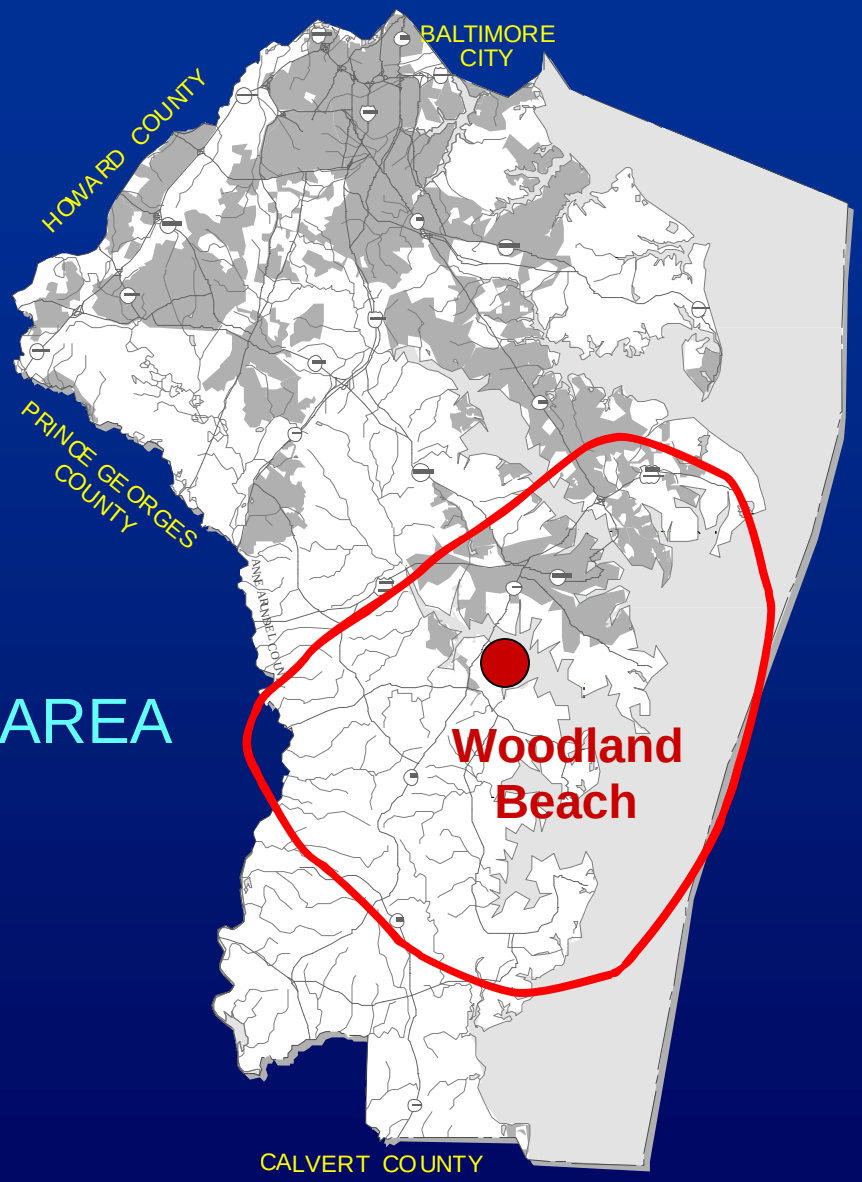
Cadmium in groundwater and sediment samples in the Aquia aquifer, Anne Arundel County, Maryland

David W. Bolton
Maryland Geological Survey

Maryland State-County
Groundwater Symposium

September 20, 2006

STUDY AREA


BALTIMORE CITY
HOWARD COUNTY
PRINCE GEORGES COUNTY
ANNE ARUNDEL COUNTY
Woodland Beach
CALVERT COUNTY

HEALTH EFFECTS RELATED TO CADMIUM IN WATER

MCL in drinking water: 5 ug/L

Acute effects:

- Nausea; cramps
- Liver damage, shock
- Renal failure

Chronic effects:

- Kidney, liver, blood damage

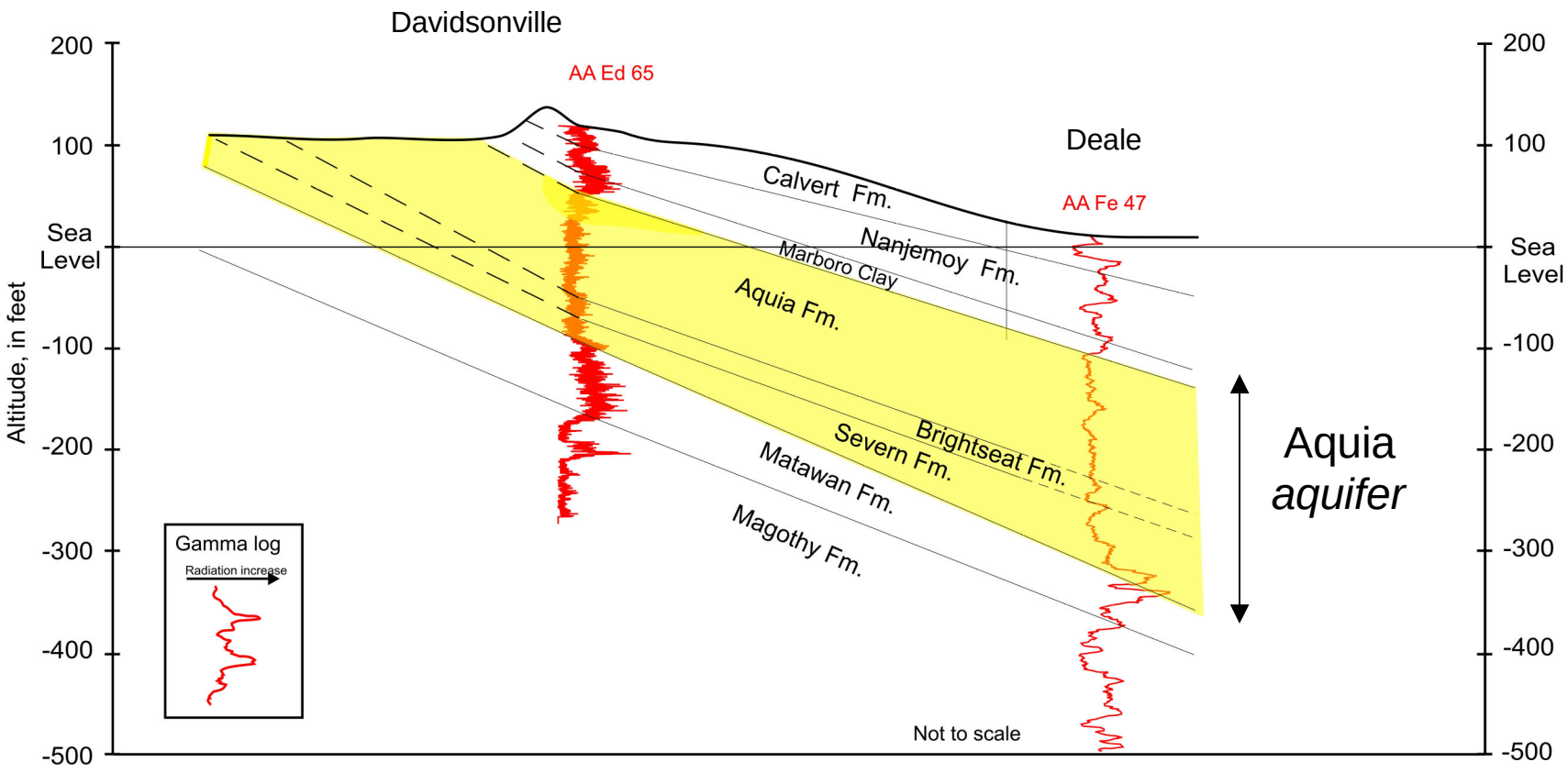
Insufficient evidence concerning cancer

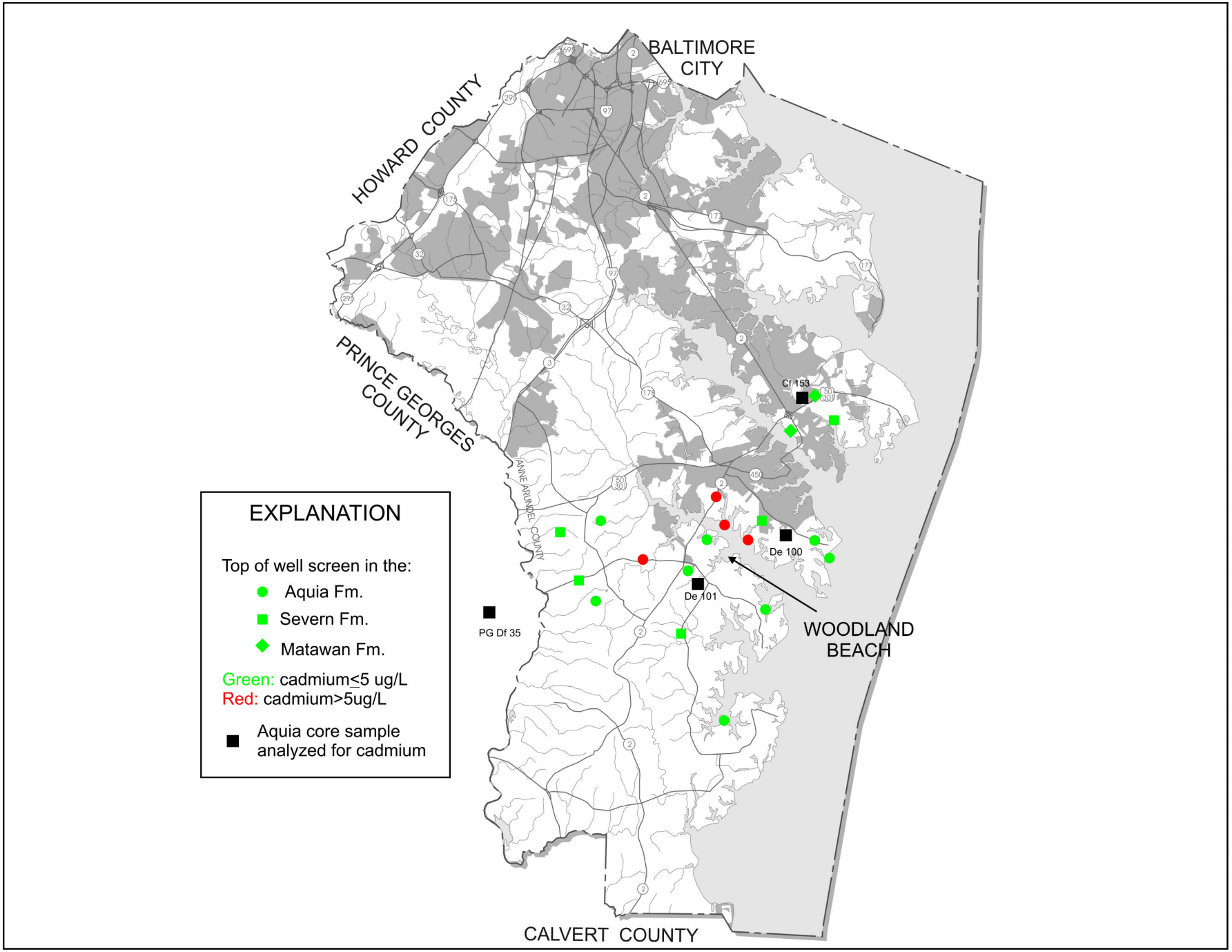
Source: U.S. Environmental Protection Agency; ATSDR

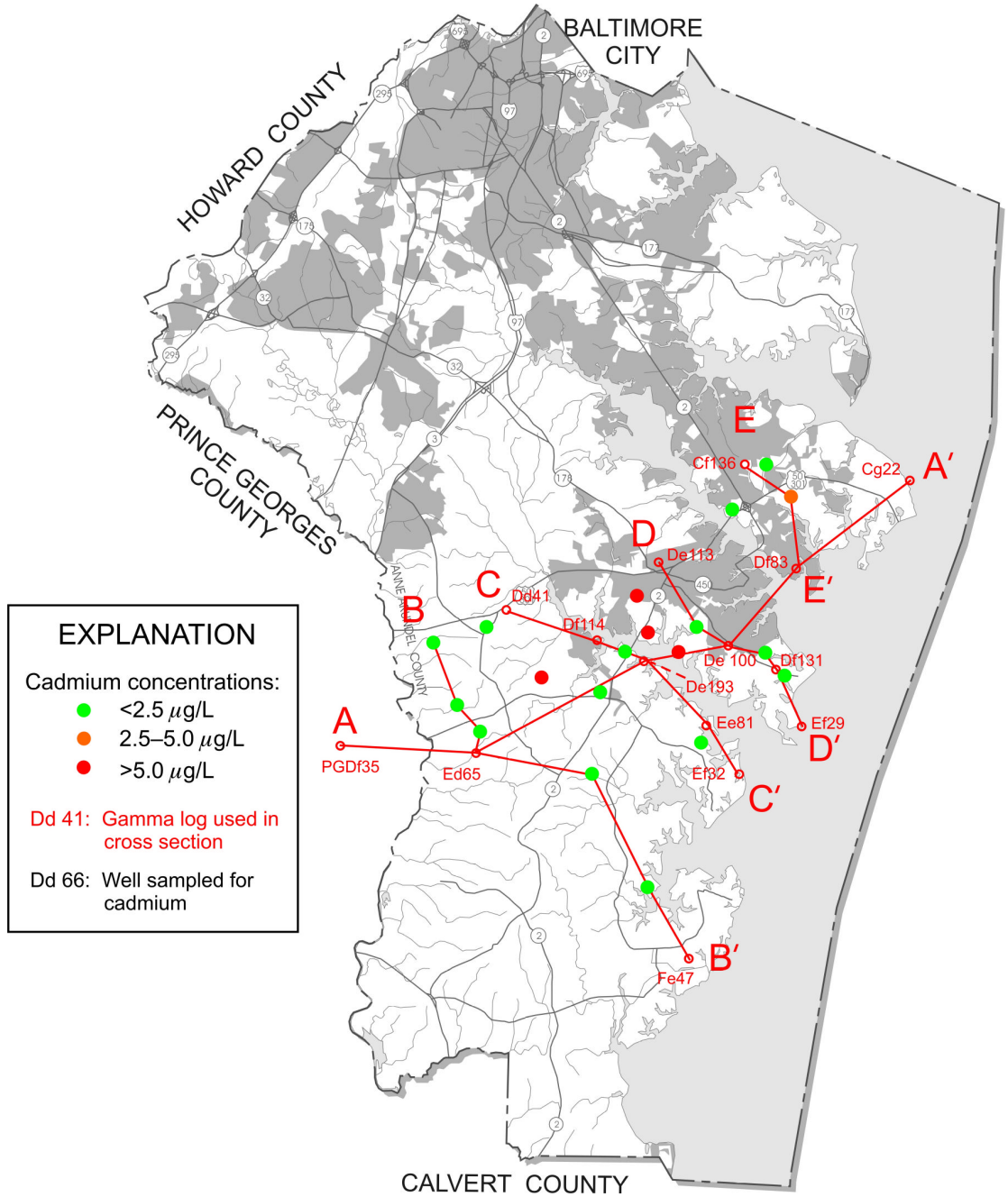
OBJECTIVES OF STUDY

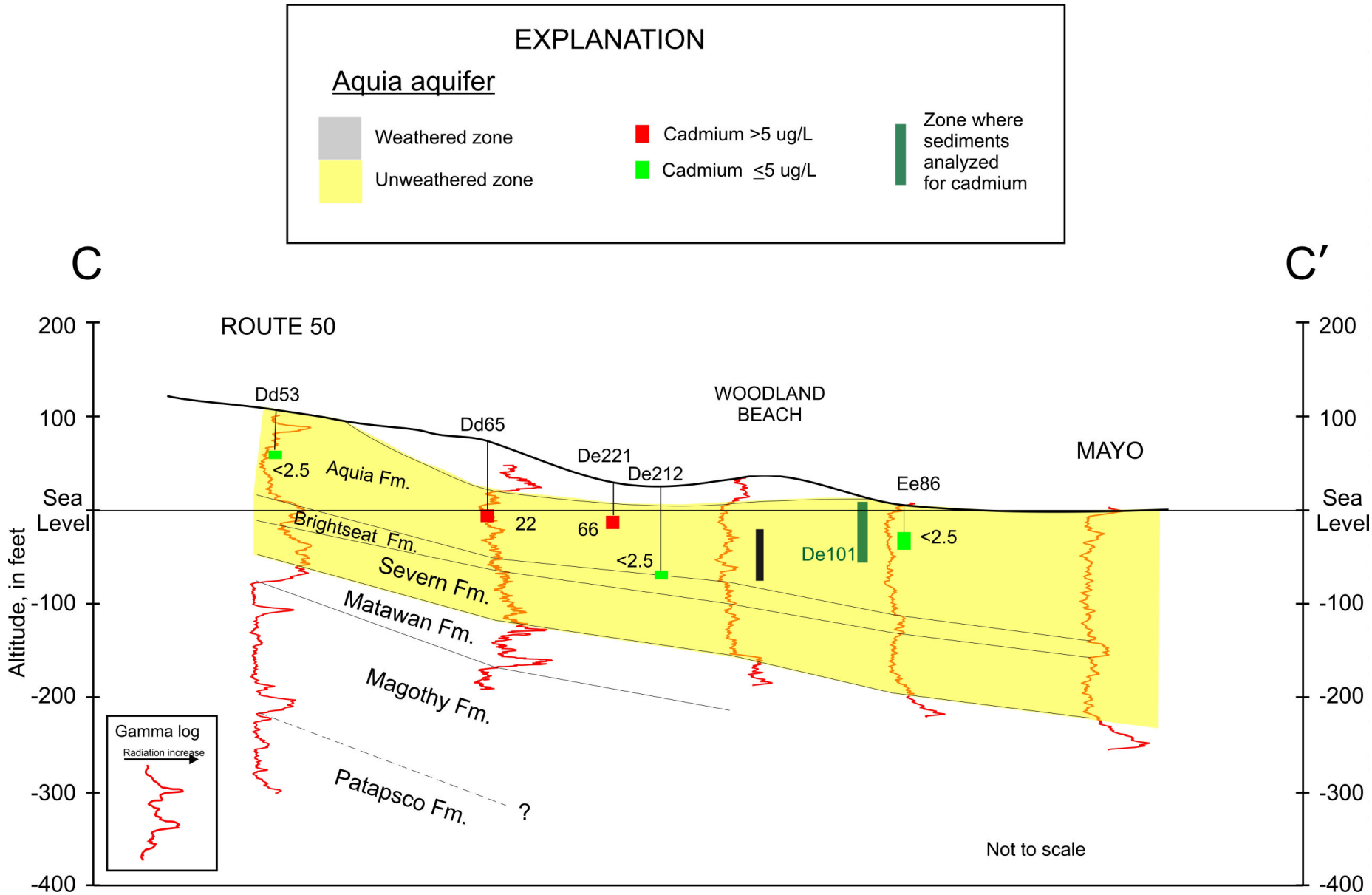
- Determine the occurrence and distribution of cadmium in the Aquia Formation in central Anne Arundel County
- Determine whether cadmium occurs naturally or has a human source

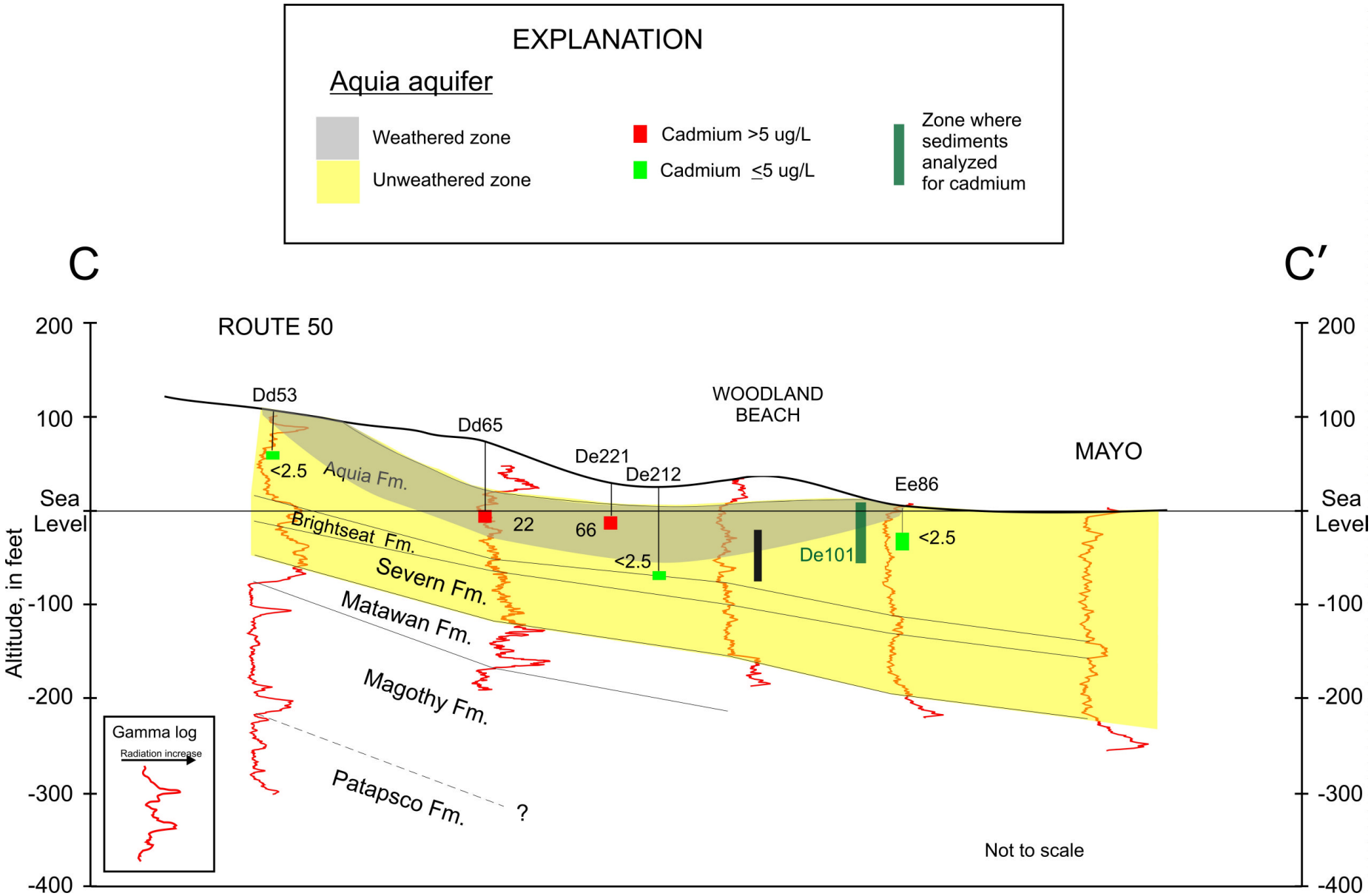
Aquia *Formation* vs. Aquia *Aquifer*




BALTIMORE CITY
HOWARD COUNTY
PRINCE GEORGES COUNTY
ANNE ARUNDEL COUNTY
CALVERT COUNTY
WOODLAND BEACH
Cf 153
De 100
De 101
PG Df 35
EXPLANATION
Top of well screen in the:
Aquia Fm.
Severn Fm.
Matawan Fm.
Green: cadmium≤5 ug/L
Red: cadmium>5ug/L
Aquia core sample analyzed for cadmium

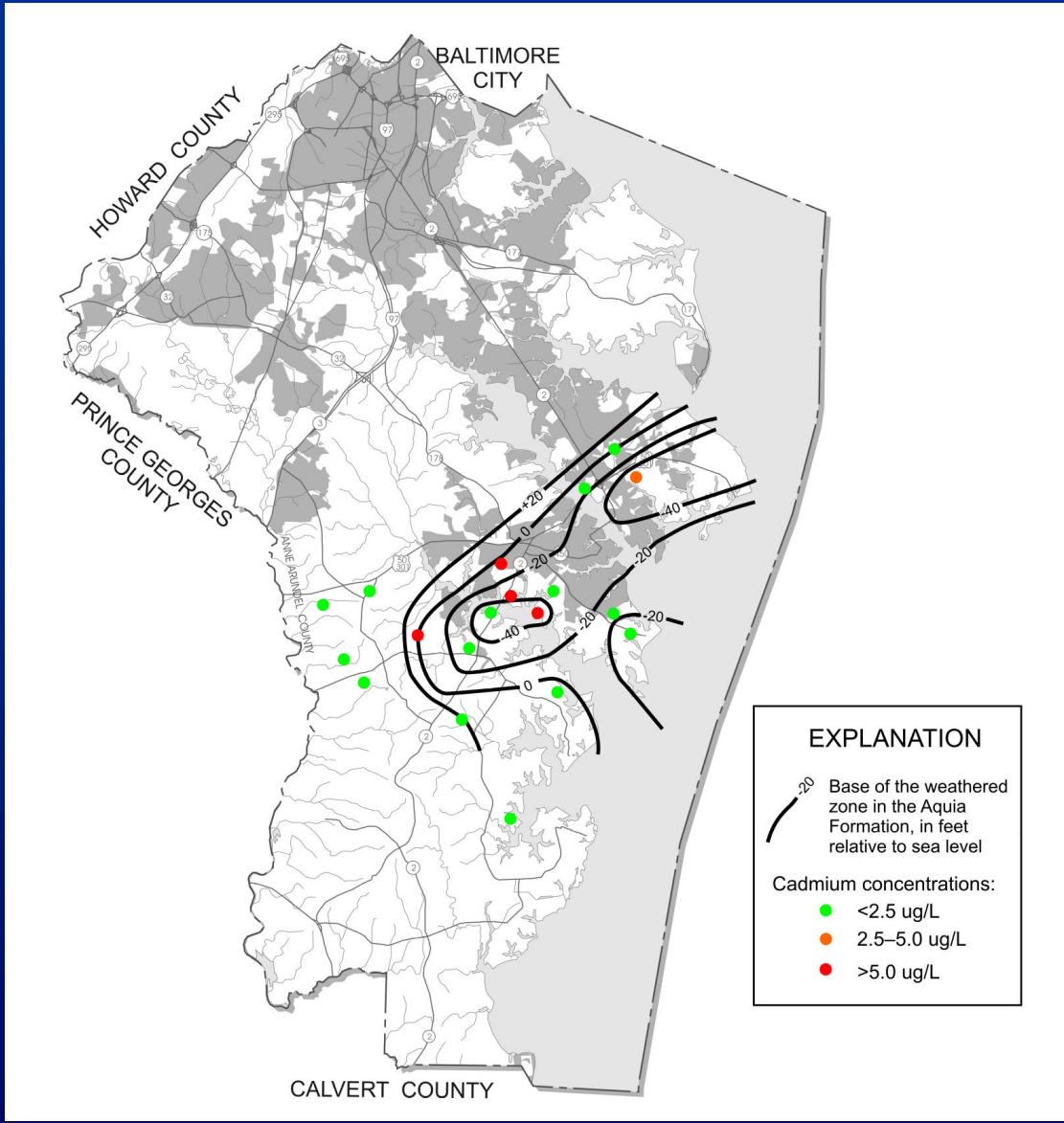

BALTIMORE CITY
HOWARD COUNTY
PRINCE GEORGES COUNTY
ANNE ARUNDEL COUNTY
CALVERT COUNTY
EXPLANATION
Cadmium concentrations:
<2.5 μg/L
2.5–5.0 μg/L
>5.0 μg/L
Dd 41: Gamma log used in cross section
Dd 66: Well sampled for cadmium
A
A′
B
B′
C
C′
D
D′
E
E′
PGDf35
Ed65
Dd41
Df114
De113
Df83
Cf136
Cg22
De 100
Df131
De193
Ee81
Ef29
Ef32
Fe47


EXPLANATION
Aquia aquifer
Weathered zone
Unweathered zone
Cadmium >5 ug/L
Cadmium ≤5 ug/L
Zone where sediments analyzed for cadmium
C
C′
ROUTE 50
WOODLAND BEACH
MAYO
Dd53
Dd65
De221
De212
Ee86
De101
<2.5
22
66
<2.5
<2.5
Aquia Fm.
Brightseat Fm.
Severn Fm.
Matawan Fm.
Magothy Fm.
Patapsco Fm.
?
Gamma log
Radiation increase
Not to scale
Altitude, in feet
200
100
Sea Level
-100
-200
-300
-400

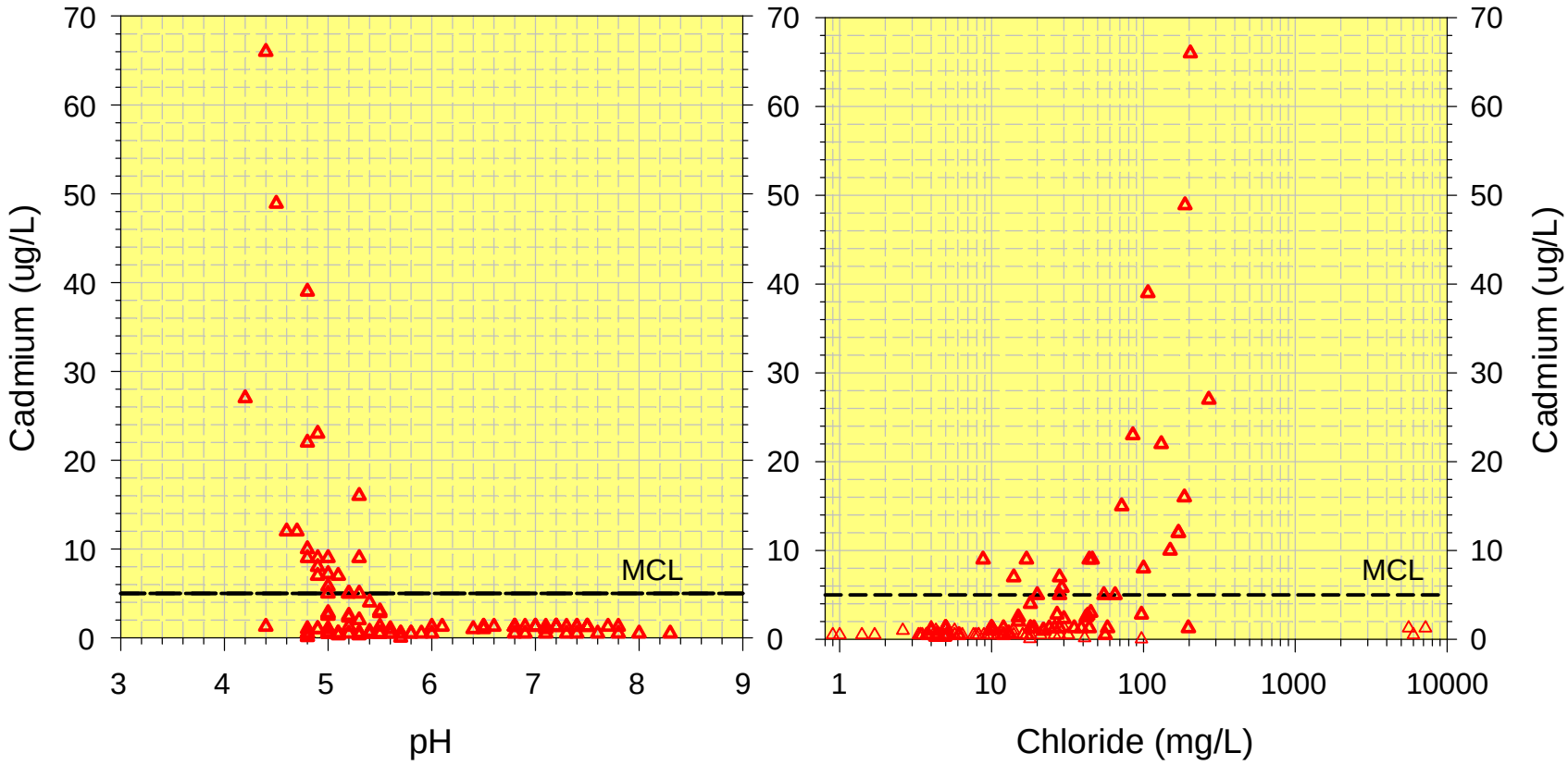

EXPLANATION
Aquia aquifer
Weathered zone
Unweathered zone
Cadmium >5 ug/L
Cadmium ≤5 ug/L
Zone where sediments analyzed for cadmium
C
C′
ROUTE 50
WOODLAND BEACH
MAYO
Dd53
Dd65
De221
De212
Ee86
De101
<2.5
22
66
<2.5
<2.5
Aquia Fm.
Brightseat Fm.
Severn Fm.
Matawan Fm.
Magothy Fm.
Patapsco Fm.
?
Gamma log
Radiation increase
Not to scale
Altitude, in feet
200
100
Sea Level
-100
-200
-300
-400

How is this useful?

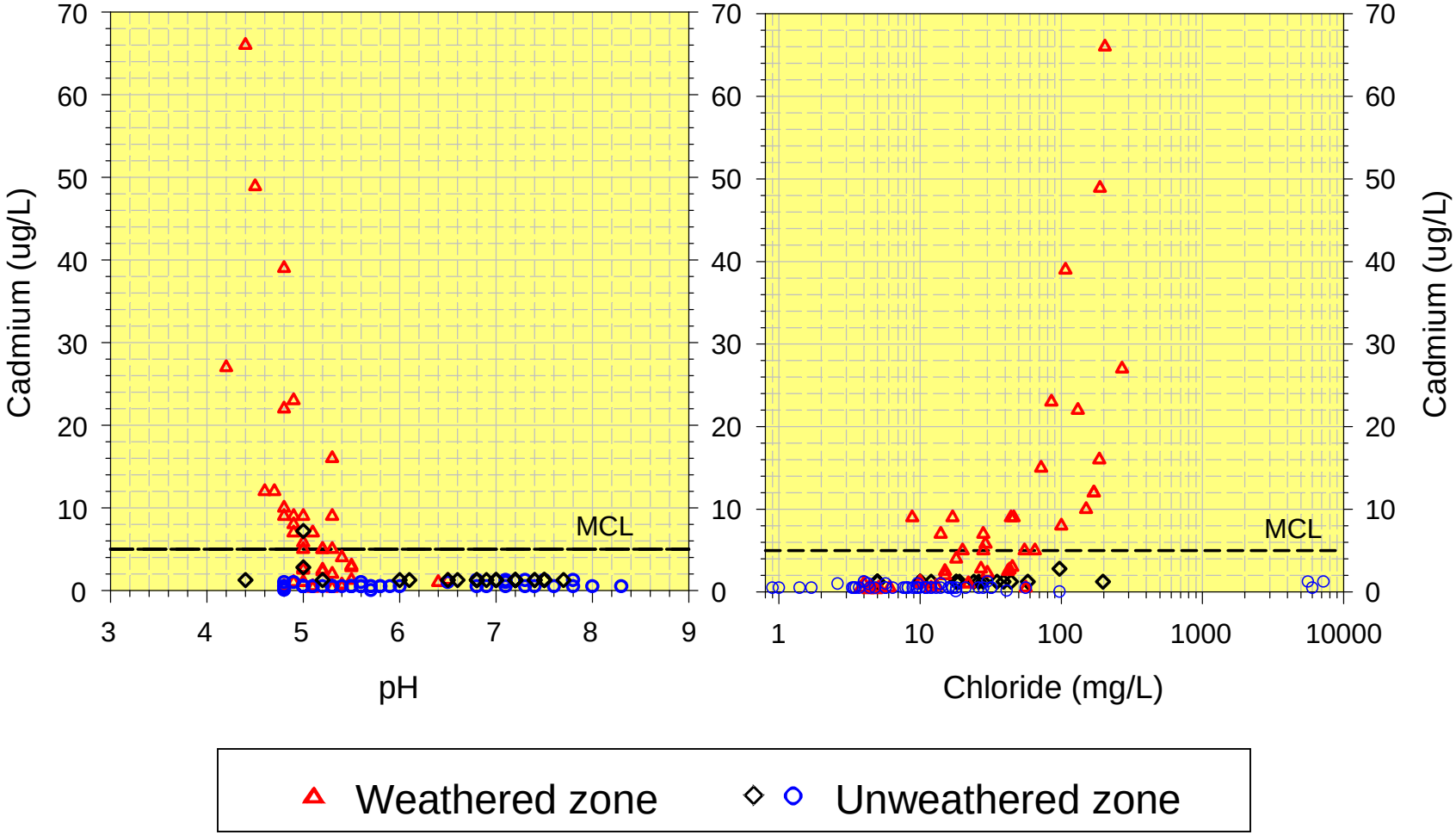
- Map constructed that showed depth to bottom of weathered zone
- Map used to specify minimum screen depths

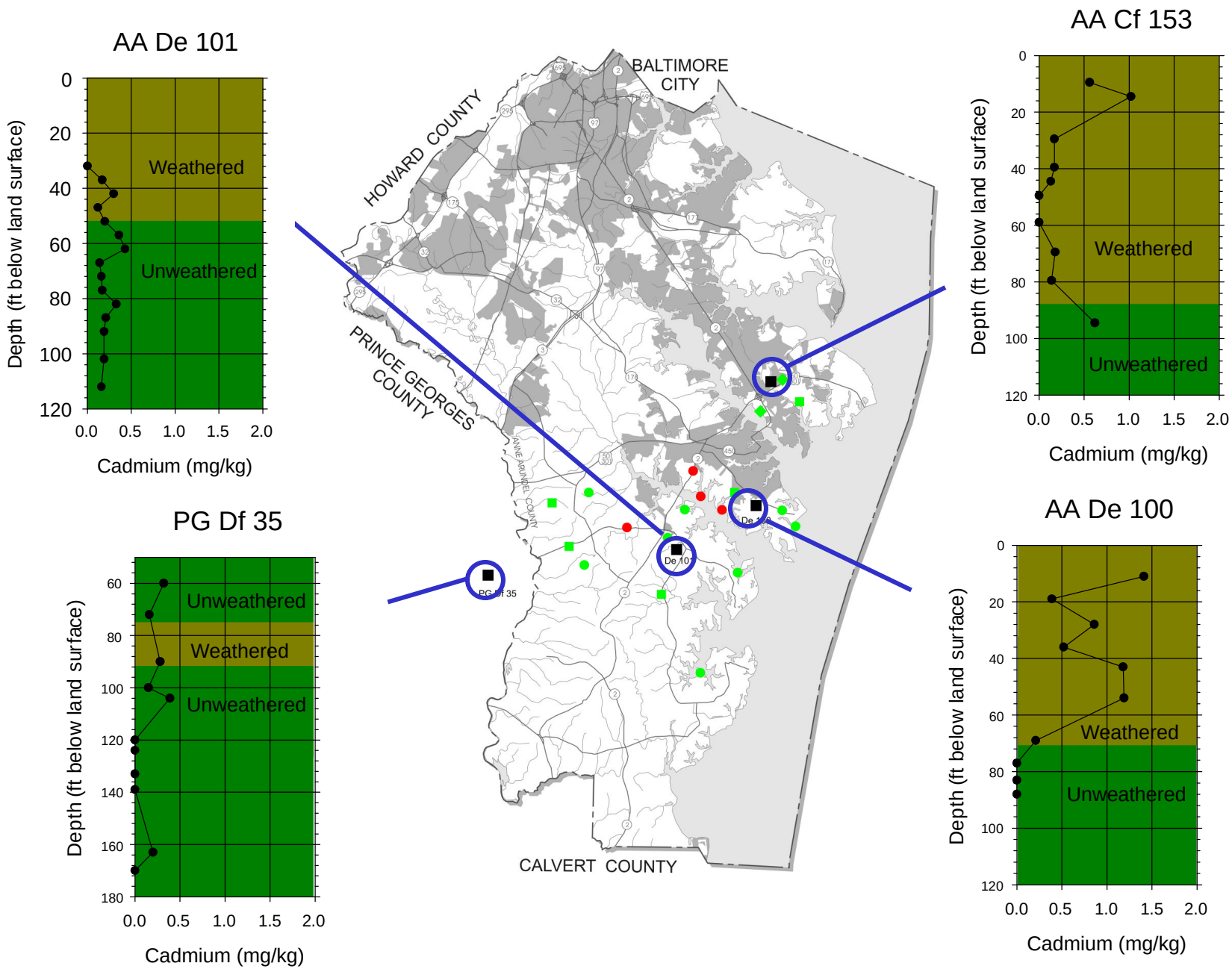


Cadmium vs. pH and chloride concentration



Cadmium vs. pH and chloride concentration: Relation to weathered and unweathered zones of the Aquia Aquifer




AA De 101
Depth (ft below land surface)
Weathered
Unweathered
Cadmium (mg/kg)
AA Cf 153
Depth (ft below land surface)
Weathered
Unweathered
Cadmium (mg/kg)
PG Df 35
Depth (ft below land surface)
Unweathered
Weathered
Unweathered
Cadmium (mg/kg)
AA De 100
Depth (ft below land surface)
Weathered
Unweathered
Cadmium (mg/kg)
BALTIMORE CITY
HOWARD COUNTY
PRINCE GEORGES COUNTY
ANNE ARUNDEL COUNTY
CALVERT COUNTY
De 101
PG Df 35

POTENTIAL SOURCES OF CADMIUM

Natural sources

- Accessory element in zinc ore (sphalerite) (largest industrial source)
- CdS; $CdCO_3$ (rare)

Human sources

- Industrial wastes (batteries; electroplating; pigment manufacture; video/fluorescent tubes
- Galvanized pipes
- Roadside soils (vehicle use)

Cadmium in the Aquia Formation… natural or human source?

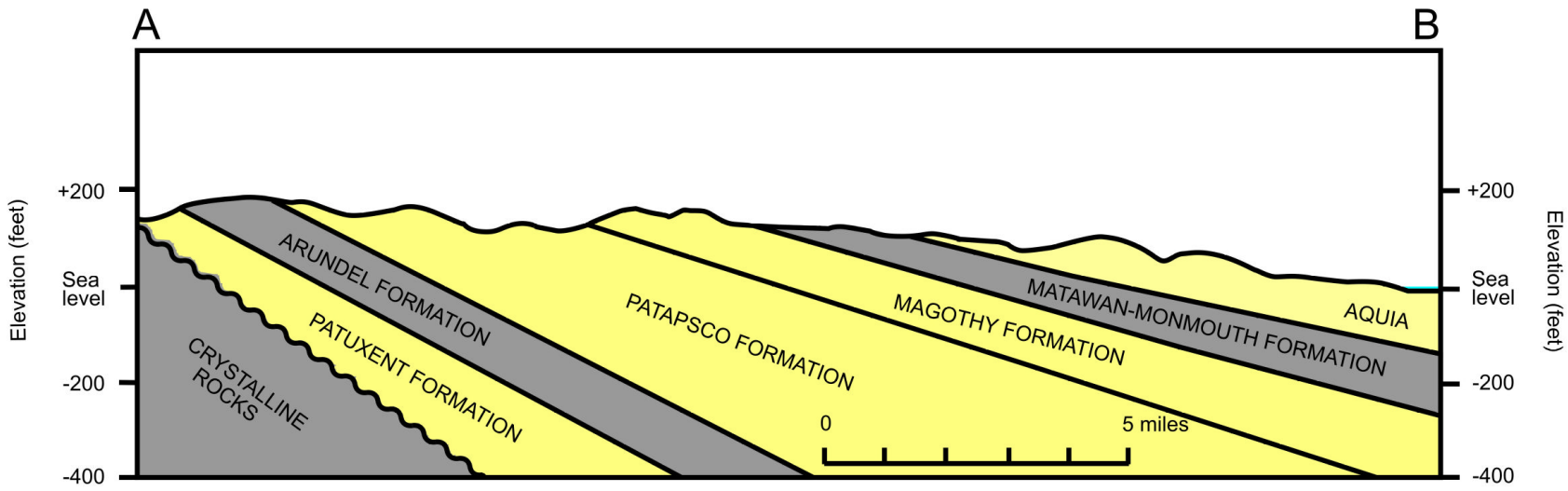
- All high-Cd samples had “unnatural” chloride levels
- Not much difference in sediment Cd concentrations between weathered and unweathered Aquia Fm.
- Zinc sulfide minerals not documented in Aquia Fm.

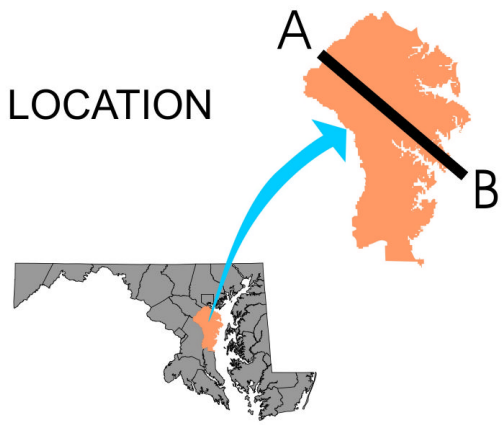
- Cd not seen in low-pH, high-Cl samples in Patapsco or Magothy aquifers
- Sediment analysis measured total (not exchangeable) CEC

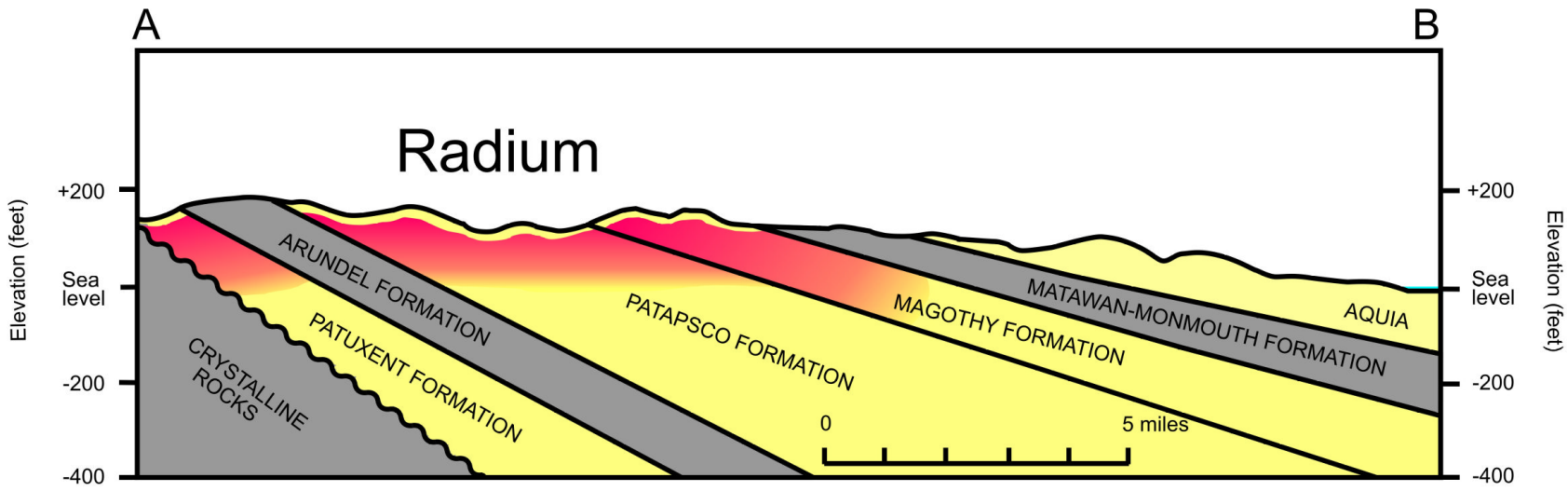
Cadmium in the Aquia…

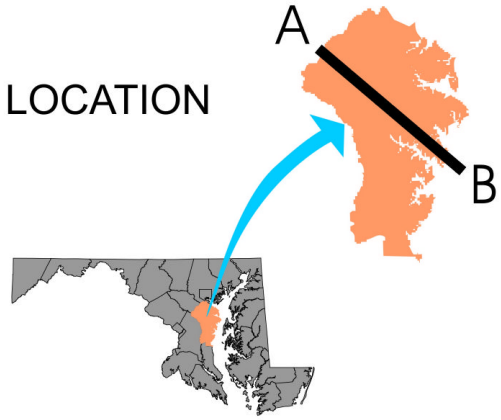
Radium in the Magothy and Potomac Group…

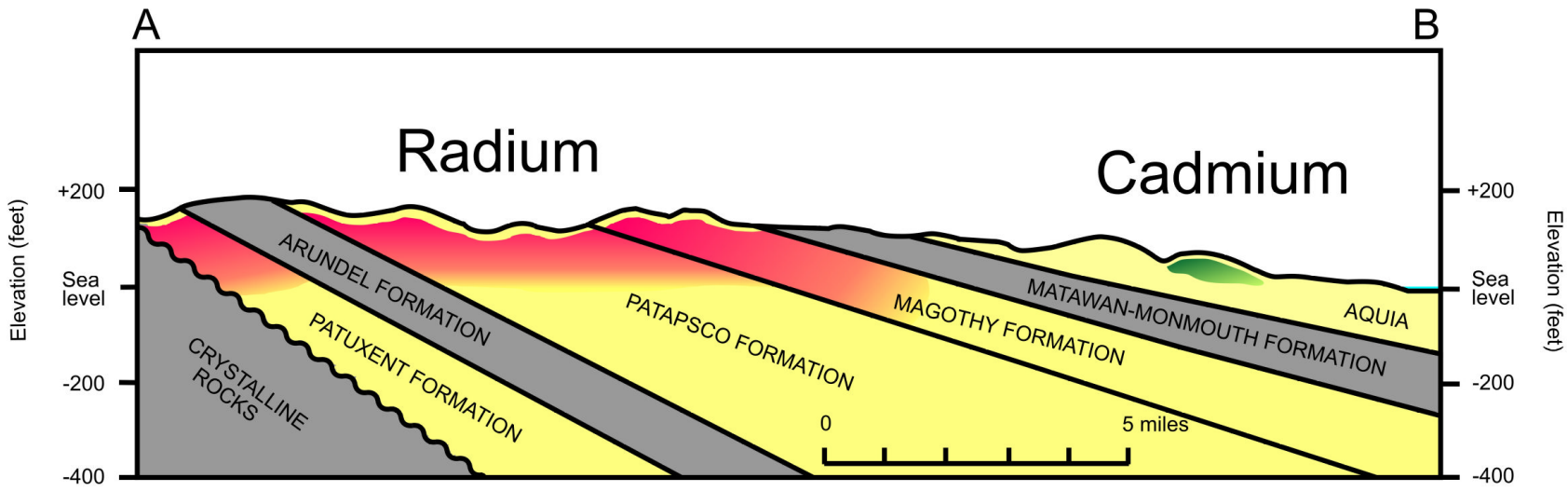
Why Anne Arundel County?

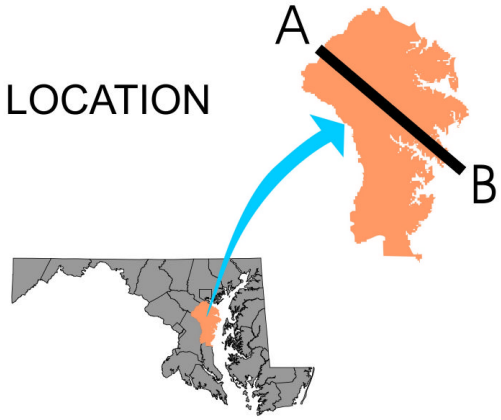

A
B
+200
Sea level
-200
-400
Elevation (feet)
CRYSTALLINE ROCKS
PATUXENT FORMATION
ARUNDEL FORMATION
PATAPSCO FORMATION
MAGOTHY FORMATION
MATAWAN-MONMOUTH FORMATION
AQUIA
0
5 miles


LOCATION
A
B


A
B
Radium
+200
Sea level
-200
-400
Elevation (feet)
ARUNDEL FORMATION
PATUXENT FORMATION
CRYSTALLINE ROCKS
PATAPSCO FORMATION
MAGOTHY FORMATION
MATAWAN-MONMOUTH FORMATION
AQUIA
0
5 miles


LOCATION
A
B





- Wide outcrop area of shallow unconfined aquifers
- Low pH groundwater
- Capacity for sorption/desorption

Miscellaneous:

Water treatment options:

- Cation-exchange, reverse osmosis systems effective
- High-chloride, high-cadmium levels may require special consideration

Low potential for migration of cadmium to other areas

- Sorption/precipitation in unweathered zone
- Most groundwater discharged to local surface water

CONCLUSIONS

- Elevated cadmium found in weathered zone of the Aquia Formation in central Anne Arundel County
- Elevated cadmium levels associated with decreasing pH and increasing chloride concentrations
- Sediment cadmium concentrations similar in weathered and unweathered zones
- Cadmium sources not clear…

COOPERATING AGENCIES

Maryland Department of the Environment

Anne Arundel County Health Department

Maryland Geological Survey
(Maryland Department of Natural Resources)