Geologic Framework and Groundwater Resources of the Aquifers of Southern Delaware

A Presentation to the USGS Mid-Atlantic Water-Use Workshop, April 19-20, 2010

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Outline

1. Objectives and Background
2. Status
3. Unconfined aquifer work
4. Confined aquifer work
5. Hydrology and water use

Issues

recurring themes

1. **Datasets** *(locations; different sources; incomplete data sets; missing data)*
2. **Geology/Hydrology** *(variable data quality; complexity vs classification; boundaries, geologic and human)*

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1. **Objectives and Background**
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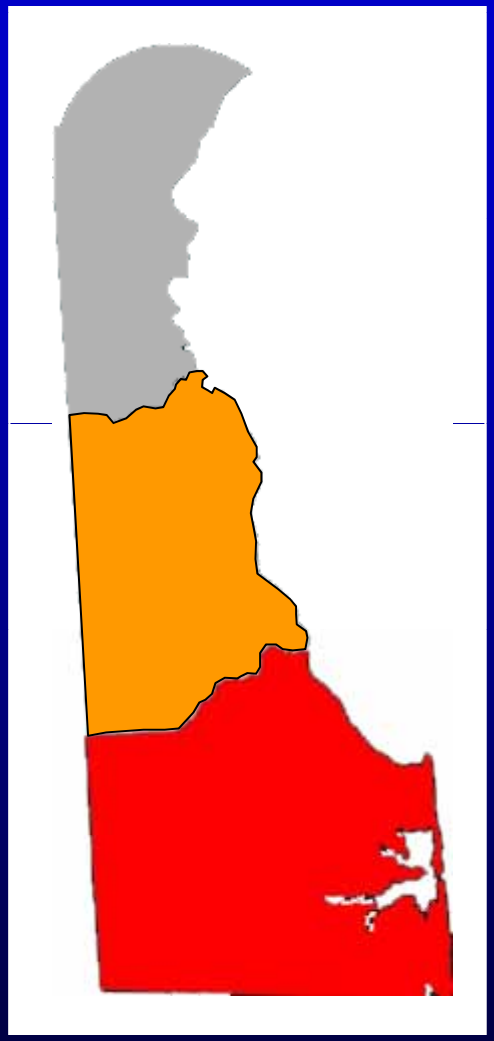
Goals

1. To establish an up-to-date summary of the ground-water resources of Sussex County, Delaware

2. To add on to previous confined aquifer mapping in Kent County, Delaware to make a complete summary of the ground-water resources for the county



Project Objectives

1. Assemble an up-to-date summary of the groundwater resources of Sussex County, Delaware:
   - Confined aquifer geology
   - Aquifer hydrology (yield, head)
   - Groundwater Use
2. Do a complementary study for Kent County:
   - Unconfined aquifer geology
   - Aquifer hydrology (yield, head)
   - Groundwater Use

   using the same methodologies as for Sussex.
3. Approach:
   - use selected, existing, high-quality data and acquire new data in key areas;
   - establish carefully documented methodologies for estimation/interpretation where high-quality data are lacking;
   - identify issues/areas for further study.

Starting Premise

Accurate Understanding of Aquifer Geology

is essential to

Accurate Understanding of Groundwater Availability

Geology controls where the groundwater is, where it goes, and how much we get

Why Do This Study?

Why do this study?

1968-70

Last comprehensive reports on southern Delaware ground-water availability and aquifers are 40 years old (Sundstrom and Pickett, 1968, 1969 & 1970)

Why do this study?

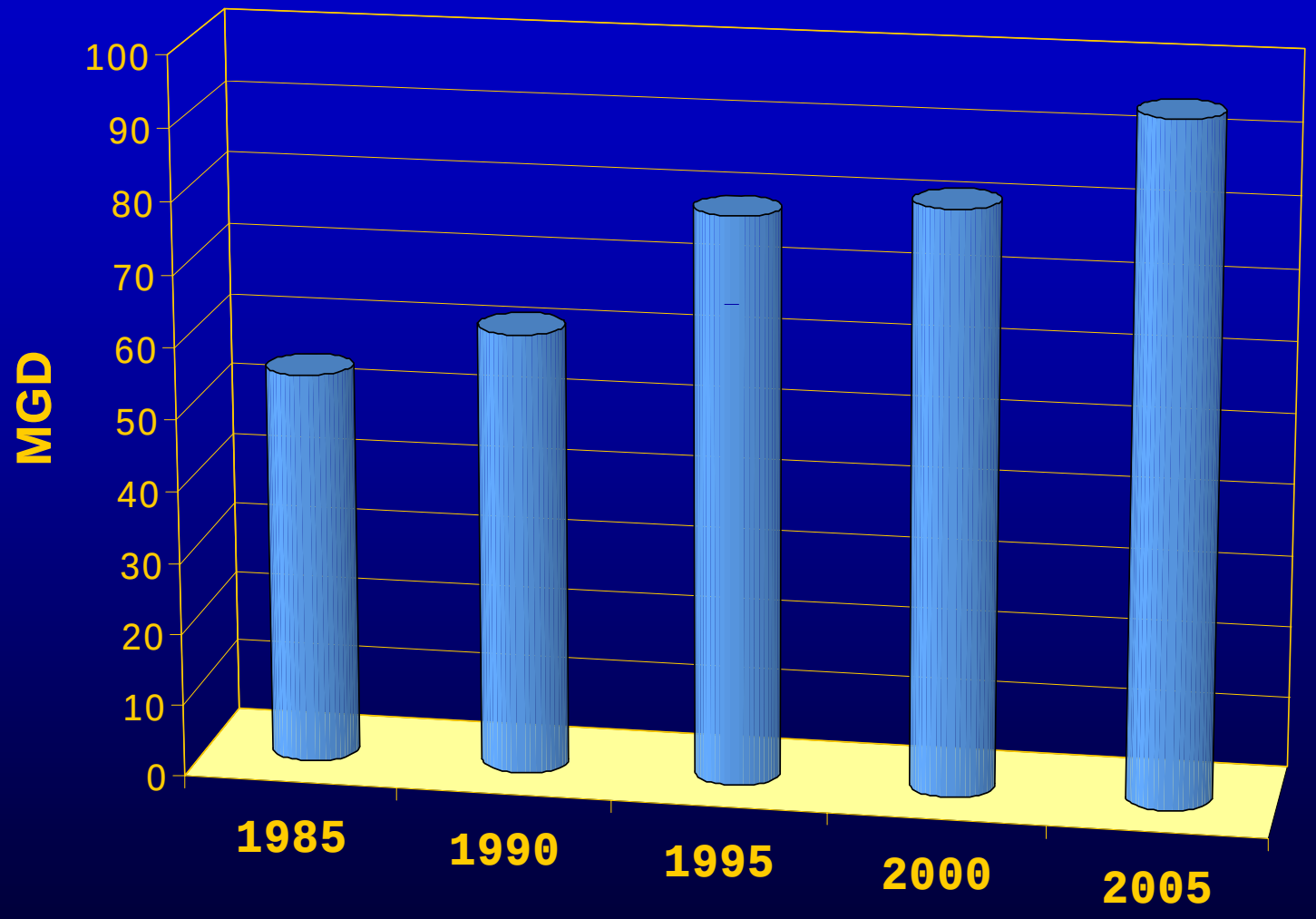
Kent/Sussex Groundwater Use

95

million gallons per day

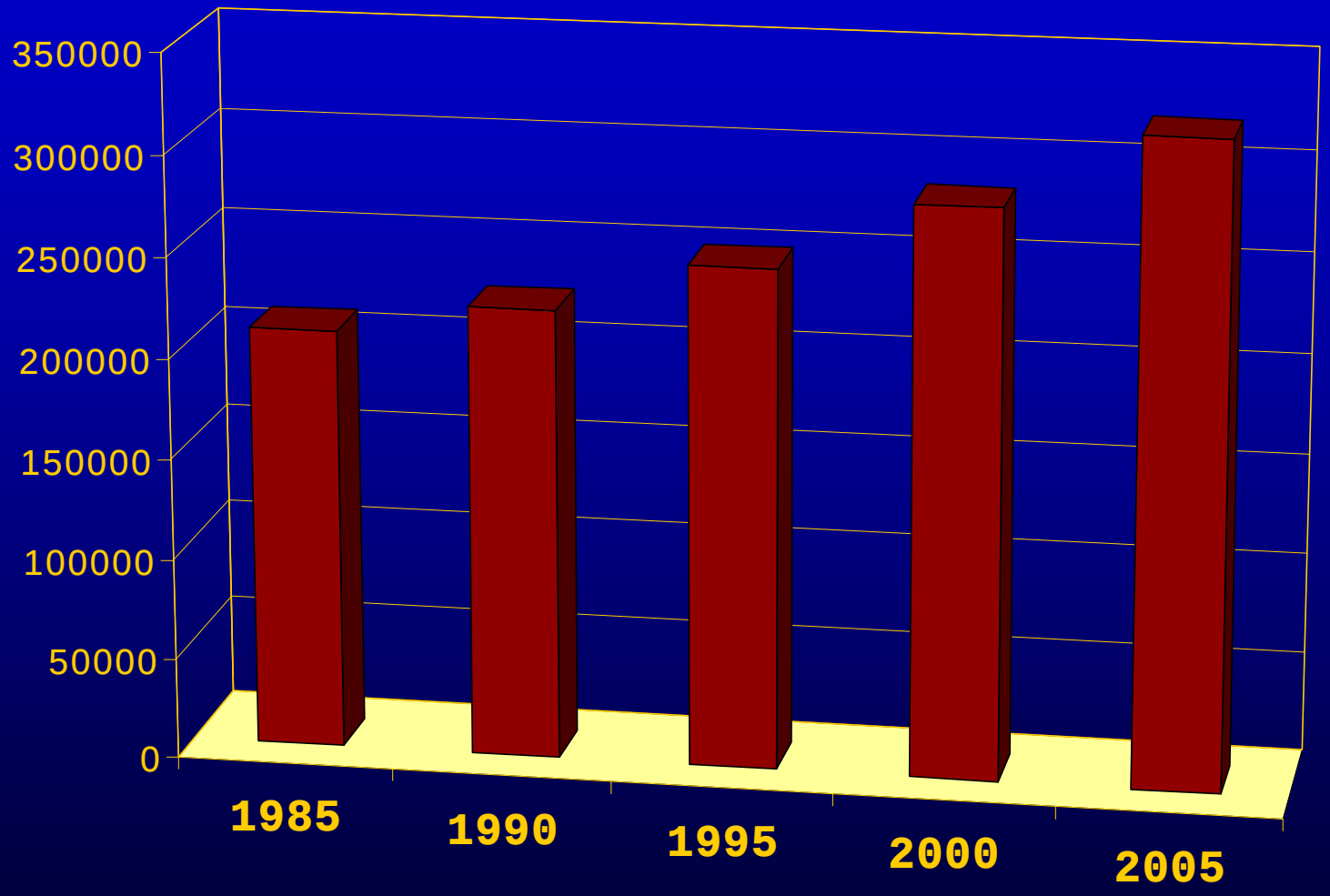
Kent + Sussex groundwater use in 2005 per USGS (http://water.usgs.gov/watuse/data/2005/)

Kent + Sussex Groundwater Use



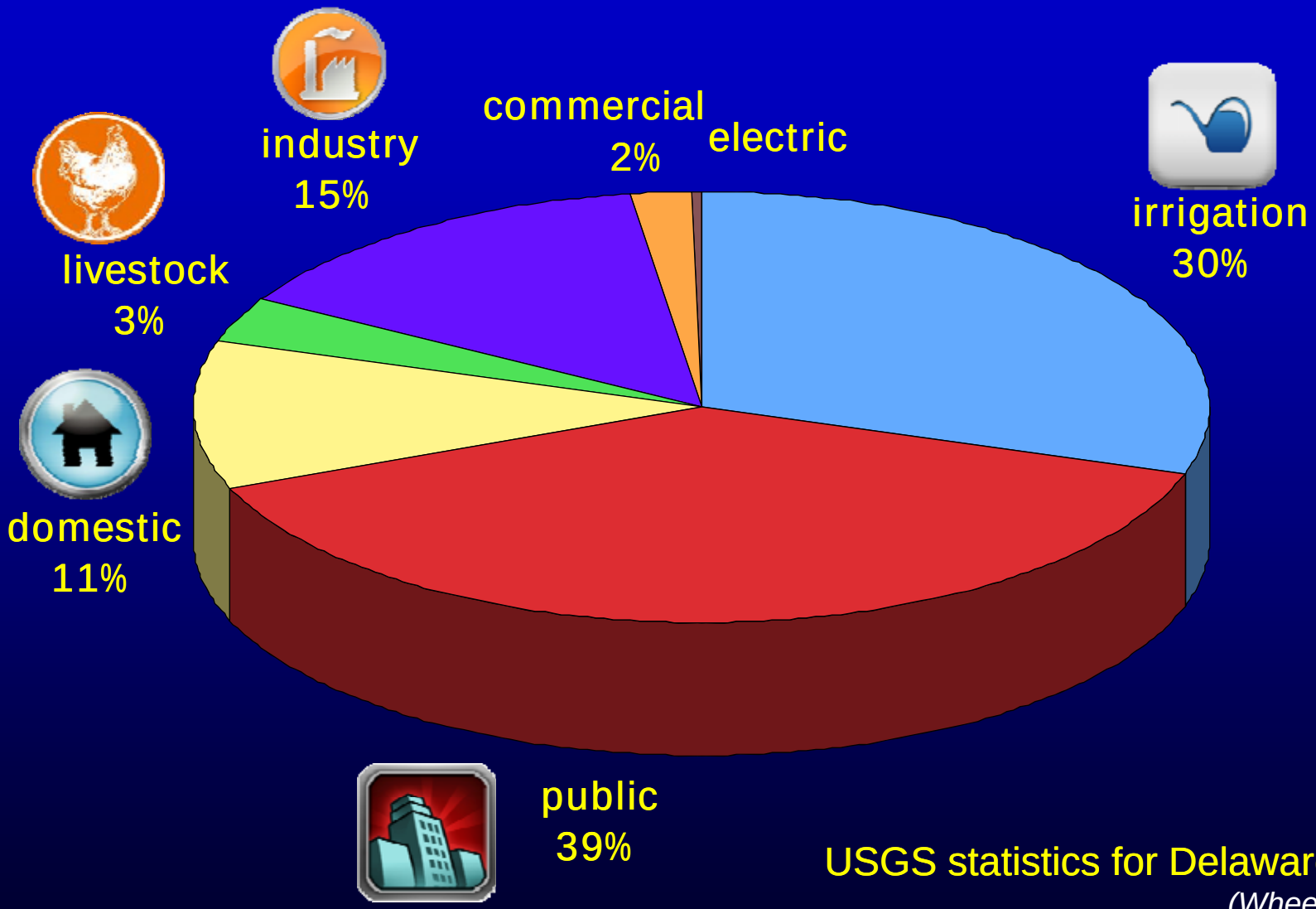
Data from USGS (http://water.usgs.gov/watuse/data/2005/)

Kent + Sussex Population



Data from USGS (http://water.usgs.gov/watuse/data/2005/)

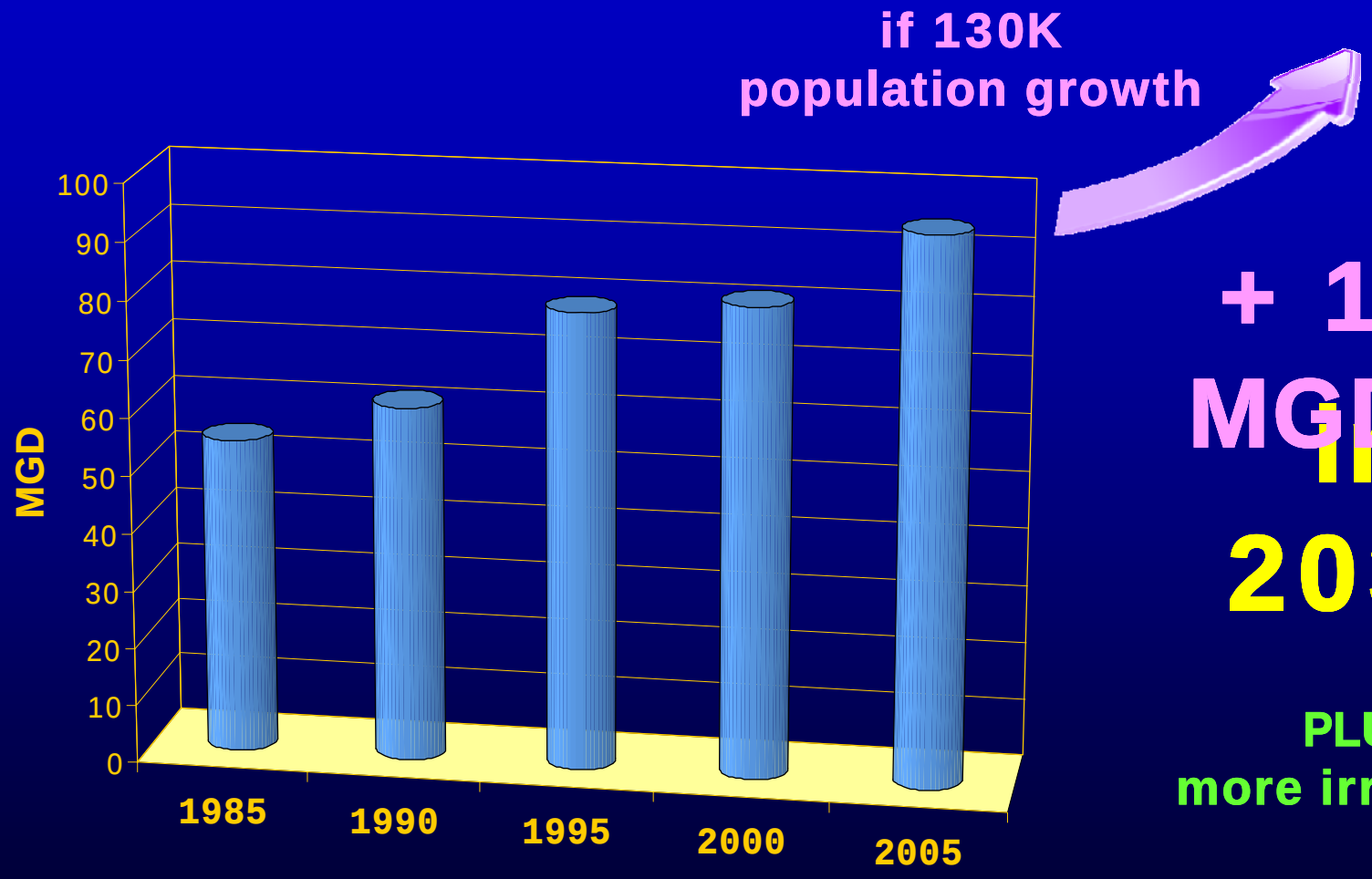
Groundwater Usage



USGS statistics for Delaware, 2000

(Wheeler, 2003)

Kent + Sussex Groundwater Use



Outline

1. Objectives and Background
2. **Status Summary**
3. Unconfined Aquifer studies
4. Confined Aquifer studies
5. Hydrology and Water Use

Status Summary

- Geology work is near completion
- Hydrology work will be focus in 2Q-3Q 2010
  - Analysis of water use data, estimation for data gaps
  - Analysis of aquifer characteristics, well test data
- Project has taken more time than planned
  - Technical difficulty of some tasks
  - Review/revision cycles (locations, consistency)
  - Unanticipated delays in acquisition of water use data

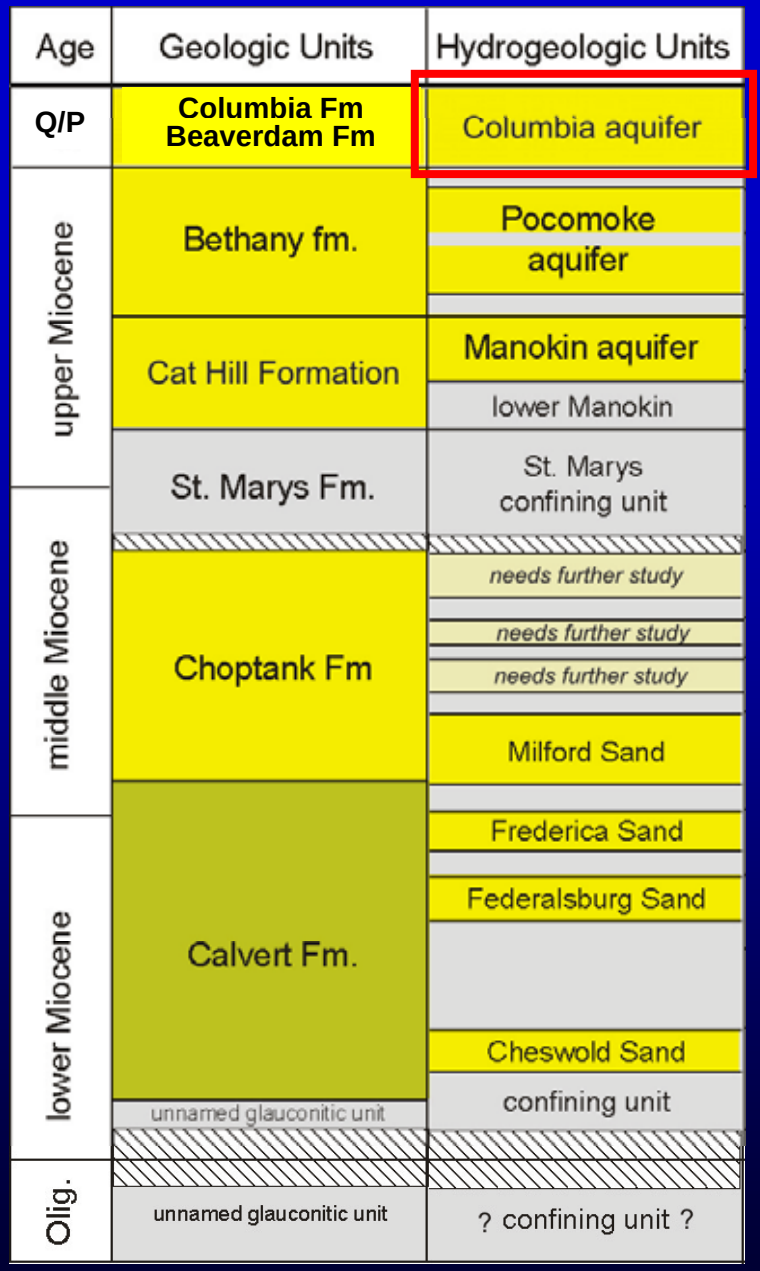
Goal: Complete analyses in 3Q 2010

Outline

1. Objectives and Background
2. Status
3. **Unconfined aquifer work**
4. Confined aquifer work
5. Hydrology and water use

Southern Delaware Aquifers

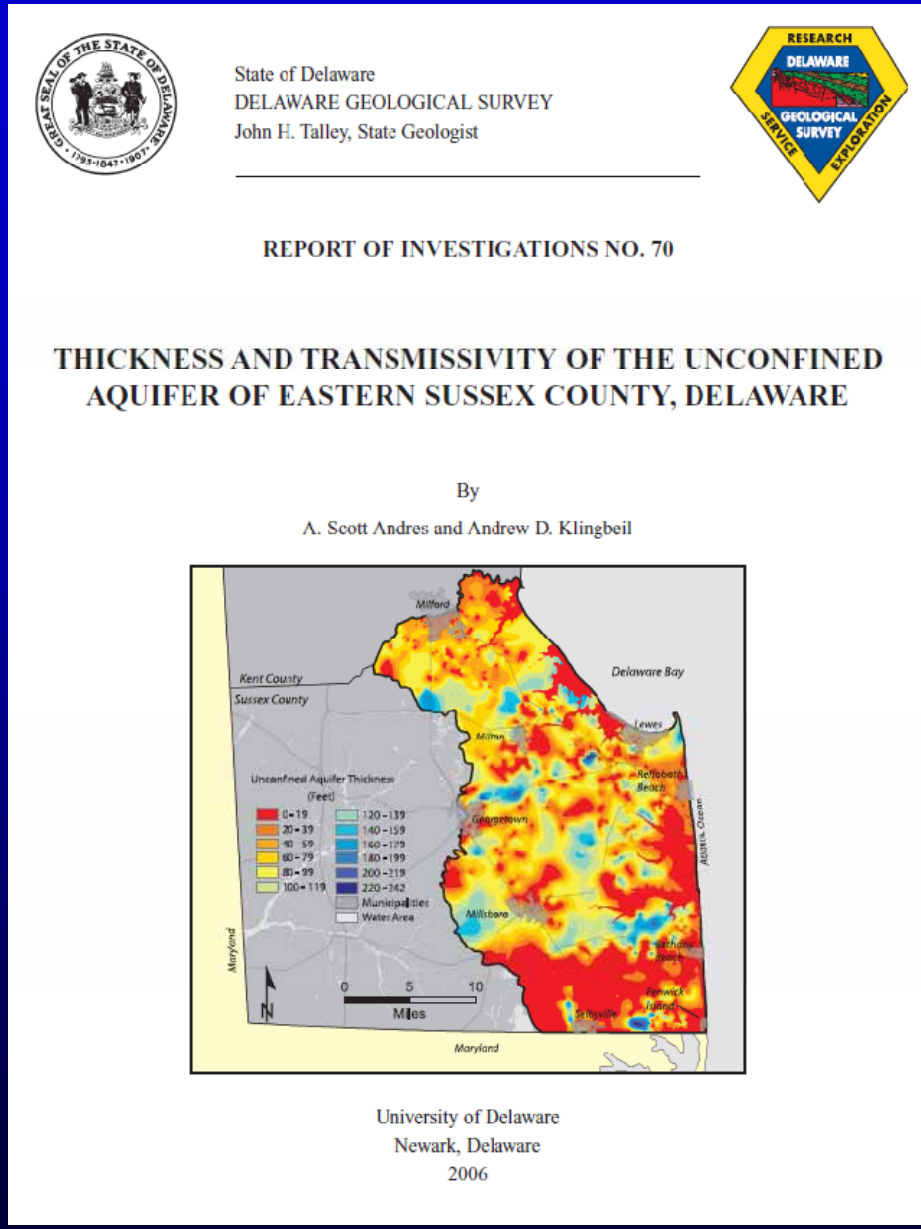
Unconfined
=
Columbia aquifer



Unconfined Aquifer, Eastern Sussex County

Andres and Klingbeil, 2006

- Thickness map
- Elevation of base
- Transmissivity map
- > 2600 data points
- Used drillers' and geophysical logs



State of Delaware
DELAWARE GEOLOGICAL SURVEY
John H. Talley, State Geologist

REPORT OF INVESTIGATIONS NO. 70

THICKNESS AND TRANSMISSIVITY OF THE UNCONFINED AQUIFER OF EASTERN SUSSEX COUNTY, DELAWARE

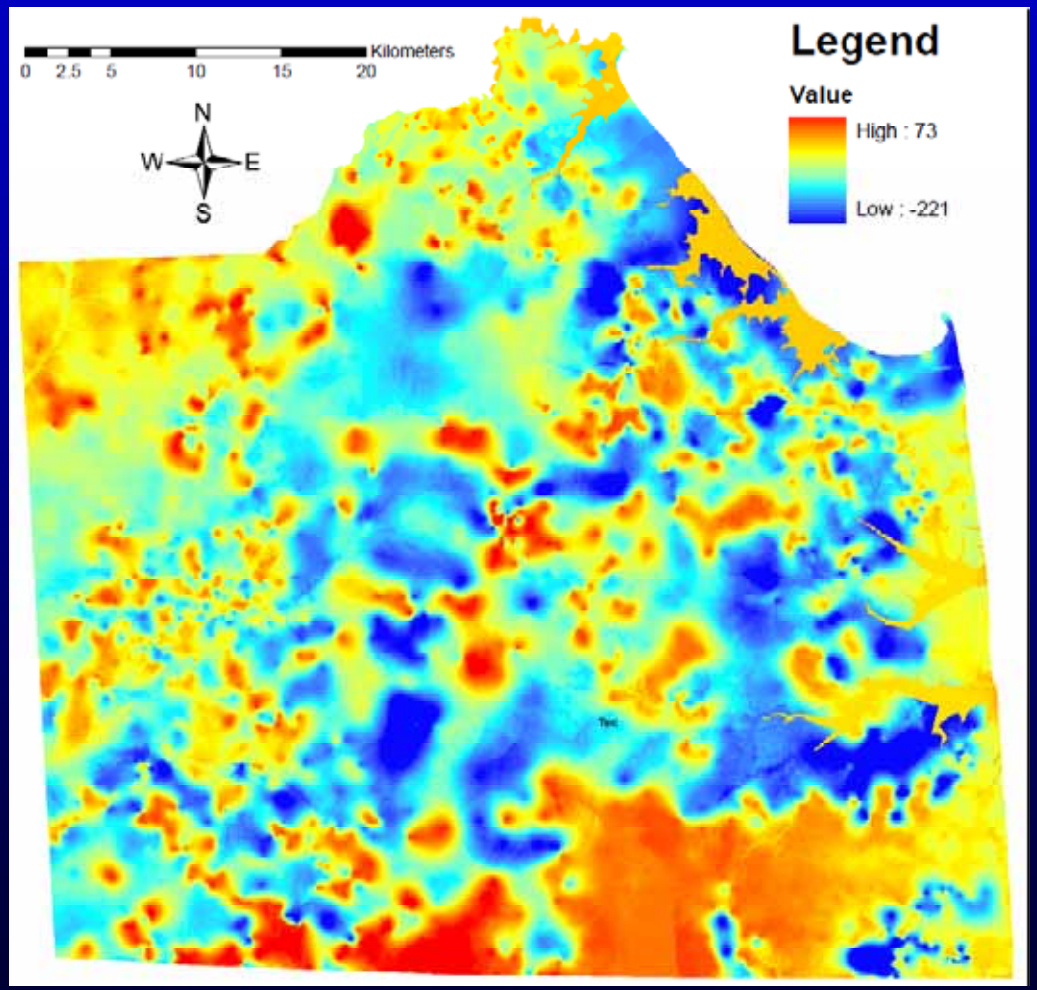
By
A. Scott Andres and Andrew D. Klingbeil

University of Delaware
Newark, Delaware
2006

Unconfined Aquifer, Sussex County

Klingbeil and Andres, 2006

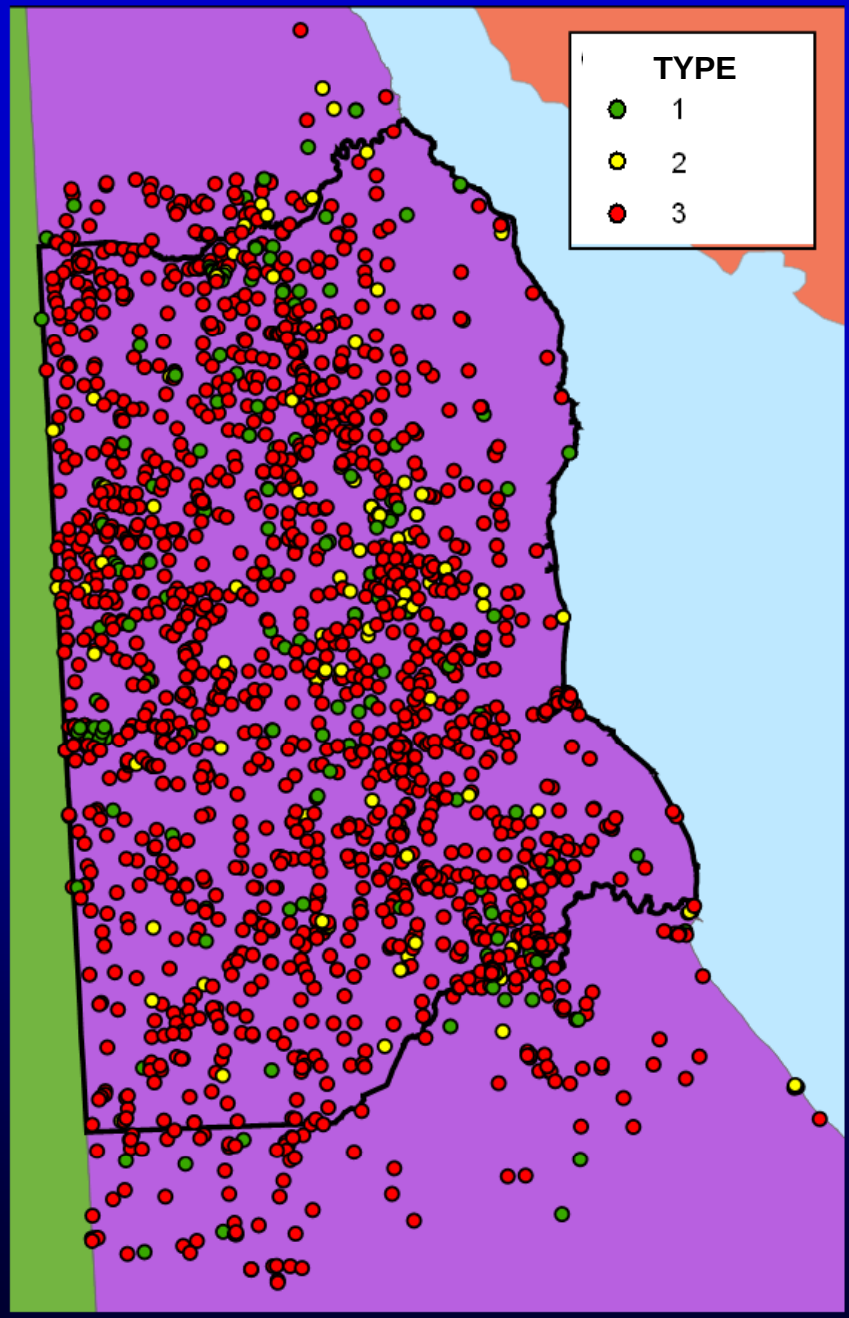
- Thickness map
- Elevation of base
- Transmissivity map
- > 4200 data points
- Used drillers' and geophysical logs



Unconfined Aquifer, Kent County

~2000 data points where entire thickness of unconfined aquifer reached

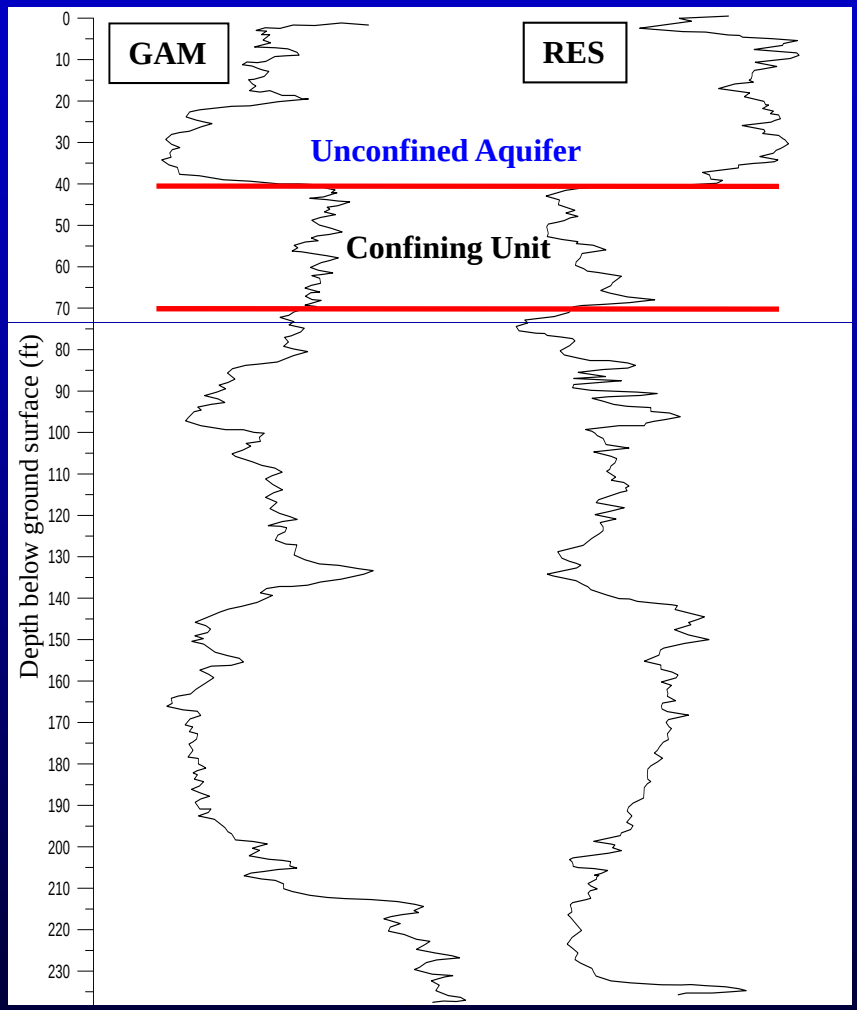
- Most only have drillers' logs (3)
- A lesser number have drillers' and geophysical logs (2)
- Some have only geophysical logs (1)
- *Well locations a MAJOR issue*



Unconfined Aquifer Mapping

Criteria

- Depth of base of unconfined = top first > 10 ft thick confining bed
- Geophysical often clear



Unconfined Aquifer Map Revision

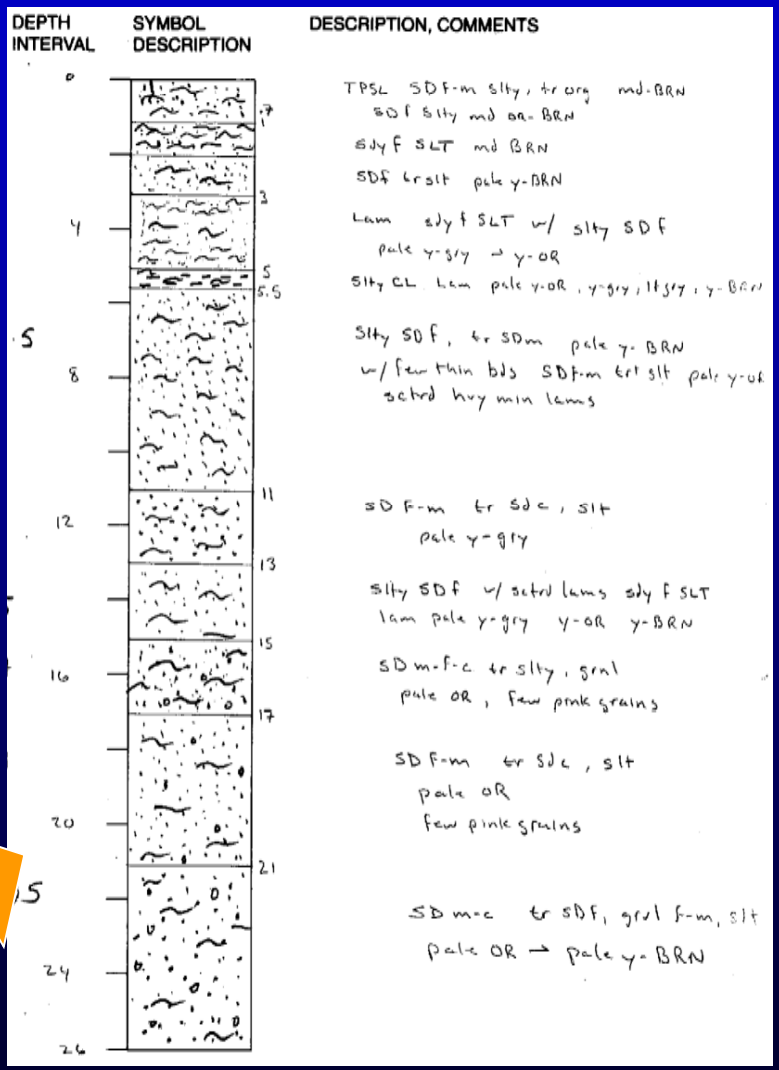
- Generally good: Geologist logs
- Wildly variable: Drillers' logs
- Best hope: consistency

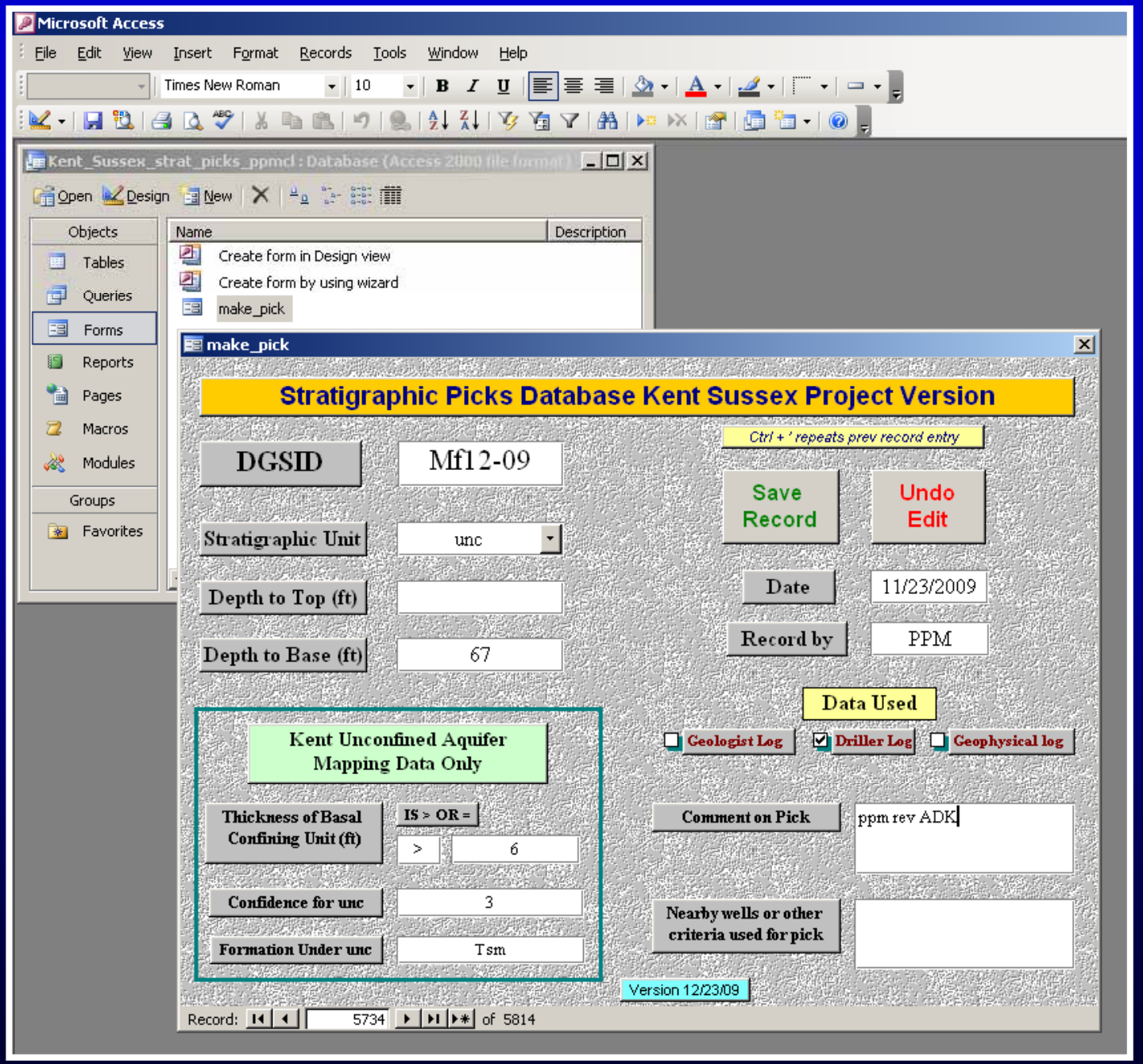
DRILLERS LOG	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
top soil	6'	6'
clayey fine tan sand	42"	4'
silty, sandy white clay	7	11
fine white sand and silt	5	16
Coarse lt. yellow sand & sm. gravel	8	24
same, orange	1	25
very fine to very coarse, white and some pieces of lt. bluish-gray silty clay (dependably wavy water)	30	55
very fine to very coarse yellow sand	5	60
very fine to coarse yellow sand	13	73
very fine to coarse light yellow sand	4	77
very fine to very coarse orange sand and small gravel	5	82

example: block Md42

WELL CONTRACTOR Kenny Used LOT 101

DESCRIPTION	TOP OF STRATA	BOTTOM OF STRATA
Sand	0	5
Sand & Clay	5	15
Tan Sand	15	40
Br. Sand	40	52

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Kent_Sussex_strat_picks_ppmcl : Database (Access 2000 file format)
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Stratigraphic Picks Database Kent Sussex Project Version
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ppm rev ADK
Nearby wells or other criteria used for pick
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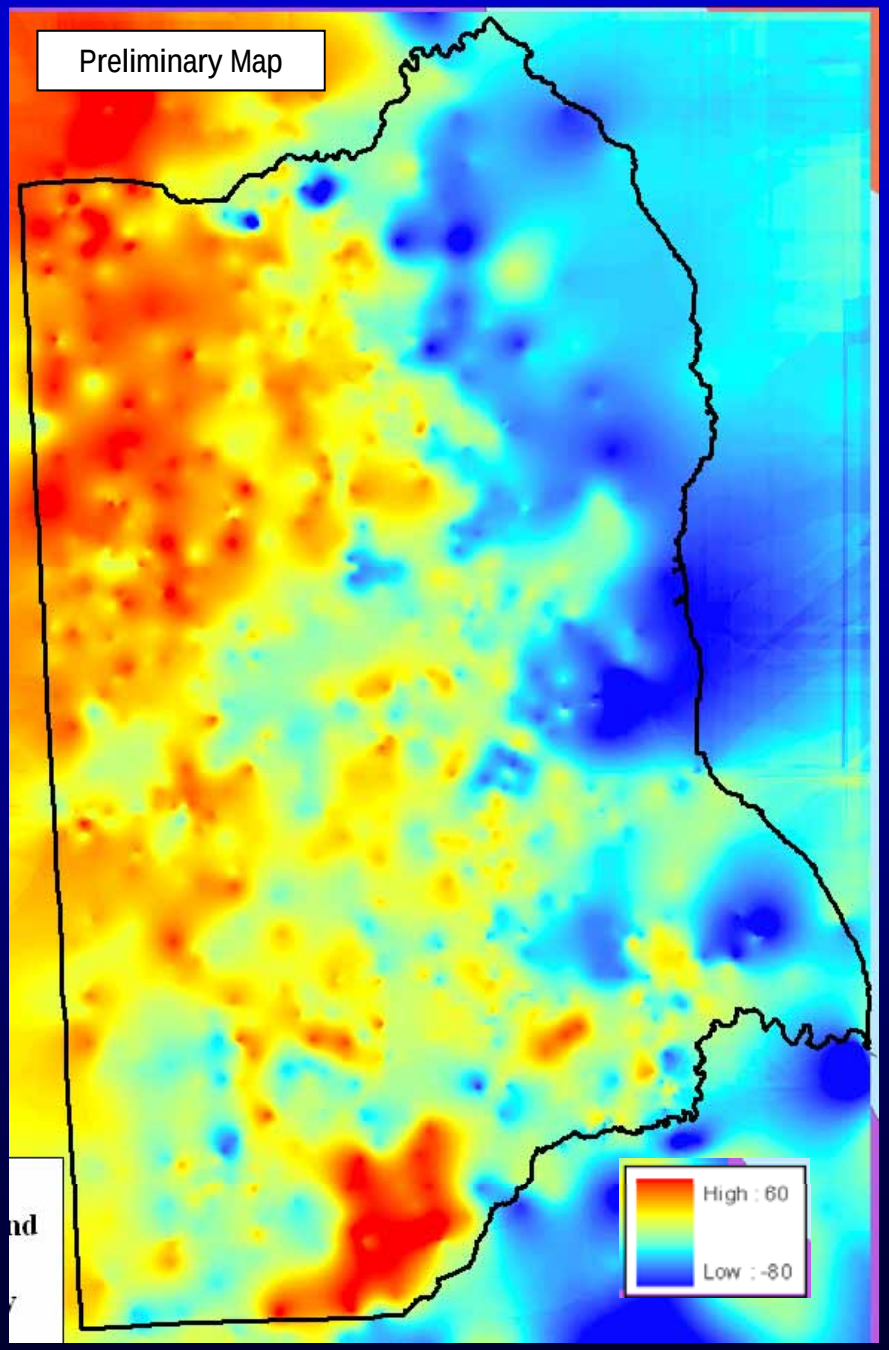
Unconfined Aquifer, Kent County

Data QC and review processes are critical

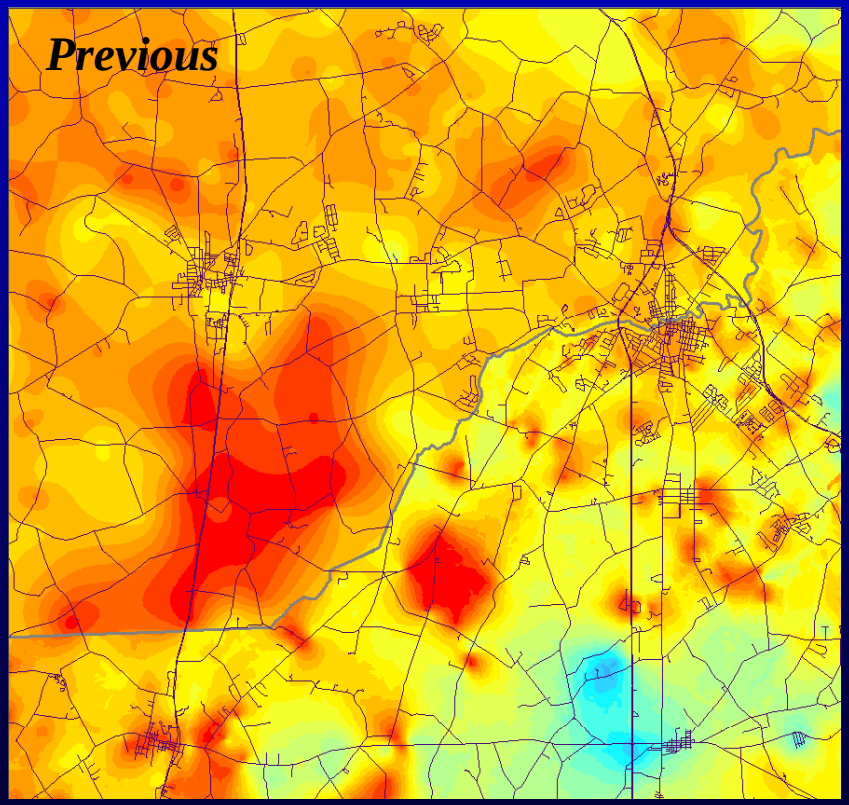
Preliminary grid required significant revision

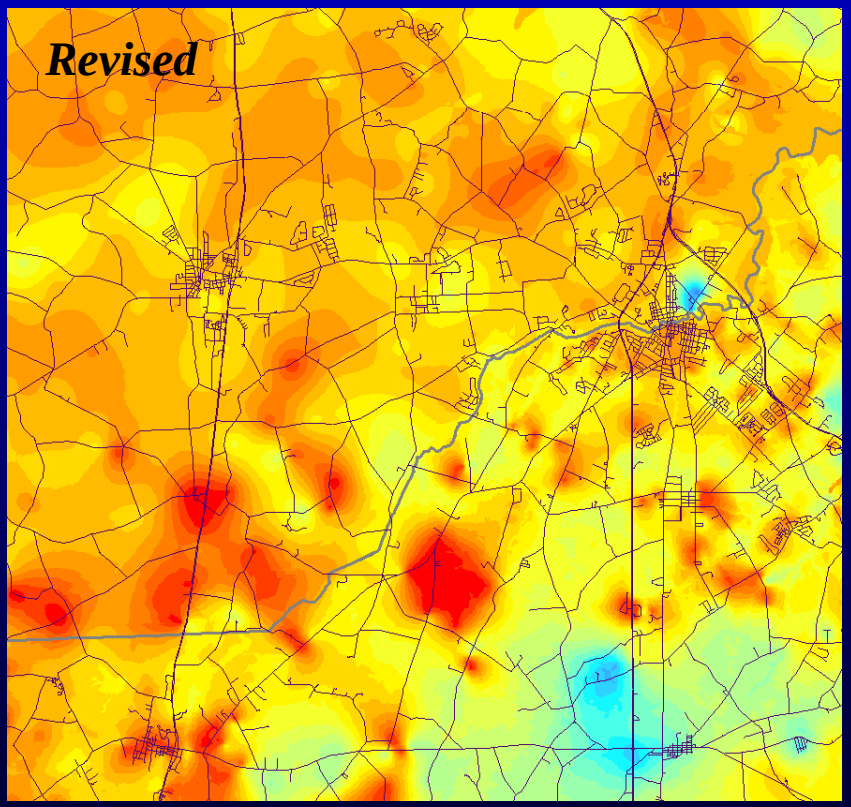
1. Inconsistent unconfined aquifer depths in places
2. Kent grid did not fit with Sussex grid in some areas of county line
3. 3-dimensional constraints



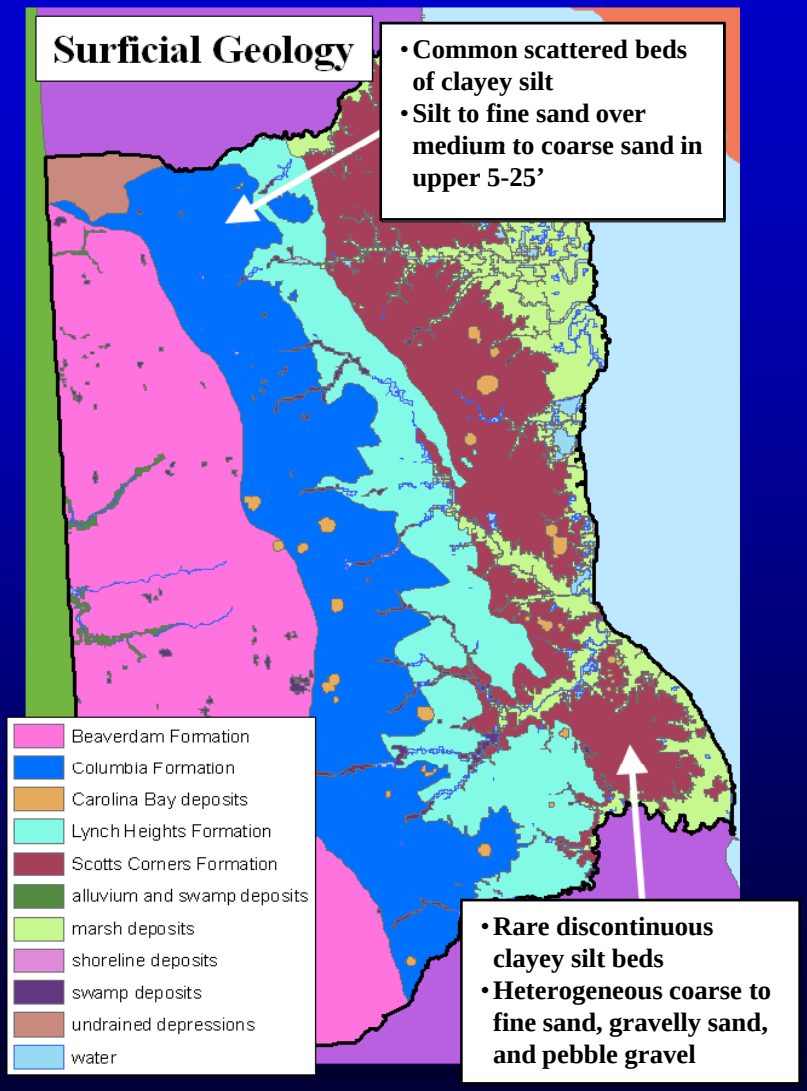
Unconfined Aquifer Elevation Grids: Seams

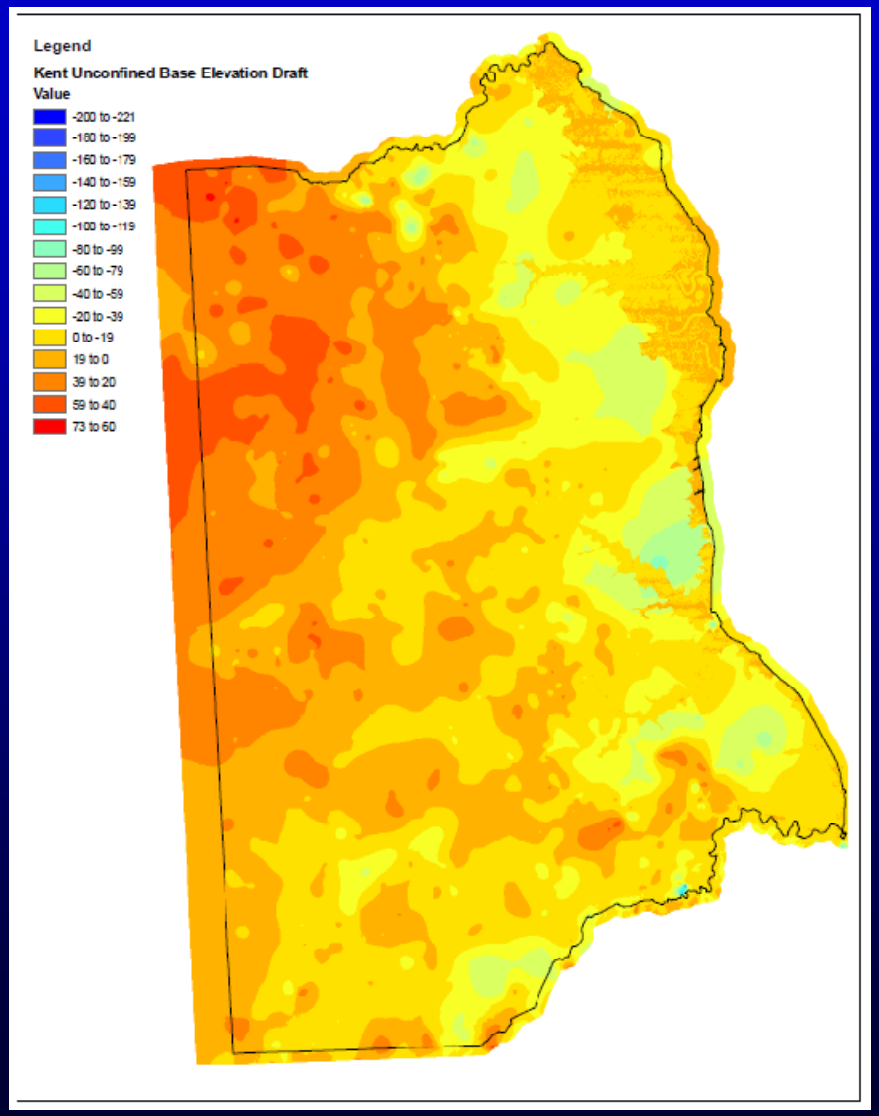
County Boundary Before and After



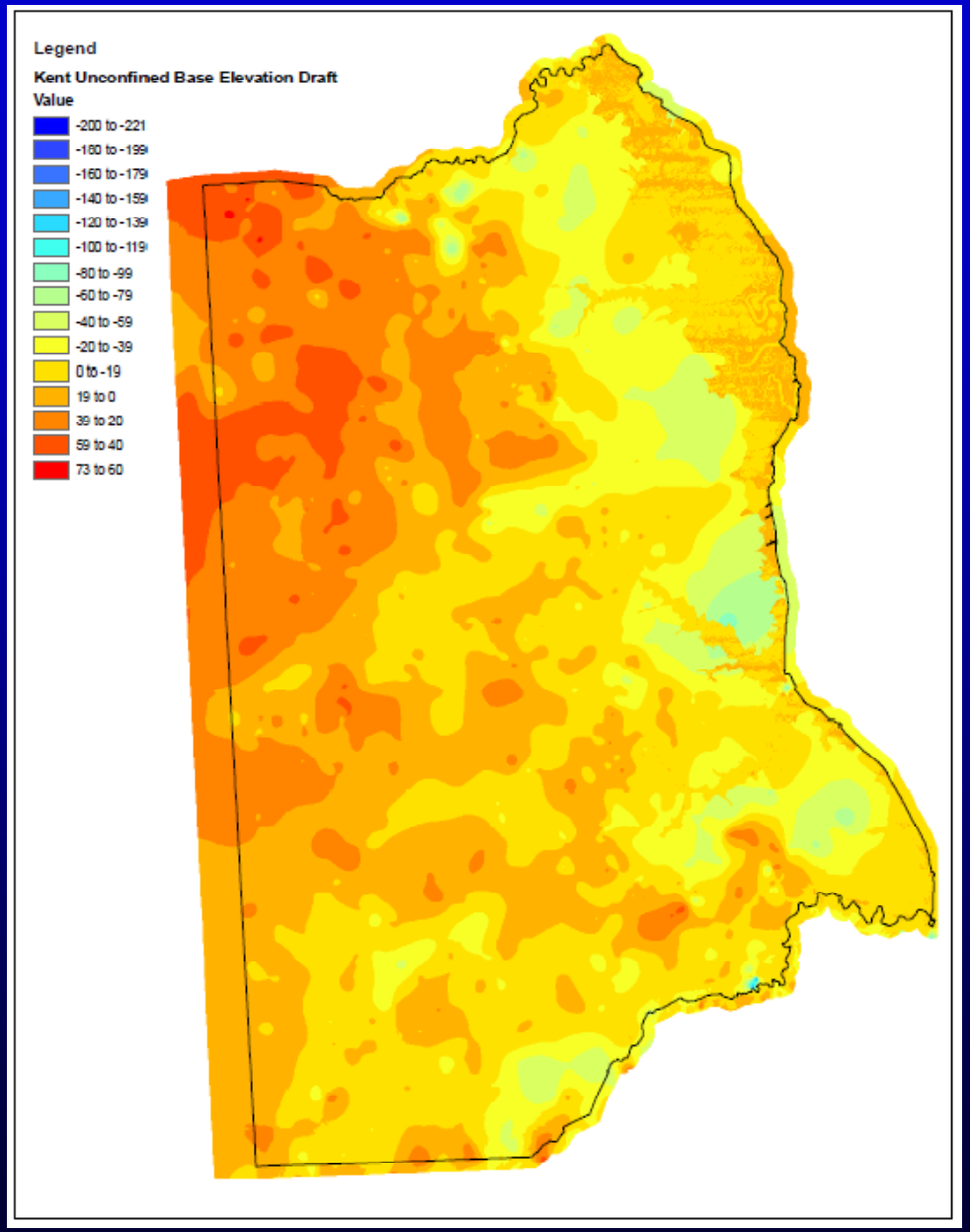


Unconfined Aquifer: Geologic Trends

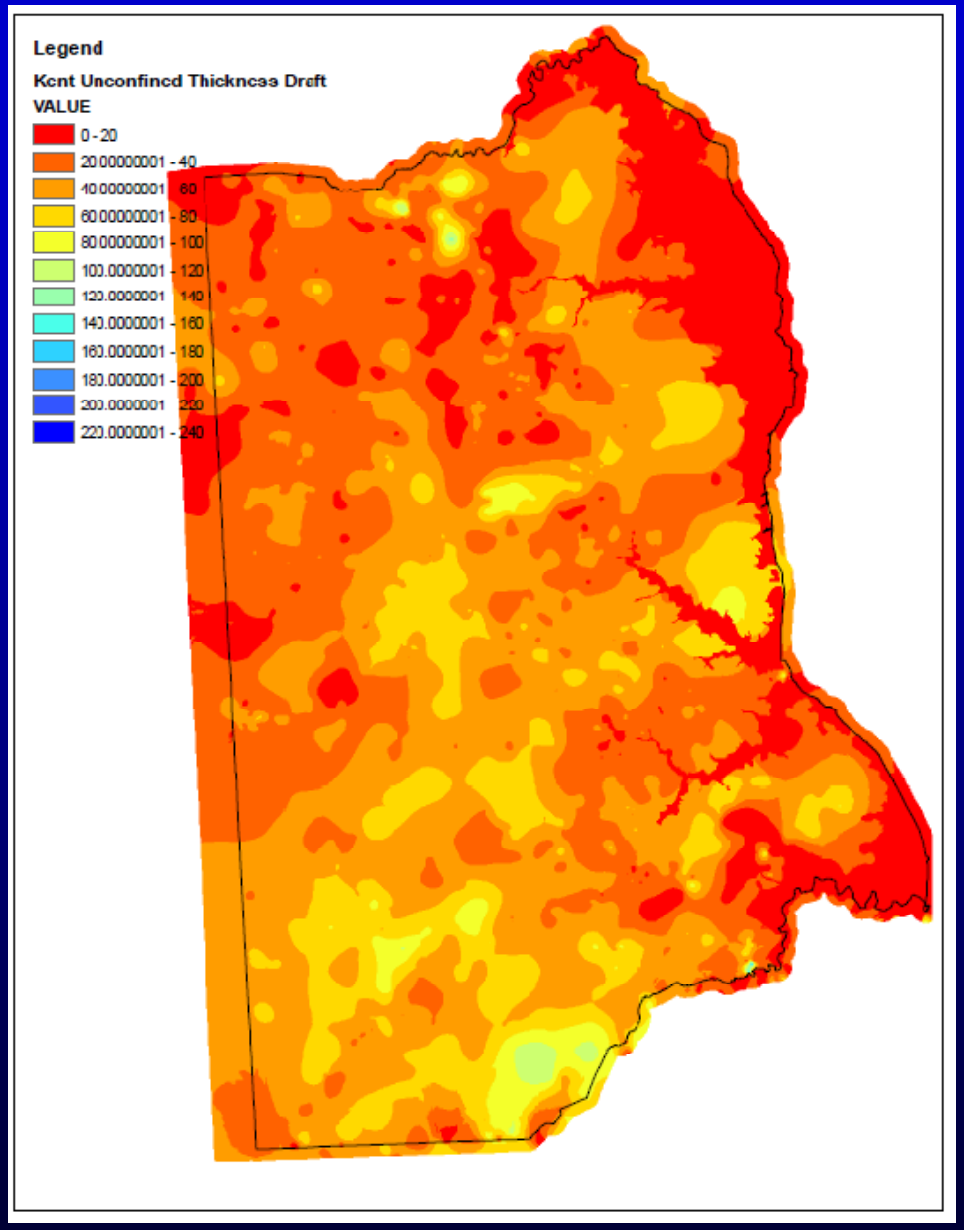




Unconfined Aquifer Elevation Grid: Revised



Unconfined Aquifer Thickness Grid: Revised



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Southern Delaware Aquifers

southern & eastern Sussex County confined aquifers

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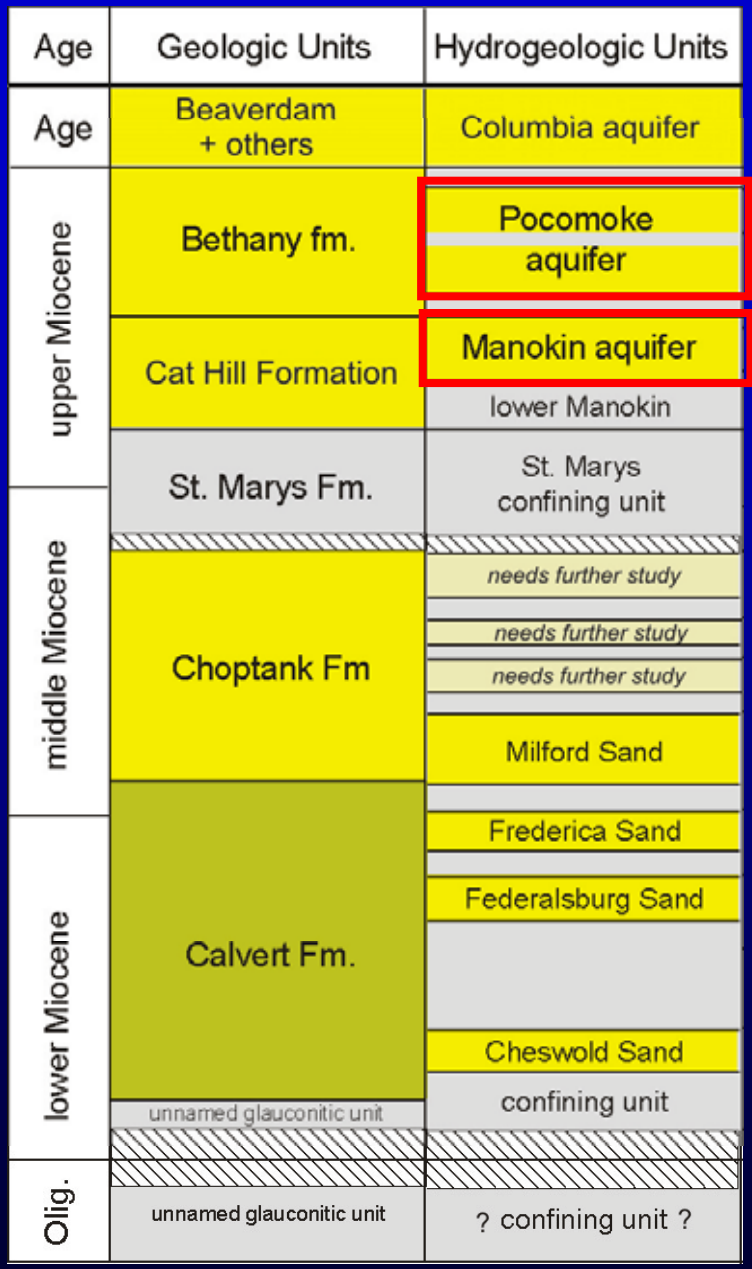
Upper Miocene complex



Southern Delaware Aquifers

confined aquifers of Kent and northern and western Sussex

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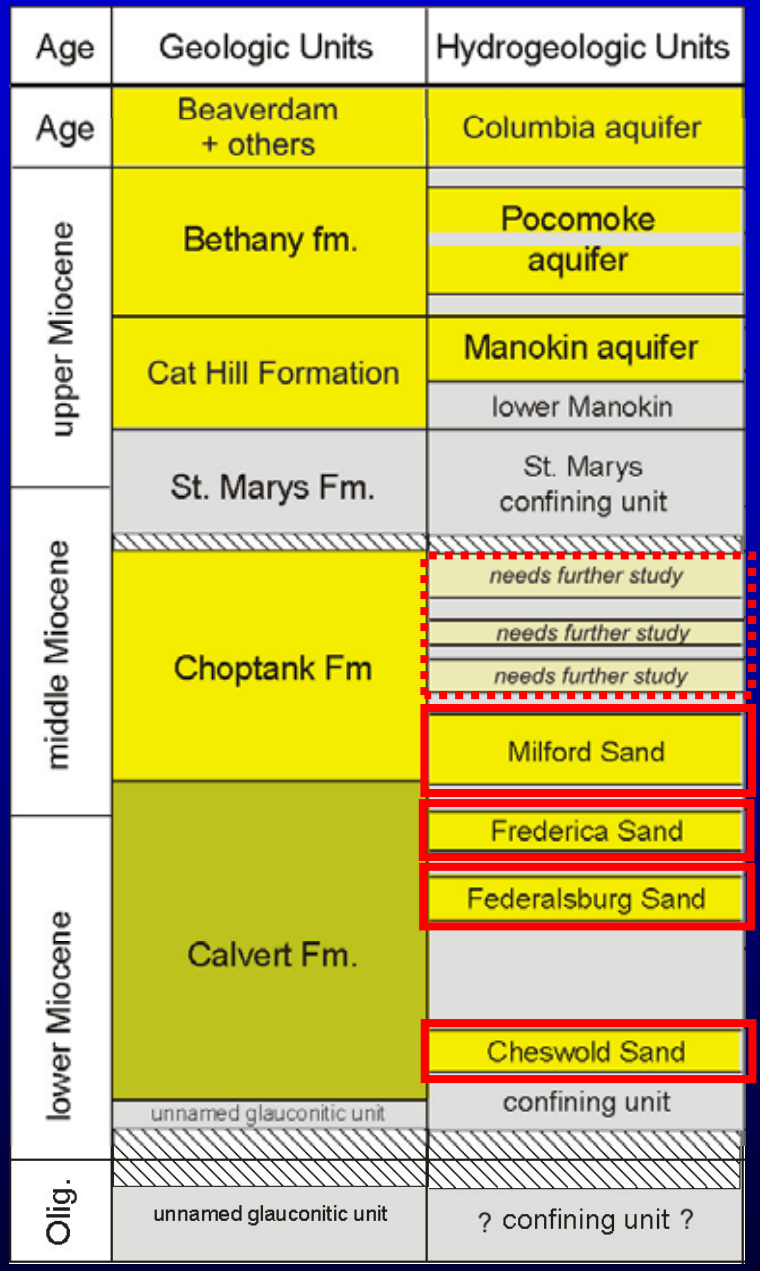
Choptank-Calvert complex



Southern Delaware Aquifers

northern to central Kent confined aquifers

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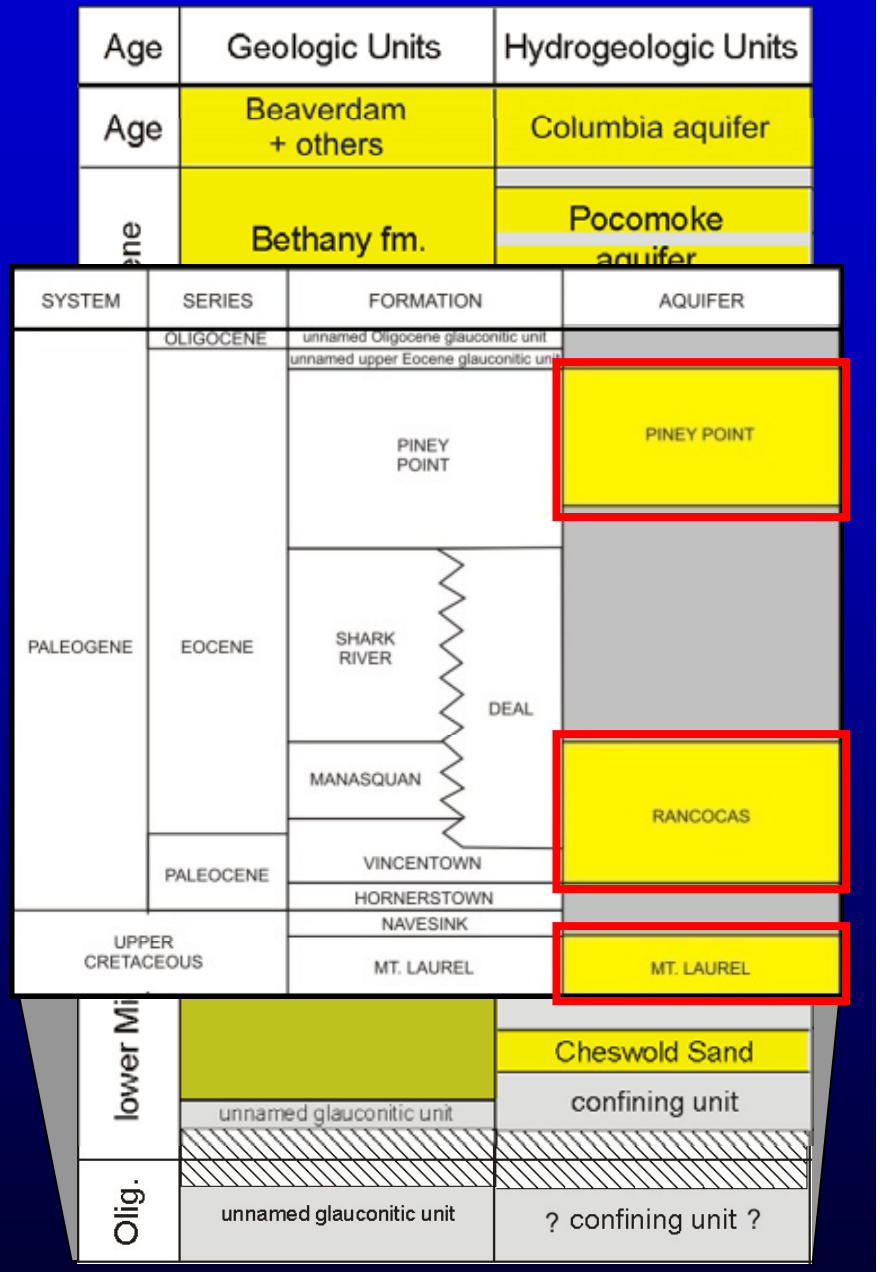
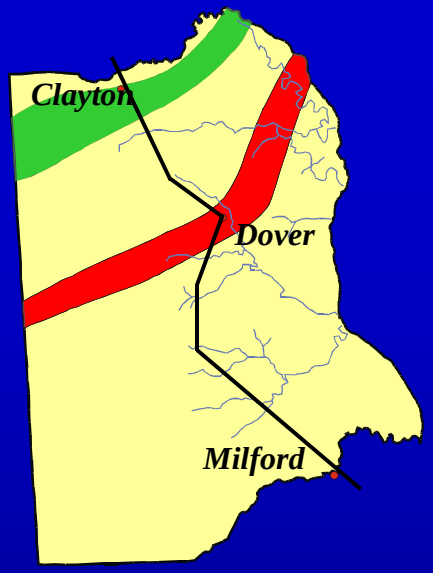
Piney Point

Rancocas

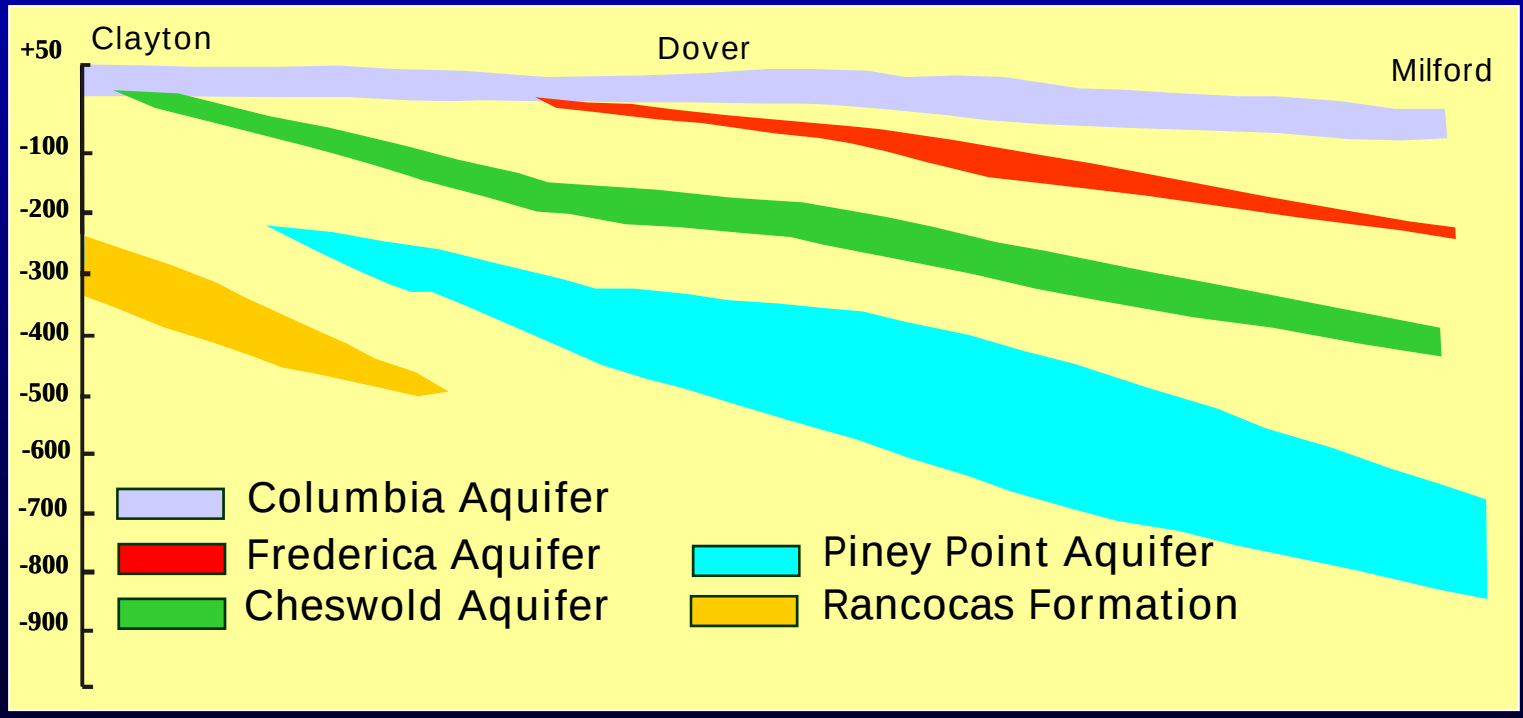
Mount Laurel

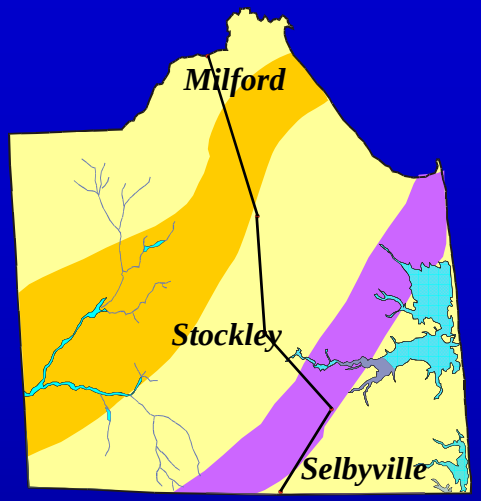




Kent County Aquifers

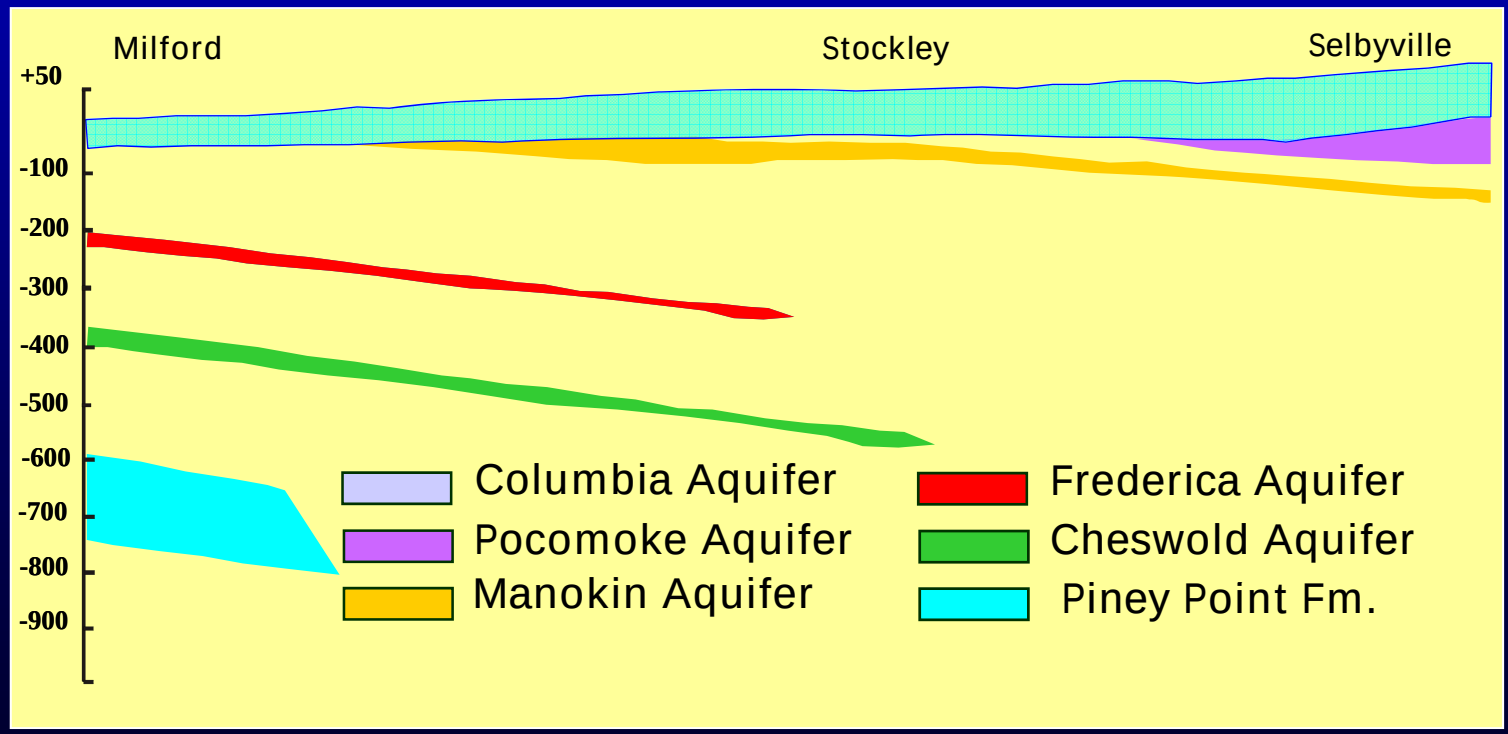
- A broad, extensive unconfined aquifer near surface in most of Delaware's Coastal Plain
- Deeper aquifers dip gently to southeast
- Older aquifers (on bottom) are near the surface to the NW, very deep in the SE





Sussex County Aquifers

- Younger aquifers (on top) occur progressively further southeast, also deepen to SE
- Confined aquifer usage and recharge areas change in a north-south direction because of tilt



Confined Aquifers

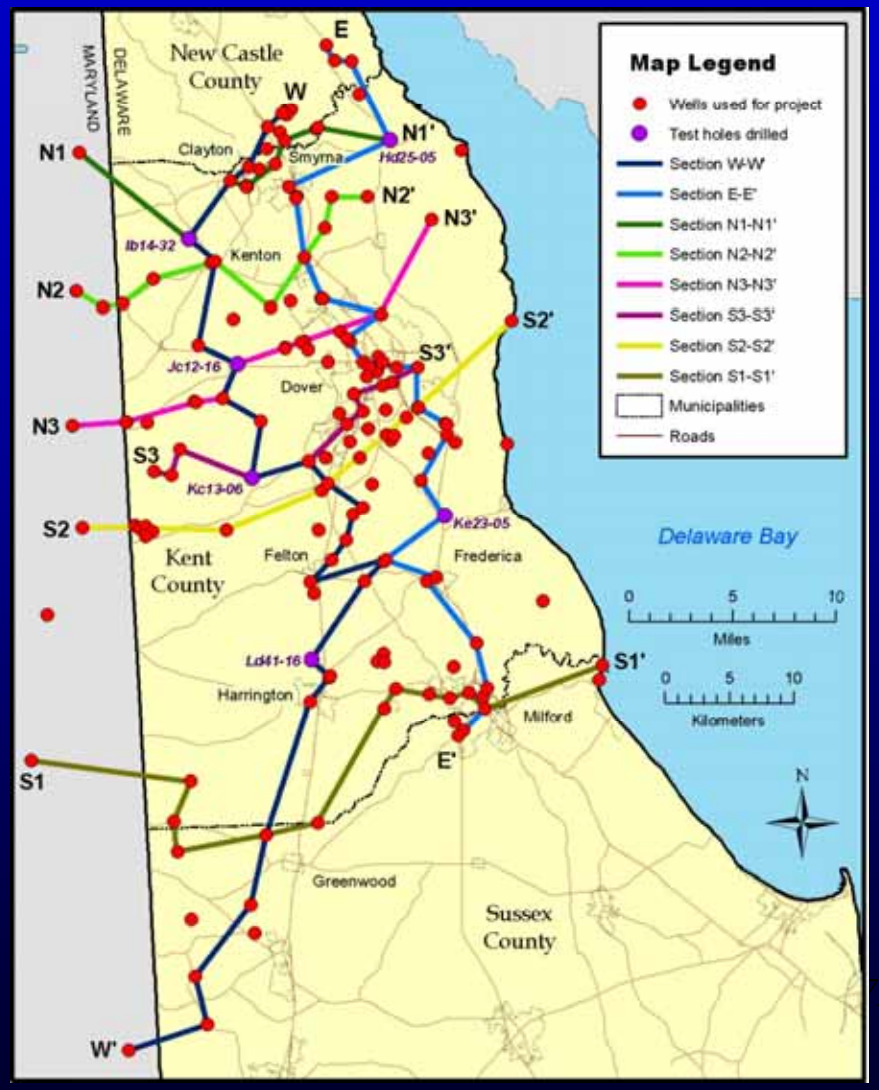
Those basics are clear…

… but the devil is in the details

Kent County Aquifer Project

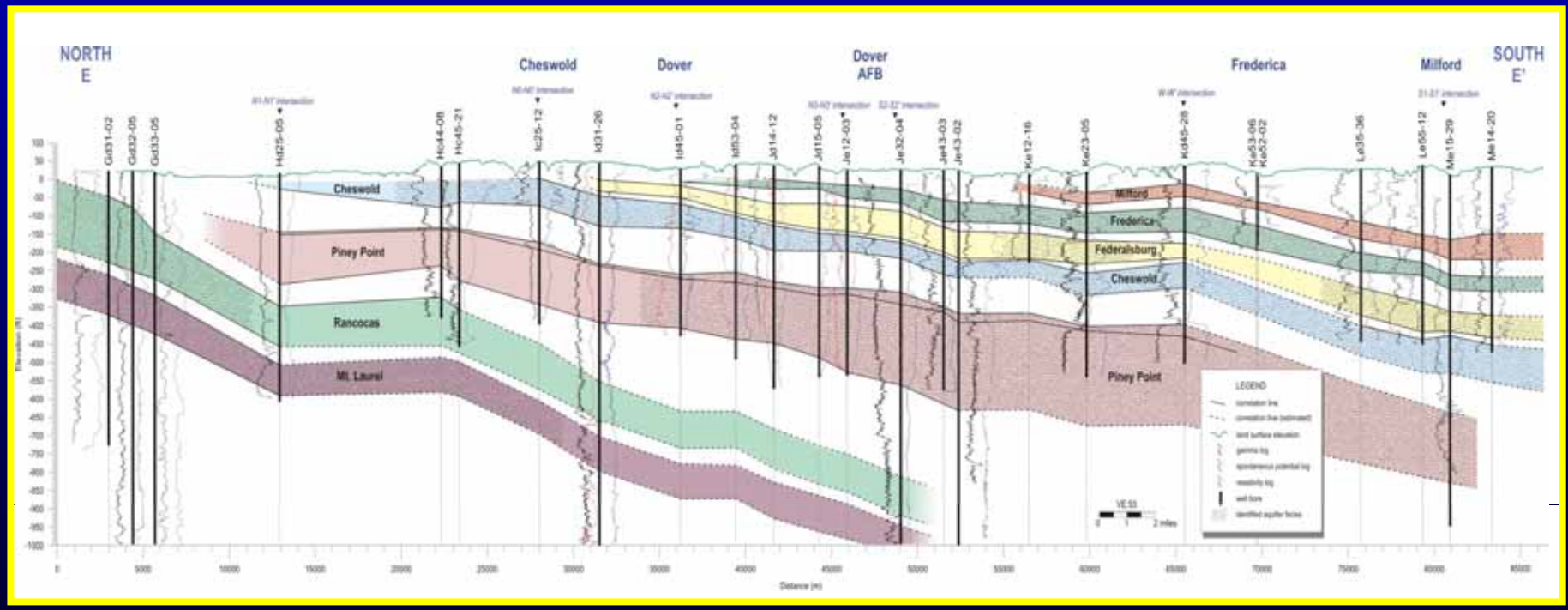
McLaughlin and Velez, 2005

- Compiled available well data
  - wireline logs
  - geologists logs
  - drillers logs
- Correlation on eight cross sections
  - 2 north-south lines
  - 6 east-west lines
- Utilized sequence stratigraphy for correlation and aquifer characterization



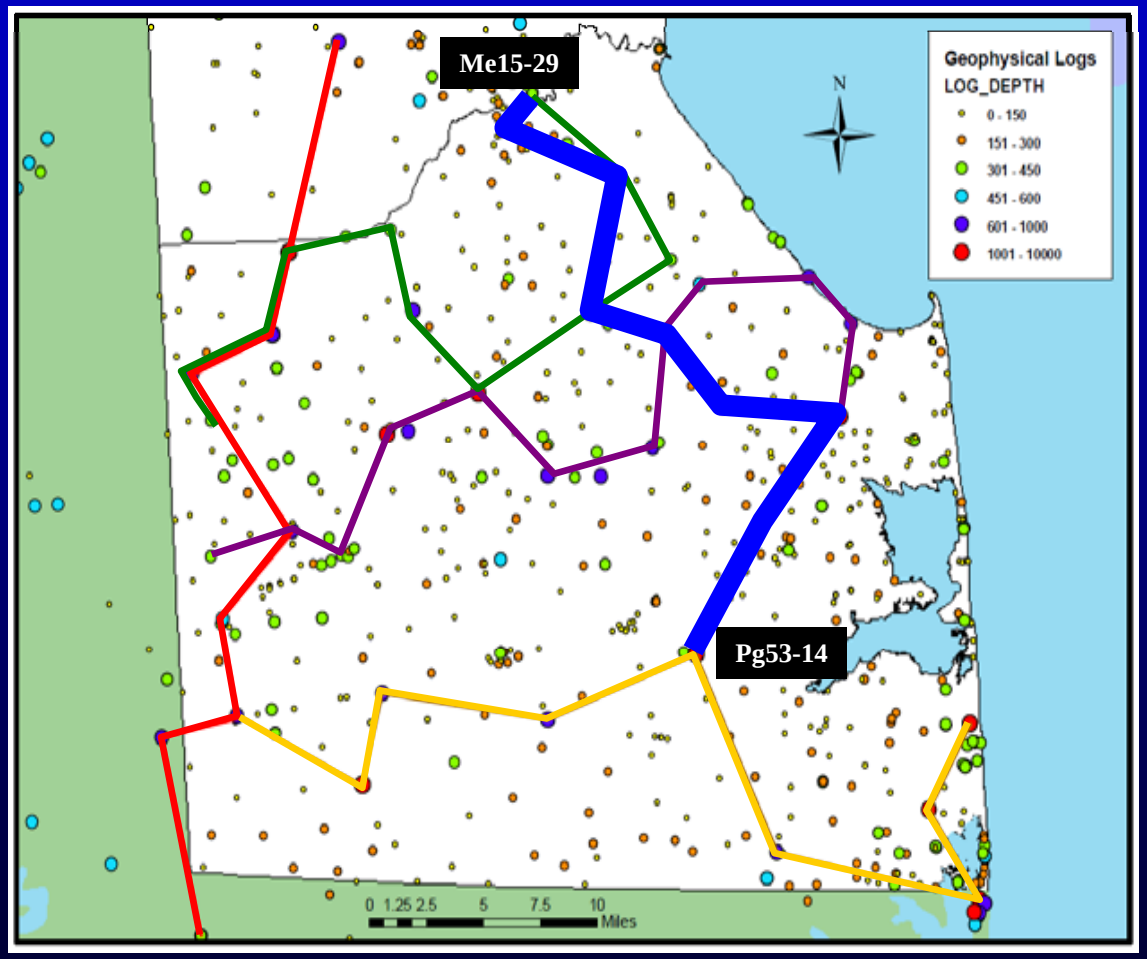
Kent County Cross Sections

- Vertical slices through subsurface layers reveal aquifer trends
  - Detailed correlations in along multiple transects
  - Addresses potential miscorrelations (i.e. Frederica-Milford)



Sussex County Cross Sections

- Same approach as Kent County, tied together

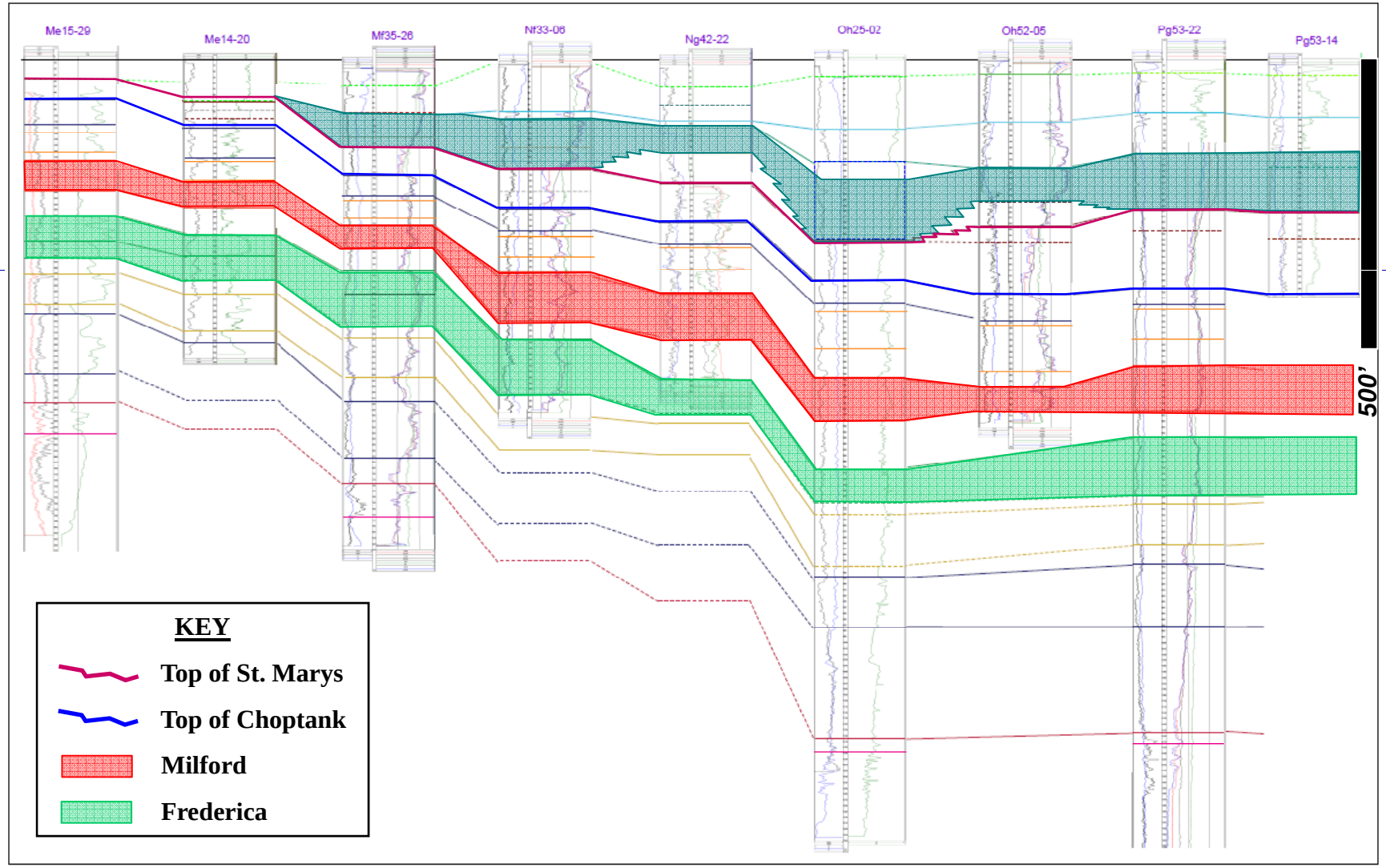


- Serve as basis for interpretation of holes in between sections
- All borehole picks data are entered in database for mapping

Cross Section – Eastern Sussex

N

S



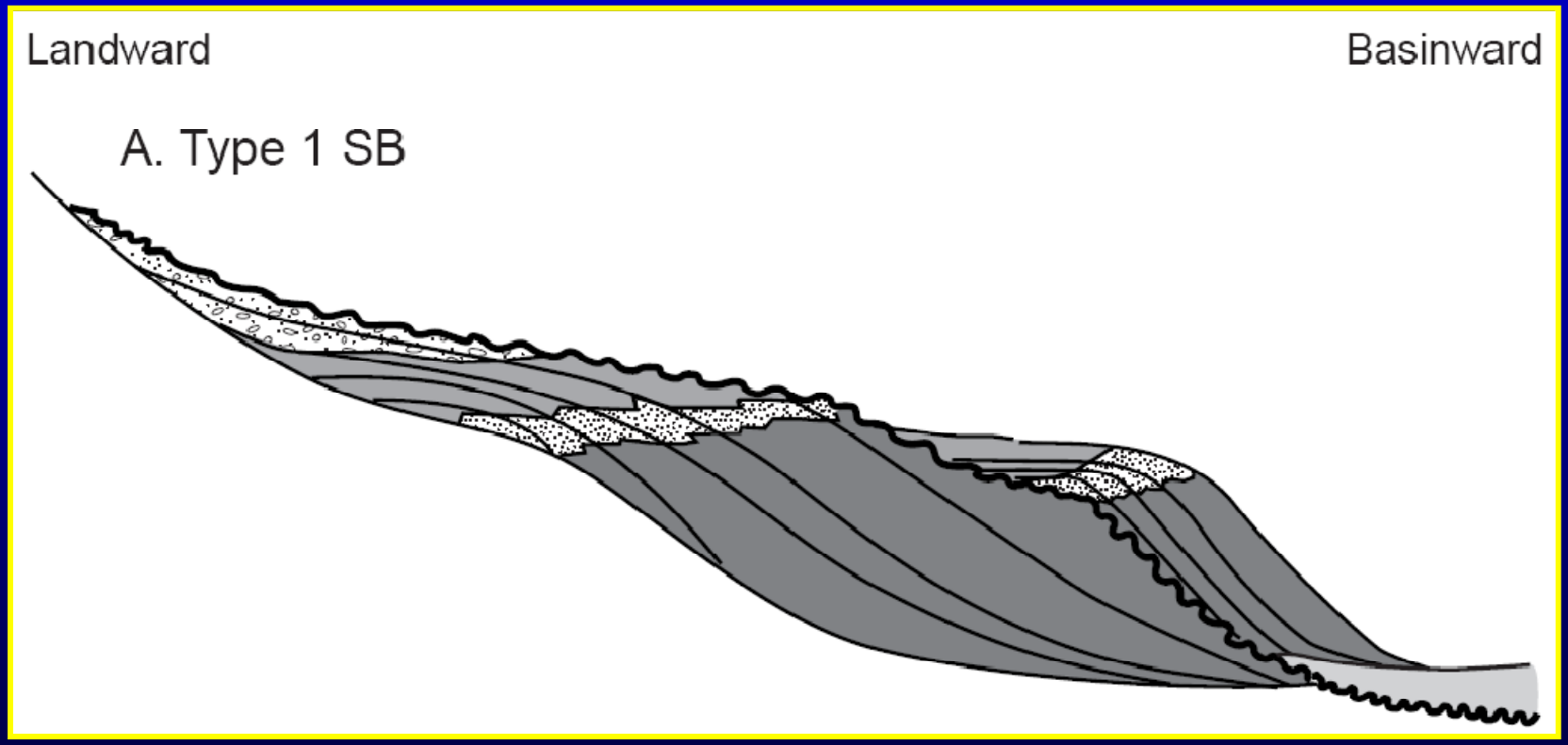
Aquifer Characterization

Sedimentary environments have unique physical & chemical processes that give diagnostic characteristics to their sediments…

…and these affect the shape and qualities of aquifer sand bodies

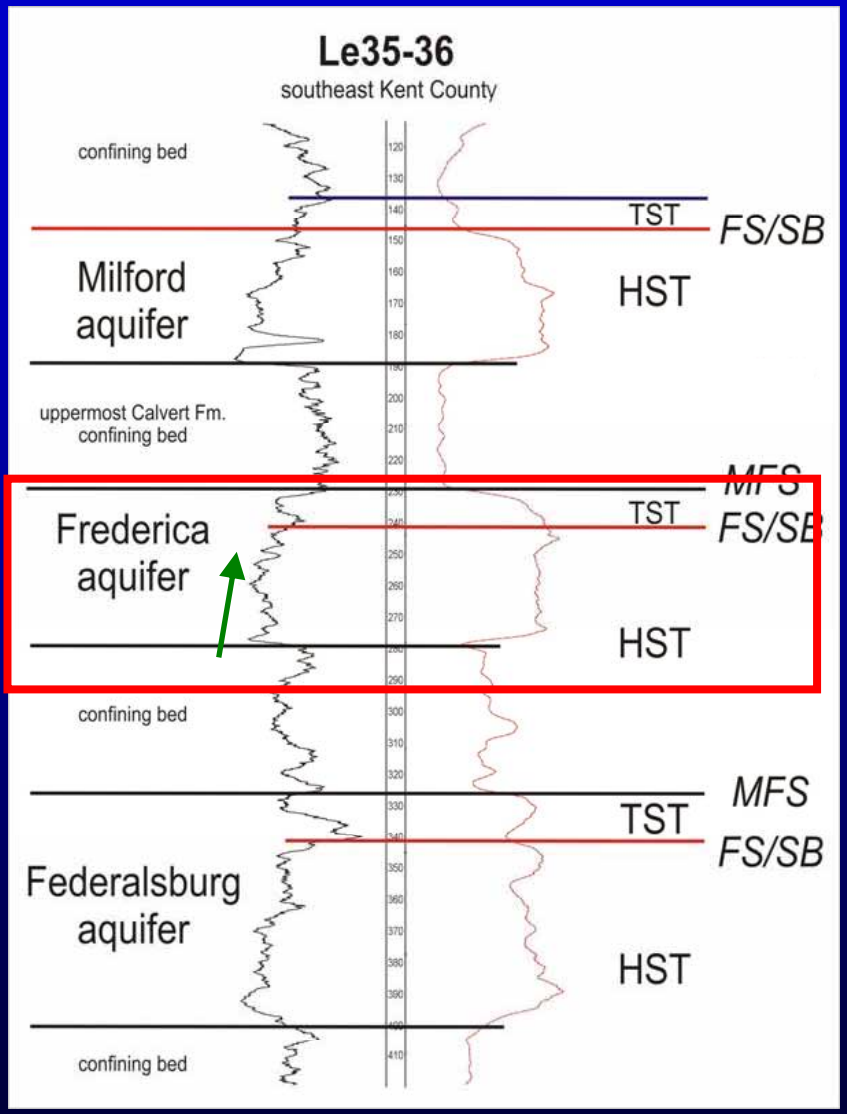
Aquifer Characterization

Sequence stratigraphy: genetic packaging of sediments…



…helps understand and predict aquifer characteristics

Frederica aquifer



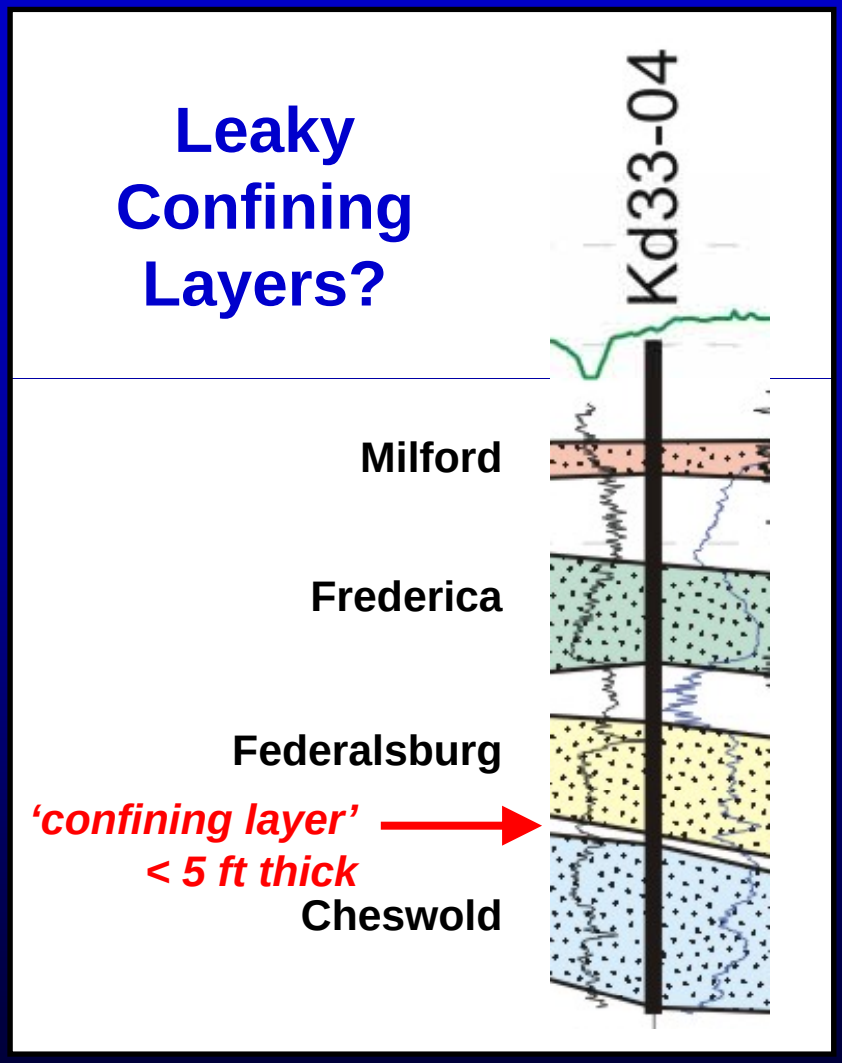
- Nearshore, shallowing-upward, quartz sand, may be shelly
- Commonly exhibits a fining-upward pattern and, in places, a thin coarsening-upward interval at the base
- SB at or near top of aquifer, marked by gamma spike
- HST, in some instances with reworked TST sand at top
- *Correlatable trend*

Chesapeake Group Aquifer System?

A hydrologic note…

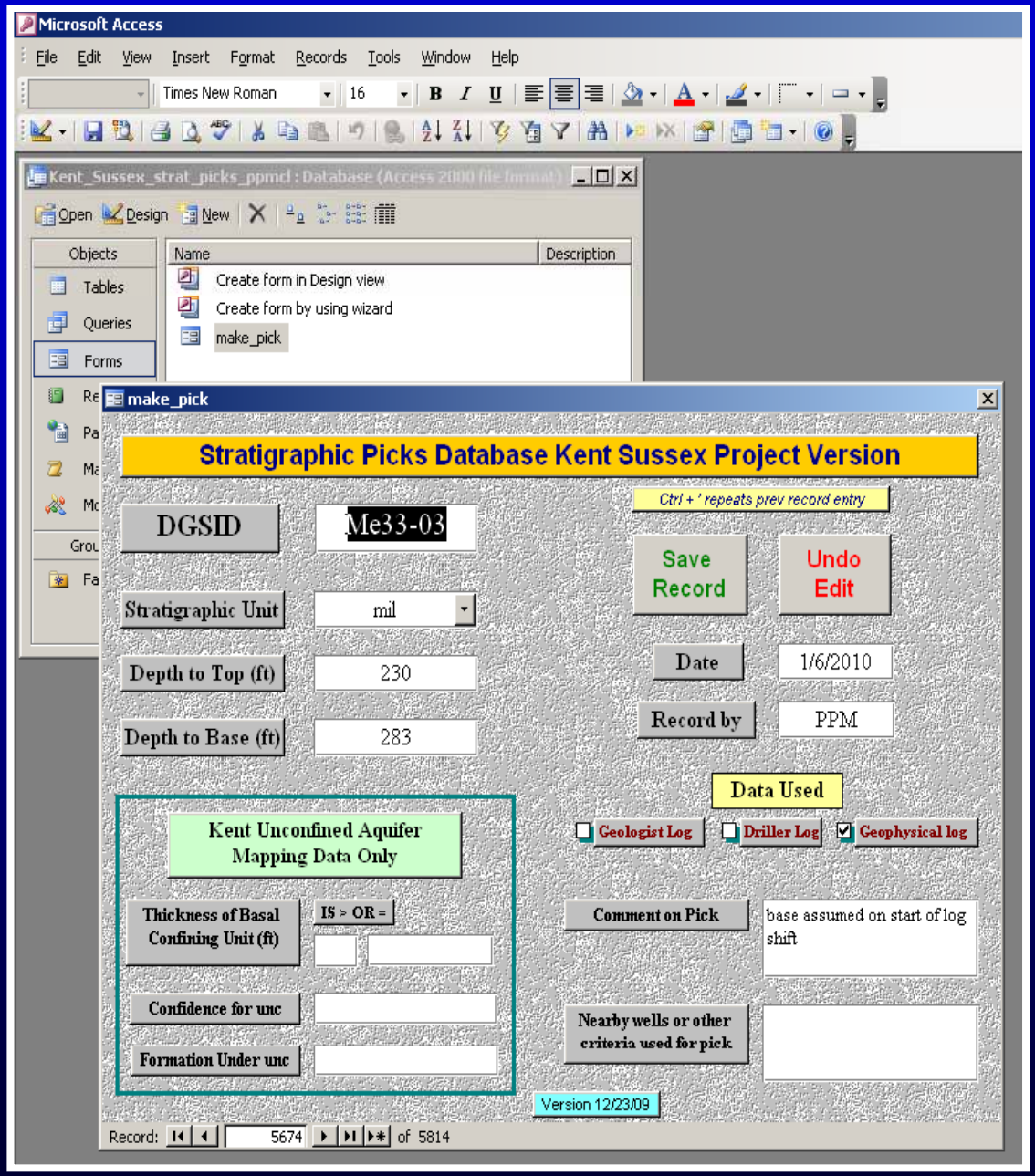
- The four Miocene aquifers may in places be in hydrologic communication with stratigraphically adjacent brethren through leaky, thin confining layers

➢ *are they actually a single aquifer system?*

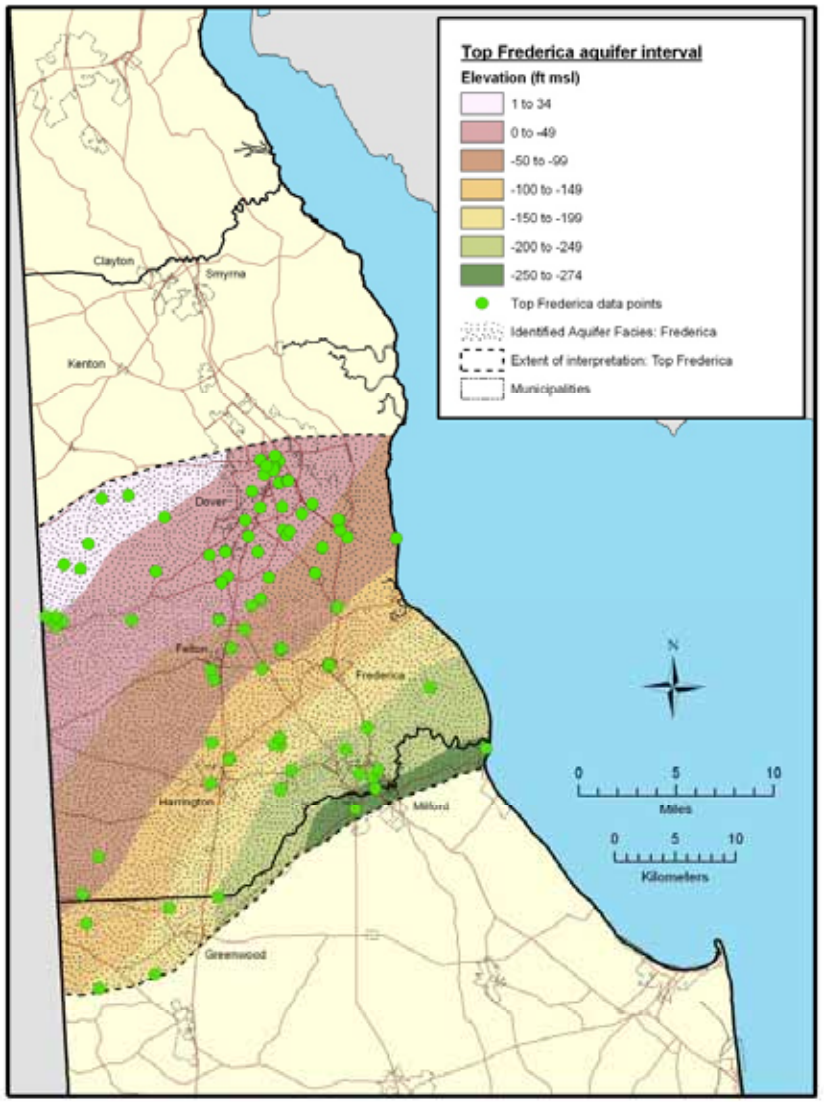


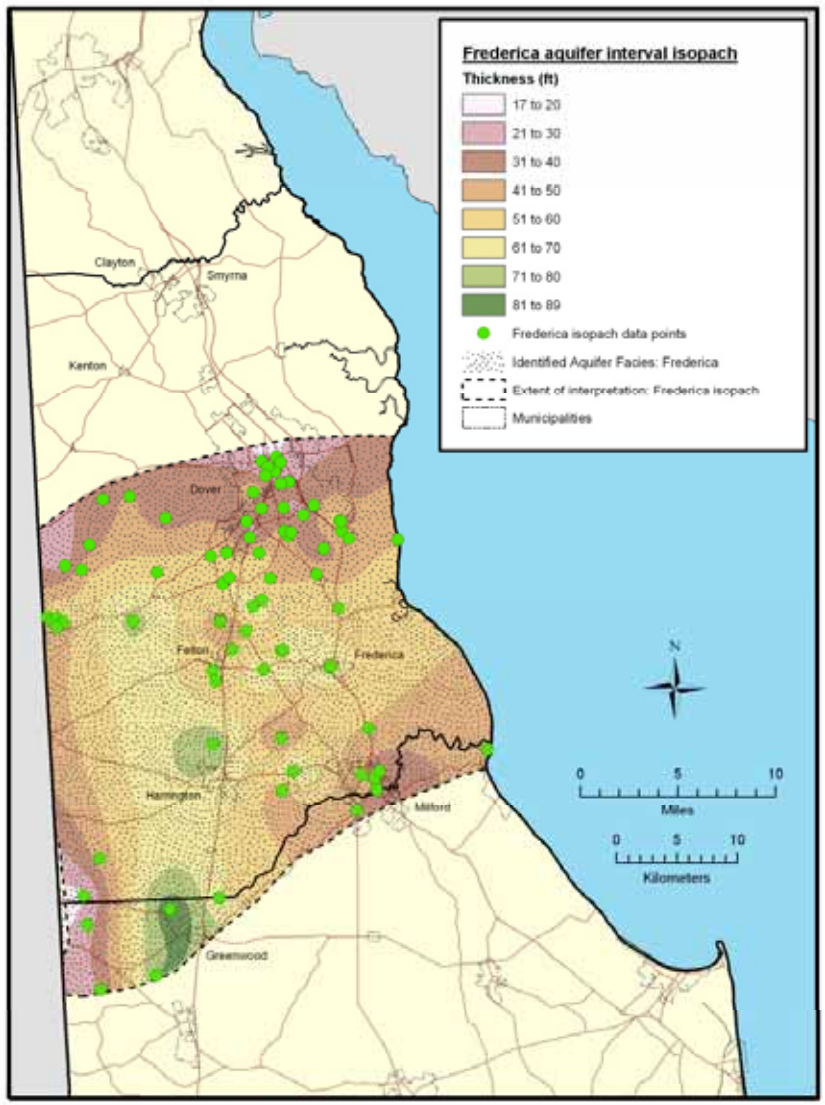
Stratigraphic Database: Confined Aquifers

1. depths of confined aquifers for wells on cross-sections
2. depths of confined aquifers in wells not on cross-sections



Kent County: Frederica aquifer

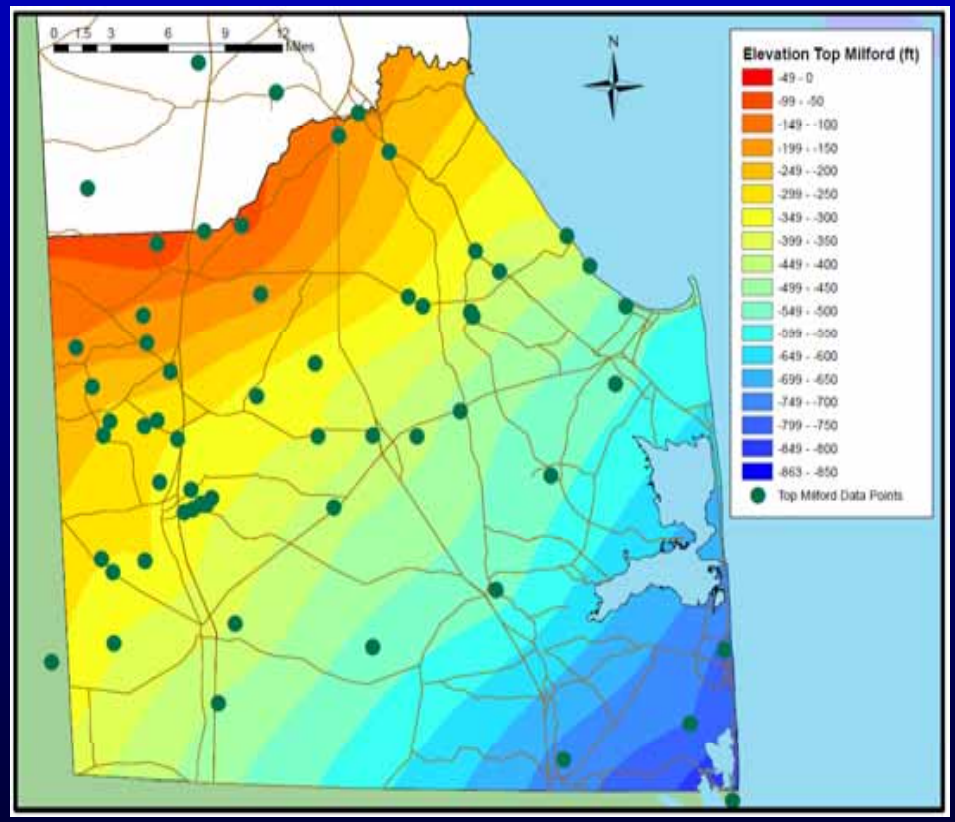




Sussex County Aquifer Maps
in progress

- Preliminary depth maps for several intervals
- Additional aquifer depth picks done, now being entered
- Confined aquifer depth and thickness maps generated by gridding values from database using Surfer (kriging, 100 m grid spacing)
- Final maps will be produced using ArcGIS

Preliminary Milford aquifer map – elevation of top surface



Outline

1. Objectives and Background
2. Status
3. Unconfined aquifer work
4. Confined aquifer work
5. **Hydrology and water use**

Hydrology and Water Use

Focal points:

1. **Hydrologic characteristics** of each aquifer
2. Recent **water use** compilation by aquifer

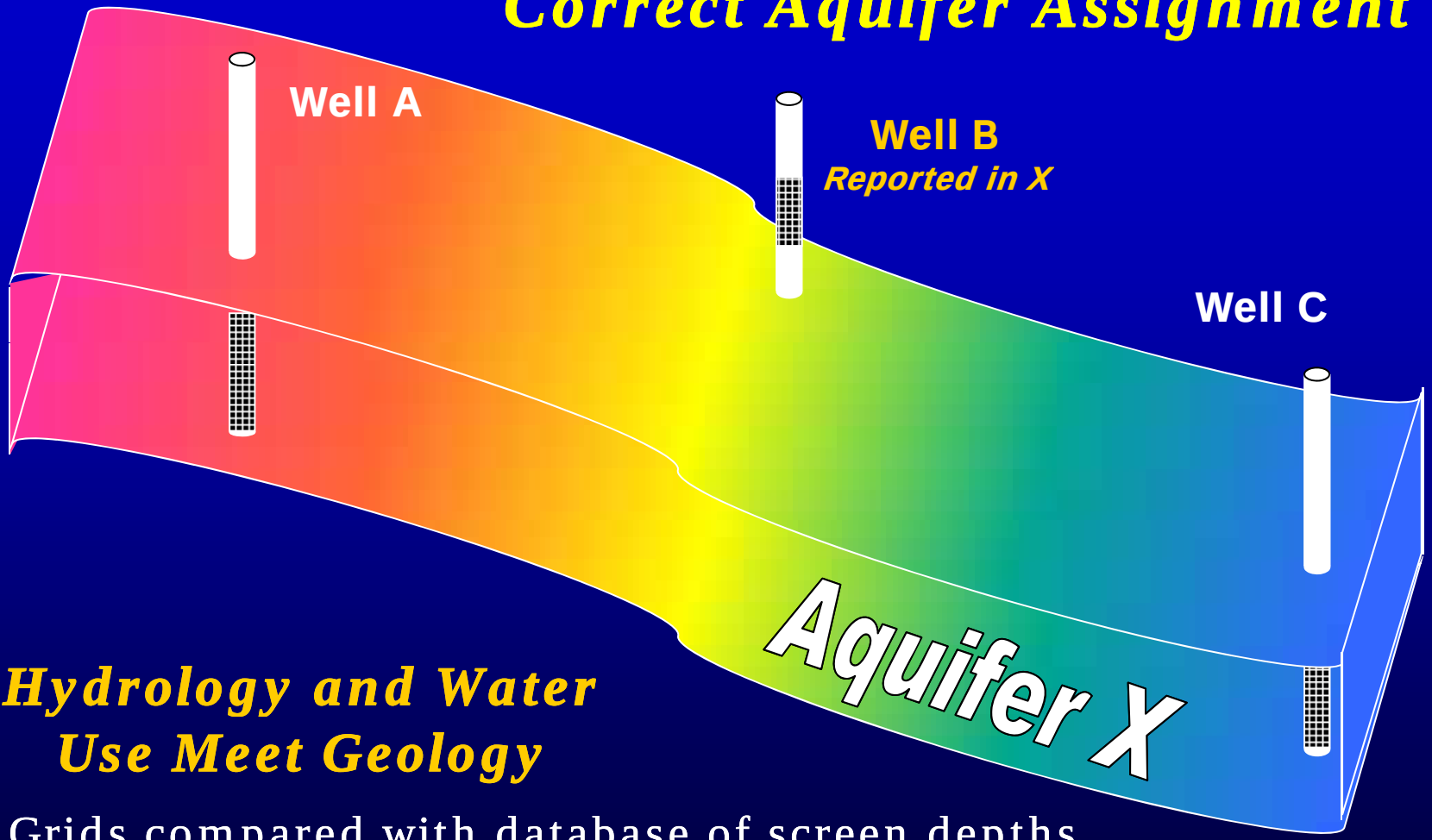
Approach

- Use selected, high-quality data
- Establish carefully documented or accepted methodologies for estimation/interpretation where high-quality data are lacking
- Identify issues where a lack of adequate data indicates a need for further study*

*(*the project is not intended to resolve organizational/quality control issues of all potentially available data)*

Emphasis

Correct Aquifer Assignment



Hydrology and Water Use Meet Geology

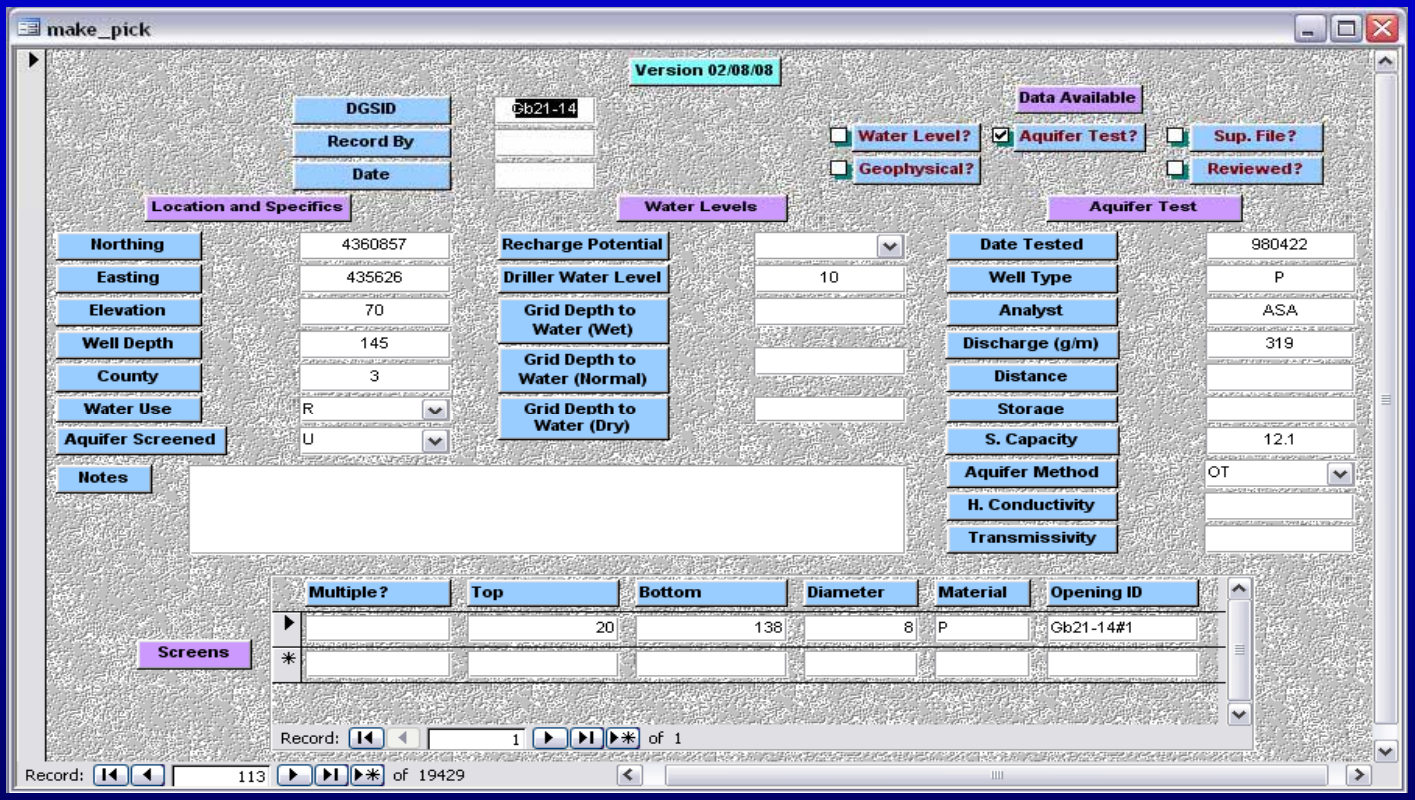
- Grids compared with database of screen depths
- **Water use** and **hydrological characteristics** assigned to aquifer where screened instead of reported aquifer

Aquifer Hydrology

Goal: Document the hydrologic characteristics and ground-water conditions the confined aquifers of Kent and Sussex County

- *Water levels, including maps of aquifer heads for Sussex and Kent Counties where sufficient data of adequate quality are available*
- *Yields (hydraulic conductivity, transmissivity, well tests)*

Aquifer Hydrology



- Hydrogeology database compilation (Access)
  - ✓ aquifer test data from DGS database
  - ➢ New pump-test and water-levels data from major providers recently acquired, to be entered

Water Use

Goal: Compile and analyze water use data for Sussex and Kent Counties

- *Include DGS, DNREC, USGS, other agency (e.g. Ag), and provider data sources*
- *Focus on high quality data*
- *Document methodologies for estimating poorly documented usage*
- *Assess usage trends by aquifer, geographical area, and types of water use*

Groundwater Use Compilation

Considerations in assessing recent groundwater usage

Agricultural

1) Allocated capacity

and

2) Estimated water use for irrigated acres

and

3) Average water use/type of livestock

Domestic

Municipal

1) Metered totals

and/or

2) Allocated capacity

Private

(Total population – municipal population)

Estimated with per capita coefficient

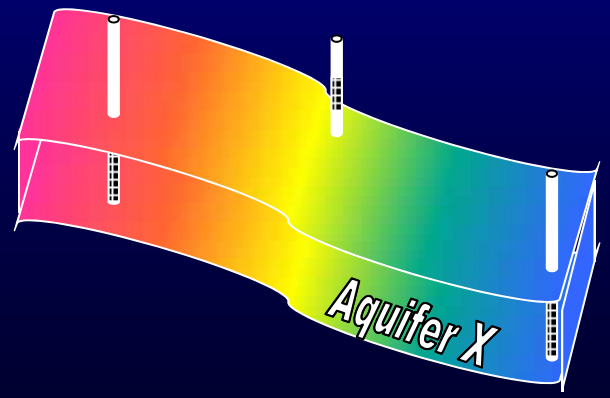
Industrial/ Commercial

1) Metered totals

or

2) Allocated capacity

Key will be assigning individual wells to specific aquifers

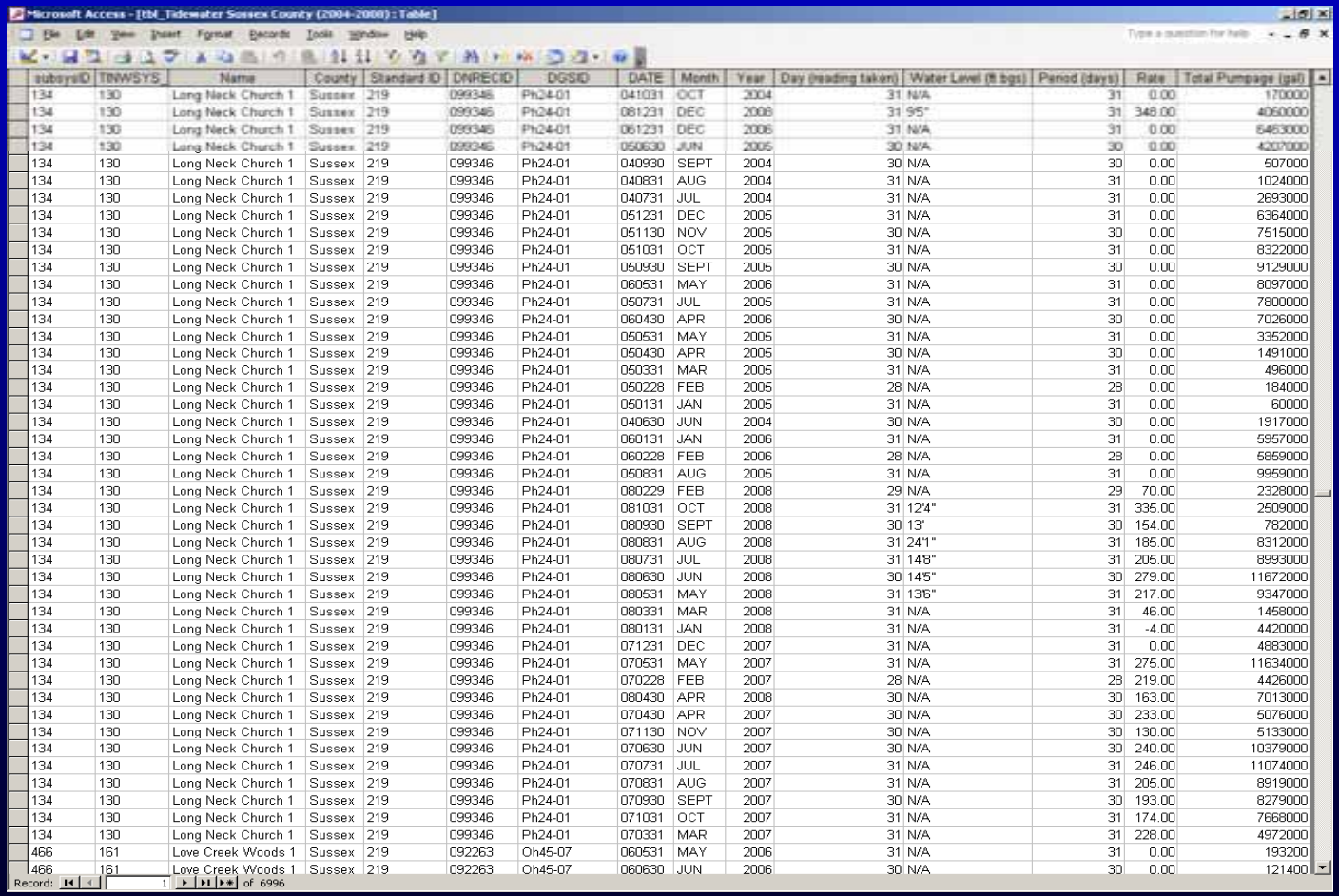


Water Use

Previously: incomplete datasets available…

Water Use

Now: updated/QCed public supply datasets (DNREC, Artesian) obtained, to be massaged/imported into one database for analysis



Microsoft Access - [tbl_Tidewater Sussex County (2004-2008) : Table]

subsysID	TNWSYS	Name	County	Standard ID	DNRECID	DGSID	DATE	Month	Year	Day (reading taken)	Water Level (ft bgs)	Period (days)	Rate	Total Pumpage (gal)
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	041031	OCT	2004	31	N/A	31	0.00	170000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	081231	DEC	2008	31	95'	31	348.00	4060000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	061231	DEC	2006	31	N/A	31	0.00	6463000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050630	JUN	2005	30	N/A	30	0.00	4207000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	040930	SEPT	2004	30	N/A	30	0.00	507000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	040831	AUG	2004	31	N/A	31	0.00	1024000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	040731	JUL	2004	31	N/A	31	0.00	2693000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	051231	DEC	2005	31	N/A	31	0.00	6364000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	051130	NOV	2005	30	N/A	30	0.00	7515000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	051031	OCT	2005	31	N/A	31	0.00	8322000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050930	SEPT	2005	30	N/A	30	0.00	9129000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	060531	MAY	2006	31	N/A	31	0.00	8097000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050731	JUL	2005	31	N/A	31	0.00	7800000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	060430	APR	2006	30	N/A	30	0.00	7026000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050531	MAY	2005	31	N/A	31	0.00	3352000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050430	APR	2005	30	N/A	30	0.00	1491000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050331	MAR	2005	31	N/A	31	0.00	496000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050228	FEB	2005	28	N/A	28	0.00	184000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050131	JAN	2005	31	N/A	31	0.00	60000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	040630	JUN	2004	30	N/A	30	0.00	1917000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	060131	JAN	2006	31	N/A	31	0.00	5957000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	060228	FEB	2006	28	N/A	28	0.00	5859000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	050831	AUG	2005	31	N/A	31	0.00	9959000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080229	FEB	2008	29	N/A	29	70.00	2328000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	081031	OCT	2008	31	12'4"	31	335.00	2509000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080930	SEPT	2008	30	13'	30	154.00	782000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080831	AUG	2008	31	24'1"	31	185.00	8312000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080731	JUL	2008	31	14'8"	31	205.00	8993000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080630	JUN	2008	30	14'5"	30	279.00	11672000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080531	MAY	2008	31	13'6"	31	217.00	9347000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080331	MAR	2008	31	N/A	31	46.00	1458000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080131	JAN	2008	31	N/A	31	-4.00	4420000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	071231	DEC	2007	31	N/A	31	0.00	4883000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070531	MAY	2007	31	N/A	31	275.00	11634000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070228	FEB	2007	28	N/A	28	219.00	4426000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	080430	APR	2008	30	N/A	30	163.00	7013000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070430	APR	2007	30	N/A	30	233.00	5076000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	071130	NOV	2007	30	N/A	30	130.00	5133000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070630	JUN	2007	30	N/A	30	240.00	10379000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070731	JUL	2007	31	N/A	31	246.00	11074000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070831	AUG	2007	31	N/A	31	205.00	8919000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070930	SEPT	2007	30	N/A	30	193.00	8279000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	071031	OCT	2007	31	N/A	31	174.00	7668000
134	130	Long Neck Church 1	Sussex	219	099346	Ph24-01	070331	MAR	2007	31	N/A	31	228.00	4972000
466	161	Love Creek Woods 1	Sussex	219	092263	Oh45-07	060531	MAY	2006	31	N/A	31	0.00	193200
466	161	Love Creek Woods 1	Sussex	219	092263	Oh45-07	060630	JUN	2006	30	N/A	30	0.00	121400

Record: 1 of 6996

Water Use

Areas for significant estimation:

Irrigation

Individual domestic well use

Livestock

Methods will be utilized and documented to ensure reproducibility of results (GIS land use/land cover, censuses, USGS-methods)

Outline

1. Objectives and Background
2. Status
3. Unconfined aquifer work
4. Confined aquifer work
5. Hydrology and water use


RESEARCH
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