USGS
science for a changing world

# USGS Modeling for Puchack Wellfield Superfund Site

October 2008

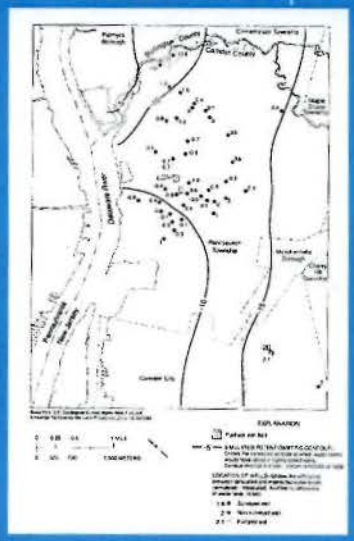
## Objectives

- How will variations in withdrawals from major well fields affect the advective movement of the plume?
- How will uncertainty in hydraulic parameters affect the movement of the plume?

# Work to Date

- Gathered and stored monthly water-use and water-level data for 2001-2007
- Converted April 2001 steady-state model to a 84 month transient model
- Calibrated transient model focusing on storage coeffients
- Created and analyzed hydrographs and residual plots of model results

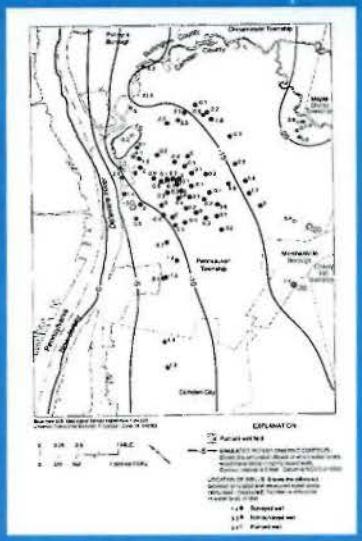
## Simulation of potentiometric surface and residuals in the Middle aquifer of the PRM, April 2001



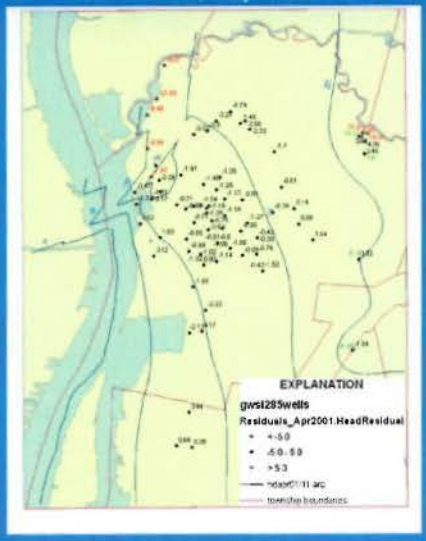
Steady-state model

Transient model

## Simulation of potentiometric surface and residuals in the Lower aquifer of the PRM, April 2001

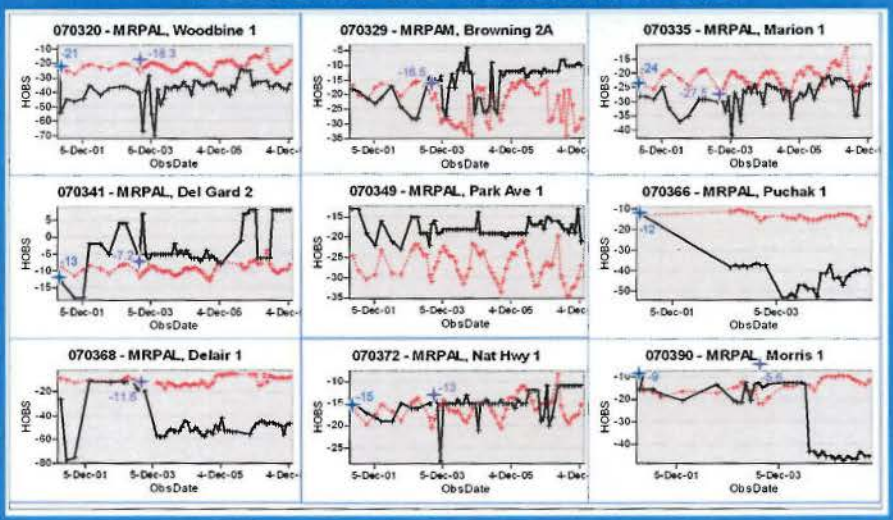


Steady-state model




Transient model

## Hydrographs of observed versus simulated heads for the transient model




Observed heads
Simulated heads

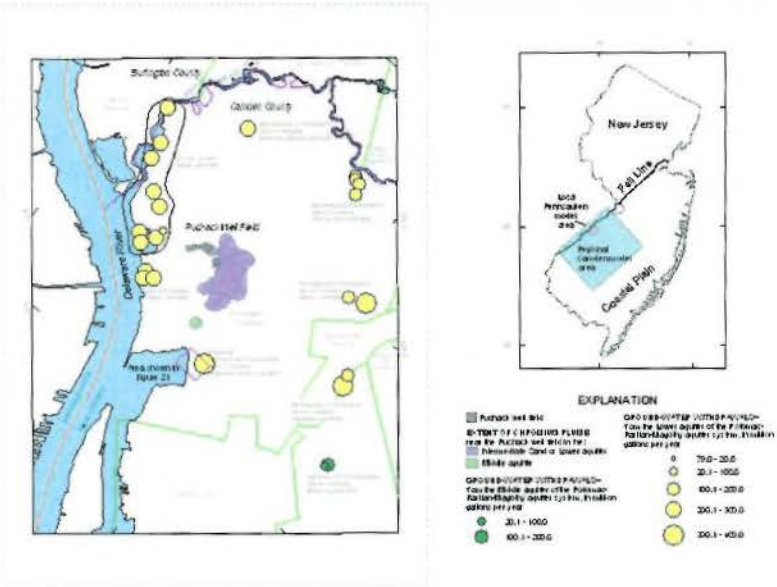
-25 April 2001 water levels – Pope and Watt, SIR 2004-5025
-25 November 2003 synoptic water levels – NWIS web

## Tasks Remaining

- Acquire location map with present position of 100 microgram per liter chromium plume
- Transient Particle Tracking
- Evaluate sensitivity of direction and travel time of GW to:
  1. Pumping Variability
  2. Parameter uncertainty

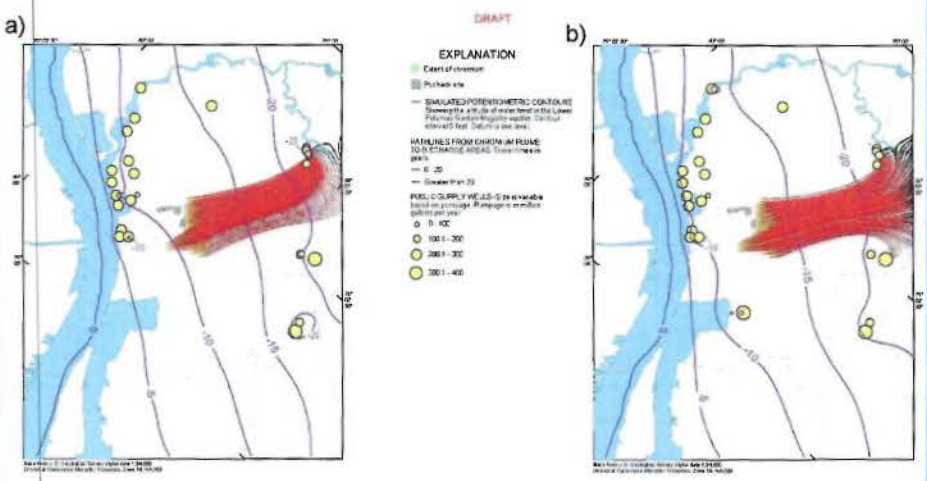
## Determine affect of pumping variability on advective movement of plume

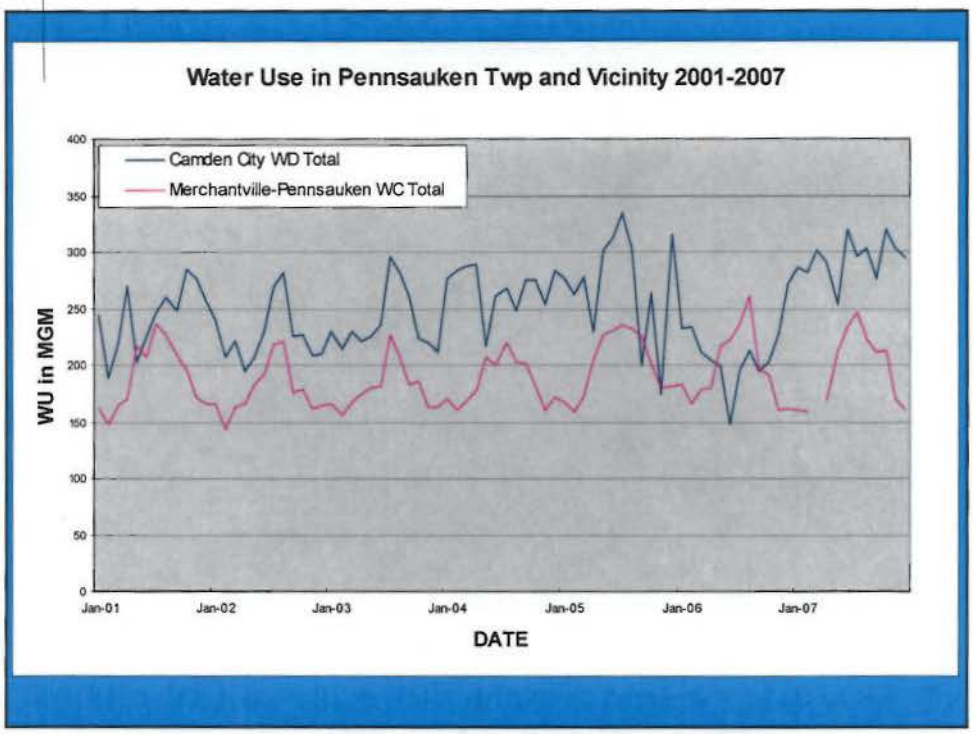
- Look at water use over time to assess usage patterns
- Run various pumping scenarios using key locations in well fields

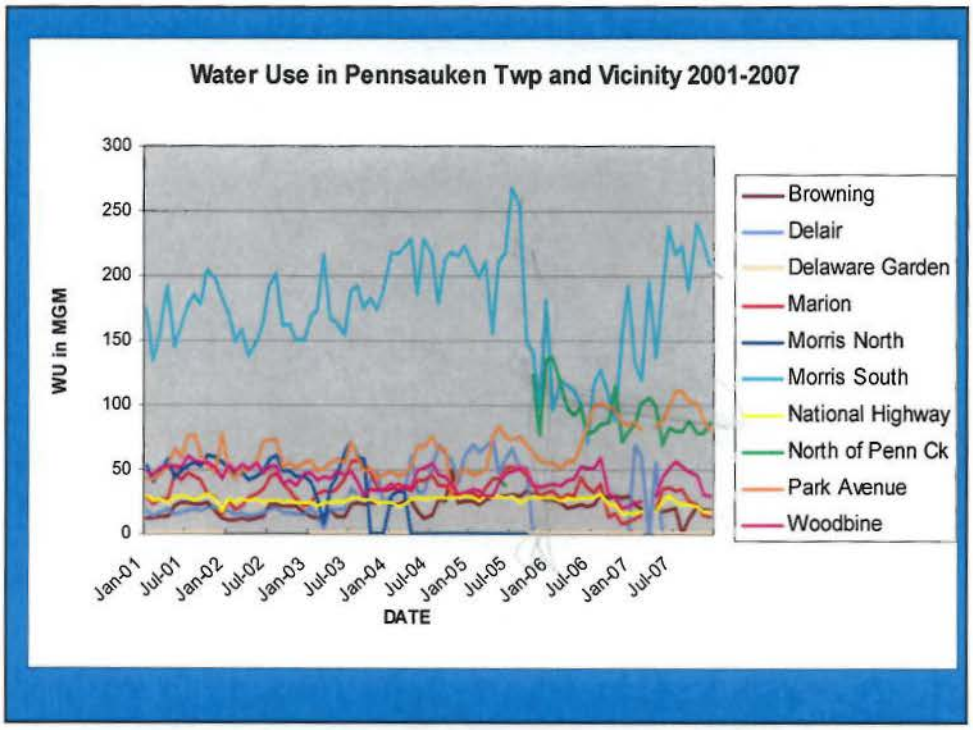



Location of the study area, chromium plumes, and baseline ground-water withdrawals, Pennsauken Township and vicinity, Camden County, New Jersey.

Flowpaths of particles originating at the chromium plume in the Lower aquifer, Scenarios a) Delaware Garden not pumping, and b) Delaware Garden pumping at 2 MGD.




Water Use in Pennsauken Twp and Vicinity 2001-2007
Camden City WD Total
Merchantville-Pennsauken WC Total
WU in MGM
400
350
300
250
200
150
100
50
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
DATE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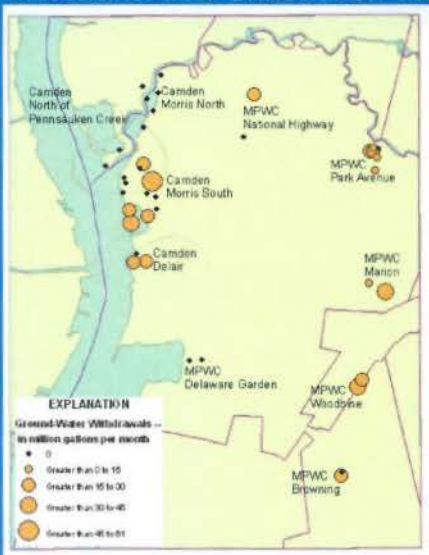
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
DATE
Browning
Delair
Delaware Garden
Marion
Morris North
Morris South
National Highway
North of Penn Ck
Park Avenue
Woodbine

# Observations

- Graphs show
  - Merchantville-Pennsuaken withdrawals relatively consistent
  - Camden withdrawals are more variable.
  - Several shifts occurred around 2006
    - Morris well field shifted north
    - Increased Park Ave pumpage

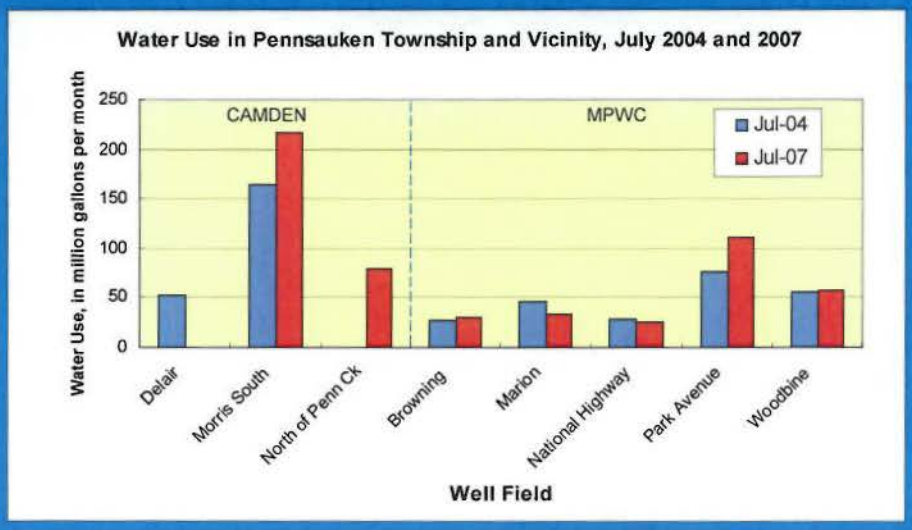
## Ground-water withdrawals for the City of Camden WD and Merchantville-Pennsauken WC for July 2004 and July 2007




July 2004

July 2007

Ground-water withdrawals by well field for the City of Camden WD and Merchantville-Pennsauken WC for July 2004 and July 2007




# Scenarios

- Two initial scenarios could be based on observed changes/shifts in withdrawals
  - Increase in withdrawals from Park Ave begins in 2006 along with decreases from Marion and National Highway
  - Shift from Morris South field to Morris field north of Pennsuaken Creek.
- Additional scenarios would be based on more hypothetical changes.

# Determine how parameter uncertainty affects plume movement

- Propose using approach similar to that used to determine affects of parameter uncertainty on contributing areas using an earlier version of the Pennsauken flow model (SIR 2004-5101)
- For that study each parameter was increased and decreased until heads changed more than 5 ft at a single cell in the model.
- See table on next slide
- Because the models are different the same parameter values can not be used for sensitivity. However, instead of rerunning all the parameter sensitivity determinations, we can assume the net affect will be similar and the percent changes determined during the previous study will be applied to current model parameters.
- Plot maps will be created of plume movement using the various parameter values.

Parameter changes used to delineate contributing areas to the Puchack Well Field.

| Model-layer designation | Initial value | Increased value to produce a maximum 5-foot change in head at any model cell | | Decreased value to produce a maximum 5-foot change in head at any model cell | | Figure number |
|---|---|---|---|---|---|---|
| | | Changed value | Percent change | Changed value | Percent change | |
| | | | | Horizontal hydraulic conductivity, in feet per day | | |
| A-1 | 50 | 77 | 54 | 37 | 26 | -- |
| A-2a, A-2b | 60 | 90 | 50 | 43 | 28 | 22, 23 |
| C-2AI | 100 | 178 | 78 | 35 | 65 | -- |
| A-3a, A-3b | 130 | 153 | 18 | 110 | 15 | -- |
| A-3c | 130, 250 | 160, 308 | 23 | 105, 202 | 19 | 24, 25 |
| | | | | Vertical hydraulic conductivity, in feet per day | | |
| C-1 | 0.001–0.01 | 0–0.0138 | 38 | 0–0.008 | 20 | -- |
| A2-c1 | 4 | 36 | 800 | .28 | 93 | -- |
| C-2a | .01–0.06 | .13–0.84 | 1,300 | 0.0039–0.0234 | 61 | -- |
| C-2b | .05–0.5 | .13–1.3 | 167 | 0.0235–0.235 | 53 | -- |
| A-1 | 5 | 6.3 | 26 | 4 | 20 | -- |
| A-2a, A-2b | 6 | 120 | 1,900 | 1.3 | 78 | 26, 27 |
| C-2AI | 10 | 200 | 1,900 | 1.8 | 82 | -- |
| A-3a | 13 | 260 | 1,900 | 1 | 92 | -- |
| A-3b | 13 | 300 | 2,200 | 1.3 | 90 | -- |
| | | | | Riverbed vertical hydraulic conductivity, in feet per day | | |
| -- | .00028–28 | .00034–33.9 | 21 | .00023–23 | 18 | -- |
| | | | | Recharge, in inches per year | | |
| All | 4.5–14 | 5.8–18.1 | 29 | 3.1–.5 | 32 | 20, 21 |
| All | 7.88 | * | * | * | * | -- |
| All | 7.88 | 0, 10.3 | 31 | 0, 5.4 | 35 | -- |
| | | | | Riverbed vertical hydraulic conductivity, in feet per day | | |
| -- | .00028–28 | .00034–33.9 | 21 | .00023–23 | 18 | -- |

Sensitivity of particle pathways

These ranges still allow model to be calibrated

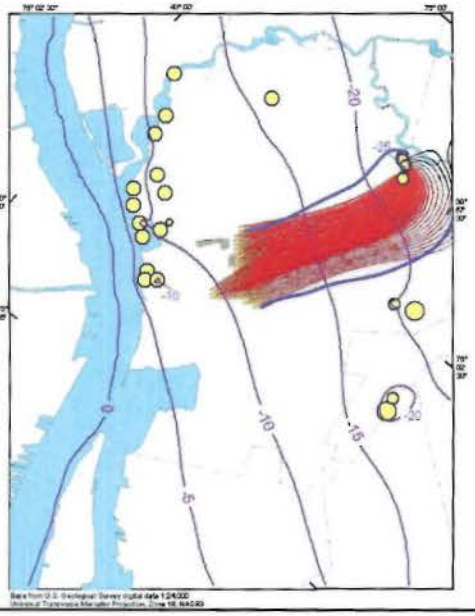
caused a 5 ft. change

pump tests with data?

Is there observed data from a pump test - no. Daryll did not use pump test data to determine the "K's" - he used existing data from the area

# Hypothetical change of flow path

DRAFT




## EXPLANATION

Extent of chromium

Pucheck site

— SIMULATED POTENTIOMETRIC CONTOURS-Showing the altitude of water level in the Lower Potomac-Raritan-Magothy aquifer. Contour interval 5 feet. Datum is sea level.

PATHLINES FROM CHROMIUM PLUME TO DISCHARGE AREAS. Travel times in years

— 0 - 20

— Greater than 20

PUBLIC-SUPPLY WELLS--Size is variable based on pumpage. Pumpage is in million gallons per year

- 0 - 100
- 100.1 - 200
- 200.1 - 300
- 300.1 - 400

400 hours

# USGS Modeling for Puchack Wellfield Superfund Site

October 2008

## Objectives

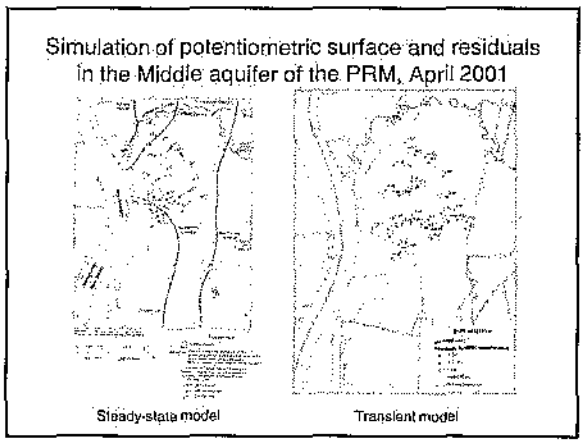
- How will variations in withdrawals from major well fields affect the advective movement of the plume?
- How will uncertainty in hydraulic parameters affect the movement of the plume?

Tony will talk here questions that we would investigate

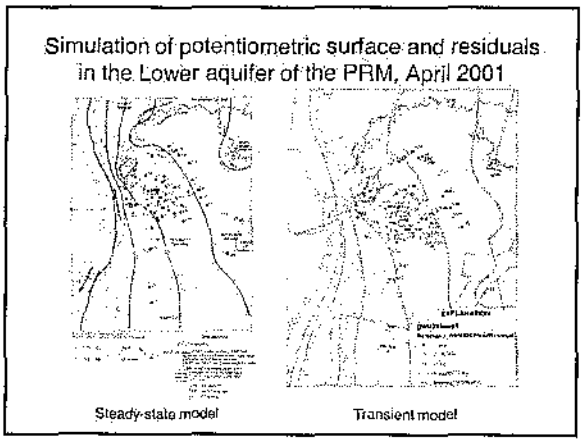
## Work to Date

- Gathered and stored monthly water-use and water-level data for 2001-2007
- Converted April 2001 steady-state model to a 84 month transient model
- Calibrated transient model focusing on storage coeffients
- Created and analyzed hydrographs and residual plots of model results

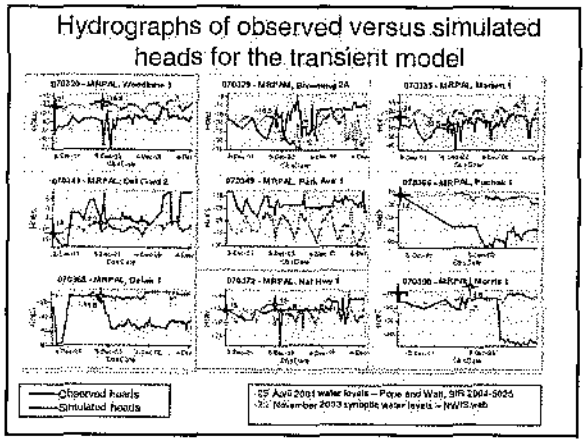
Deb




Pattern of residuals is similar
Contours are relatively the same




Transient map has more WL points
Pattern of residuals relatively the same
- Contours hand drawn for old SS model
- Contouring program would ex tend to the north on Transient model if there were data points to the north




Explain plots

- Not completely confident in purveyor reported data - observed heads are static WL's

USGS field measured April 2001 + Nov 2003 WL's show that simulated heads match reasonably well

- Seasonal range or fluctuation between observed + simulated data is reasonable

## Tasks Remaining

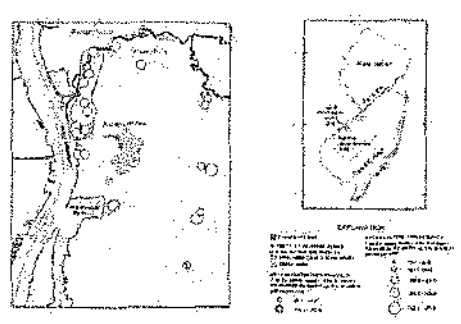
- Acquire location map with present position of 100 microgram per liter chromium plume
- Transient Particle Tracking
- Evaluate sensitivity of direction and travel time of GW to:
  1. Pumping Variability
  2. Parameter uncertainty

now 70 ppb

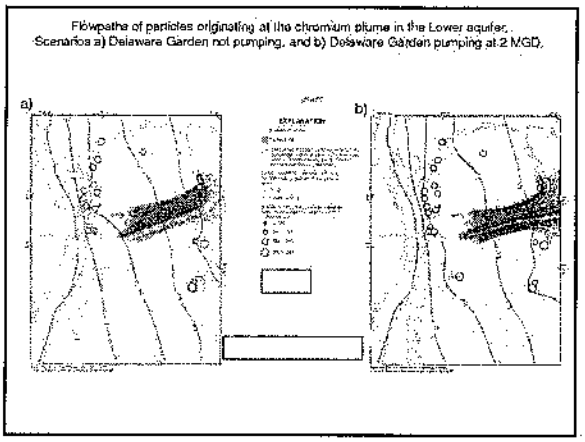
Get coverage from CDM

## Determine affect of pumping variability on advective movement of plume

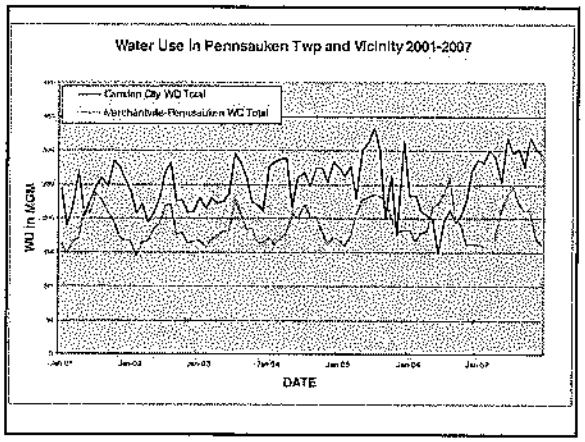
- Look at water use over time to assess usage patterns
- Run various pumping scenarios using key locations in well fields



well field locations

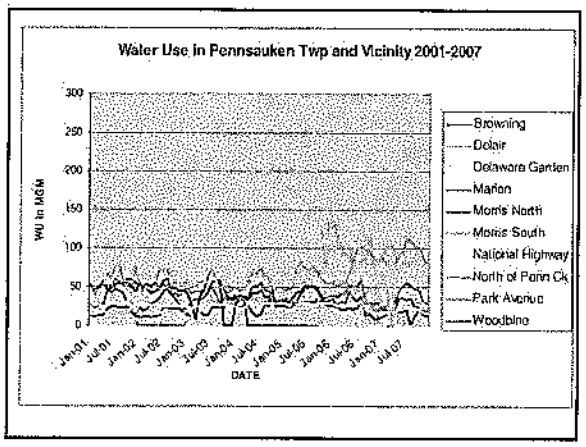



Past particle tracking work done by Daryll




Seasonal patterns
Camden withdrawals more variable
M-P more consistent

Can't find evidence for why there is a drop in pumpage for Camden in 2006



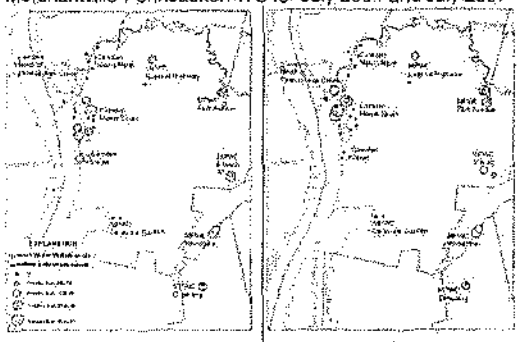

- Look at patterns
- When wellfields tend to go on + off
- 2006 - Morris wells North of Pennsauken Creek came on line

## Observations

- Graphs show
  - Merchantville-Pennsauken withdrawals relatively consistent
  - Camden withdrawals are more variable.
  - Several shifts occurred around 2006
    - Morris well field shifted north
    - Increased Park Ave pumpage

Restate graph observations

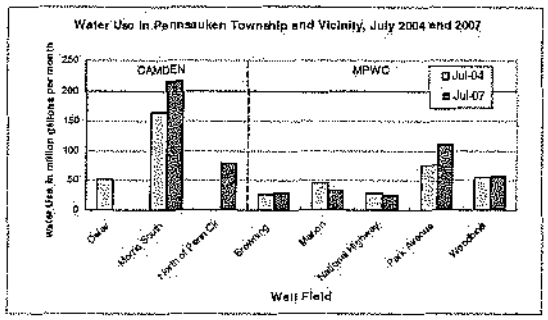
Ground-water withdrawals for the City of Camden WD and Merchantville-Pennsauken WC for July 2004 and July 2007




Camden - shift in pumping to the north near mouth of Pennsauken Creek

Merchantville - Pennsauken
Increase at Park Ave well field

Ground-water withdrawals by well field for the City of Camden WD and Merchantville-Pennsauken WC for July 2004 and July 2007




Camden
Delair - no longer being used
shift to wells North of Pennsauken Creek

Merchantville - Pennsauken
Increase at Park Ave
Decrease at Marion

## Scenarios

- Two initial scenarios could be based on observed changes/shifts in withdrawals
  - Increase in withdrawals from Park Ave begins in 2006 along with decreases from Marion and National Highway
  - Shift from Morris South field to Morris field north of Pennsuaken Creek.
- Additional scenarios would be based on more hypothetical changes.

Shift in pumping might have redirected the plume

## Determine how parameter uncertainty affects plume movement

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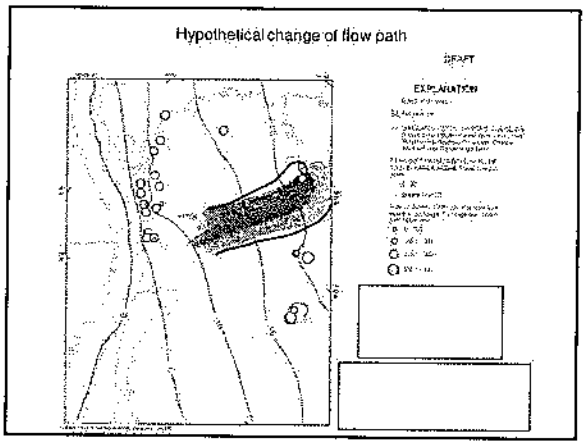
Paryll

Parameter changes used to delineate contributing areas to the Pucheck Well Field.

| Model layer designation | Initial value | Increased value for a change in head of 5 feet or more at any model cell: Changed value | Increased value for a change in head of 5 feet or more at any model cell: Percent change | Decreased value for a change in head of 5 feet or more at any model cell: Changed value | Decreased value for a change in head of 5 feet or more at any model cell: Percent change | Figure number |
|---|---|---|---|---|---|---|
| Horizontal hydraulic conductivity, in feet per day | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Vertical hydraulic conductivity, in feet per day | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Specific yield, dimensionless | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Recharge, in inches per year | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

(Biggest factor Porosity)

sensitivity analysis




Example of what a change in pumpage might show

conclusion Slide
- pumping variability effects on plume
-

Bob Schriver - this would be useful
would find boundary conditions useful
purveyors - stay pumping steadily - DEP modify permits

John Gorin - Can't change seasonal variability of pumping

advective transport + chemical degredation - 2 different processes going on with chromium

call Diane Zalastus at DEP - When are next reviews of Camden + M-P permits ?

1st senarios - Delair well charge