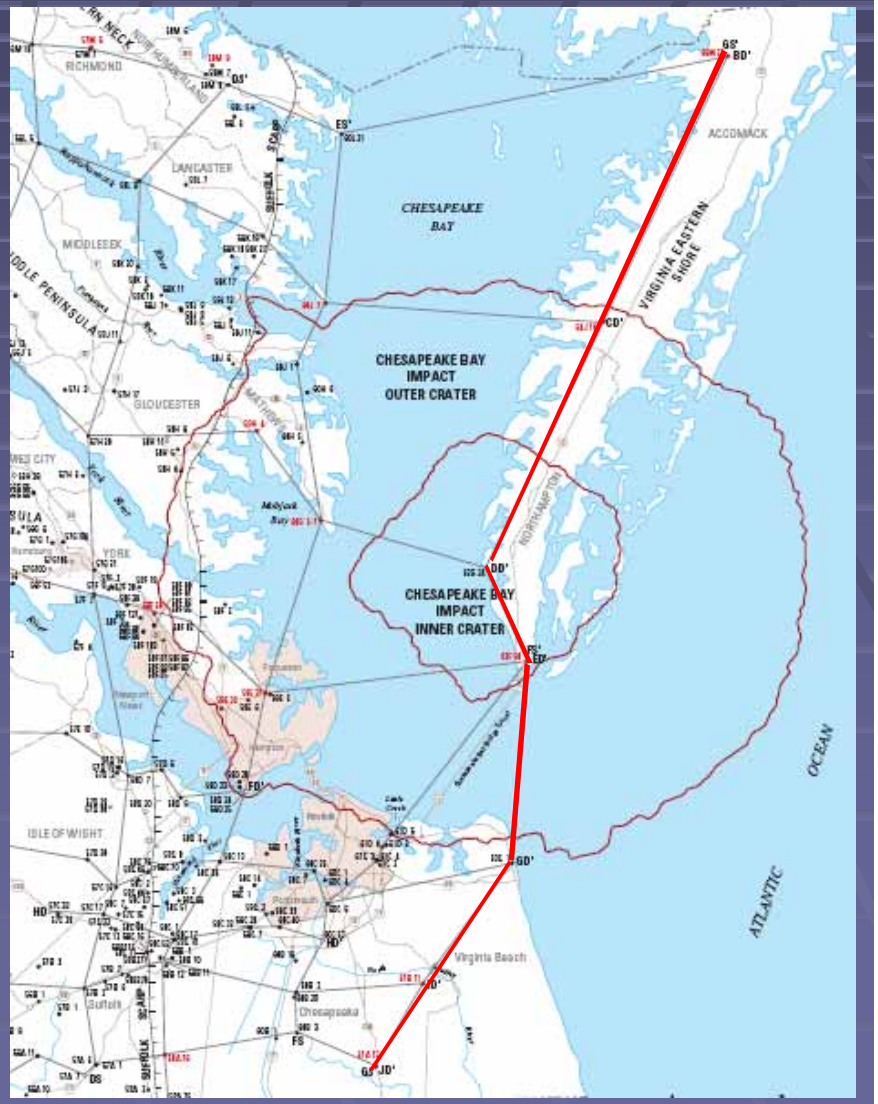
- Primary Users:
  - Individual domestic (residential)
  - Municipal / Public Water Supply
  - Developers
  - Agricultural
  - Aquiculture
  - Industrial
- Other Primary Stakeholders
  - Governmental Agencies
    - Local
    - State
    - Federal
  - Non-Governmental Organizations

Sources of Water

- Fresh Surface Water
  - Streams and Creeks
  - Dug Ponds
  - Stormwater
- Fresh Groundwater
  - Unconfined (Water Table) Columbia Aquifer
  - Yorktown-Eastover Aquifer (Confined)
- Brackish Groundwater
  - Yorktown-Eastover Aquifer (portions)
  - St. Marys Aquifer
  - Piney Point Aquifer
  - Potomac Aquifer
- Brackish / Saline Surface Water
  - Atlantic Ocean
  - Chesapeake Bay
  - Creeks and Bays
- Reuse
  - Municipal / Domestic
  - Industrial

Groundwater Aquifers on the Eastern Shore of Virginia

- Fresh Groundwater is restricted to the Columbia (Water Table) aquifer and significant portions of the Yorktown-Eastover aquifer
- Brackish groundwater is found in portions of the Yorktown-Eastover, all of the St. Marys Aquifer, Piney Point, and Potomac aquifers
- The Columbia, Yorktown-Eastover, and Piney Point aquifers are found throughout the Eastern Shore
- St. Marys and Potomac Aquifers are absent in the southern portion of the Shore



Groundwater Aquifers

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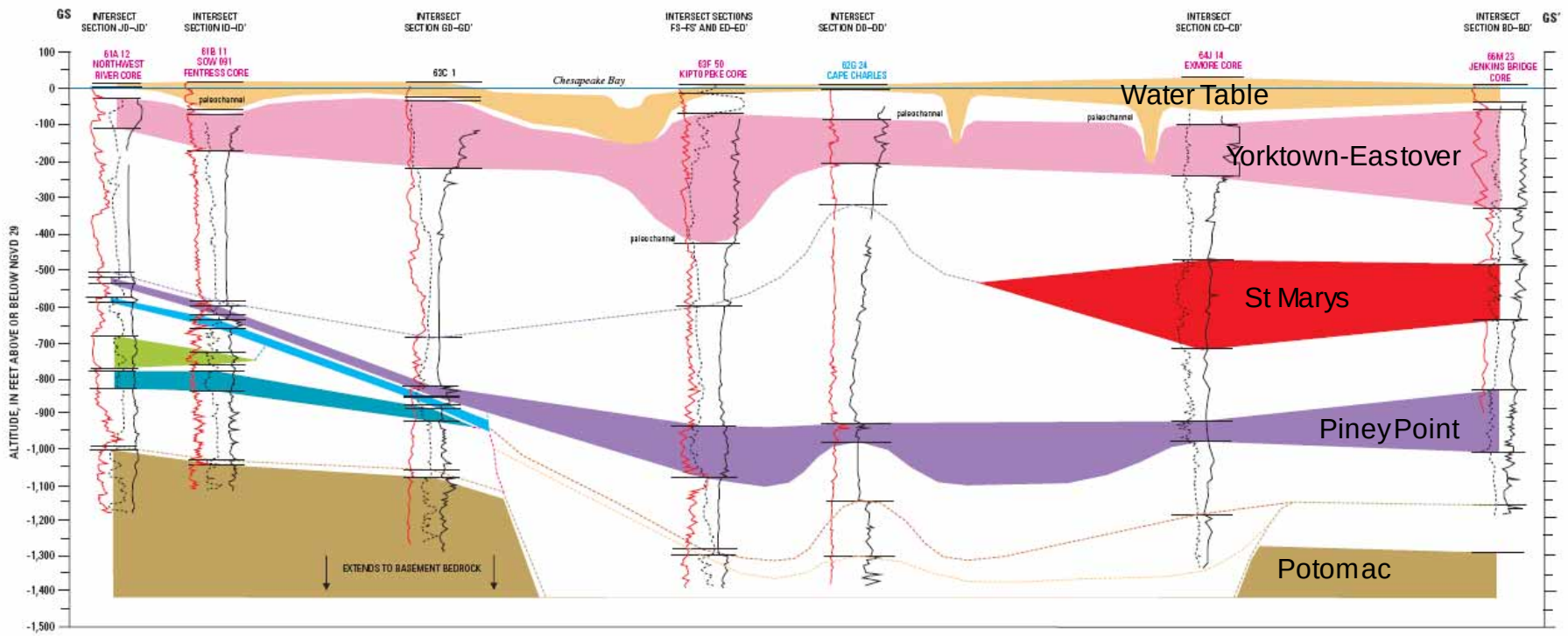

HYDROGEOLOGIC SECTIONS ES–ES', FS–FS', AND GS–GS' IN THE VIRGINIA COASTAL PLAIN

By

E. Randolph McFarland and T. Scott Bruce

2006

New and Emerging Technologies and Processes

- Alternate Sources to Fresh Groundwater:
  - Saltwater Treatment (Membrane and Ultrafiltration)
  - Reuse
  - Aquifer Storage and Retrieval / Recovery (ASR)
- Reduction:
  - Conservation
  - Buried Infrastructure and System Improvements

Cost Constraints

- Some technologies that, 20-years ago were considered cost prohibitive in many areas are now cost competitive:
  - Membrane desalting technologies have decreased on average 10% per-year over the past 10-years.