

HYDROGEOLOGIC SETTING OF A FLORISTICALLY DISTINCTIVE GROUND-WATER SLOPE WETLAND ALONG THE FALL ZONE IN NORTHERN VIRGINIA

Barcroft Magnolia Bog, Arlington, VA

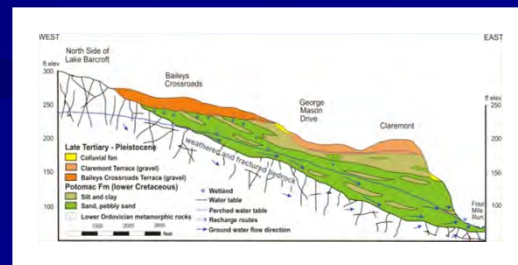
Presented By Tony Fleming, Geologist





SCOPE OF PRESENTATION

- Fall Line Magnolia Bogs: History and Background
- Barcroft Magnolia Bog
 - Physiographic and Cultural Setting
 - Floristics
 - Geology and Hydrostratigraphy
 - Weathering and Geochemistry
 - Flow System: Recharge, Discharge and travel time
 - Management Issues

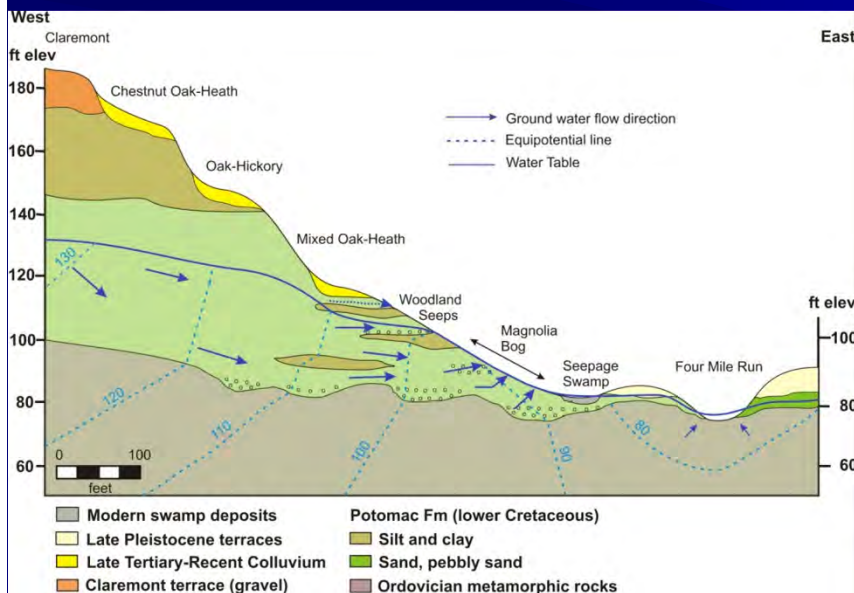


Ground Water Slope Wetlands



Major Features:

- Commonly occur in the lower parts of steep regional slopes
- Hillside intersects perennial water table
- Springs and seeps commonly concentrated along toes of slopes
- Perched systems may also be present: ground water forced to surface along tops of poorly permeable units
- Seepage faces can extend significant distances upslope depending on geology
- Geochemistry ranges widely. Most are circum-neutral to acidic
- Other names: seepage faces, seepage bogs, seepage swamps, 'poor' fens, Fall Line Magnolia Bogs



FALL LINE MAGNOLIA BOGS

Named for *Magnolia virginiana*, 'Sweetbay' or 'Swamp' Magnolia

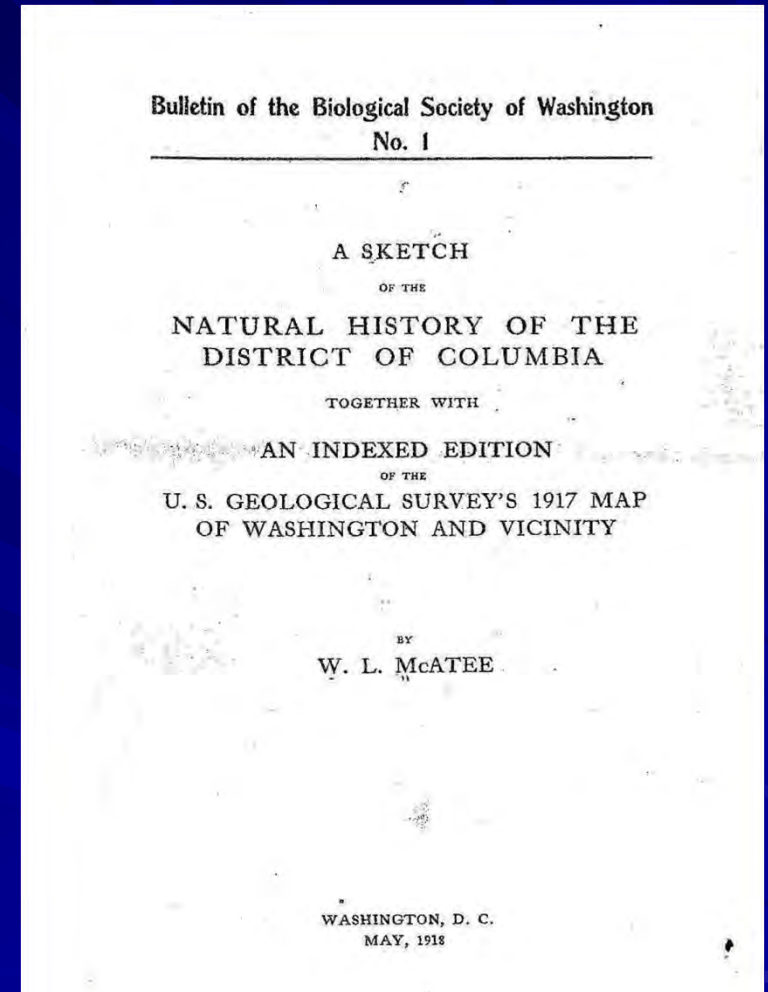
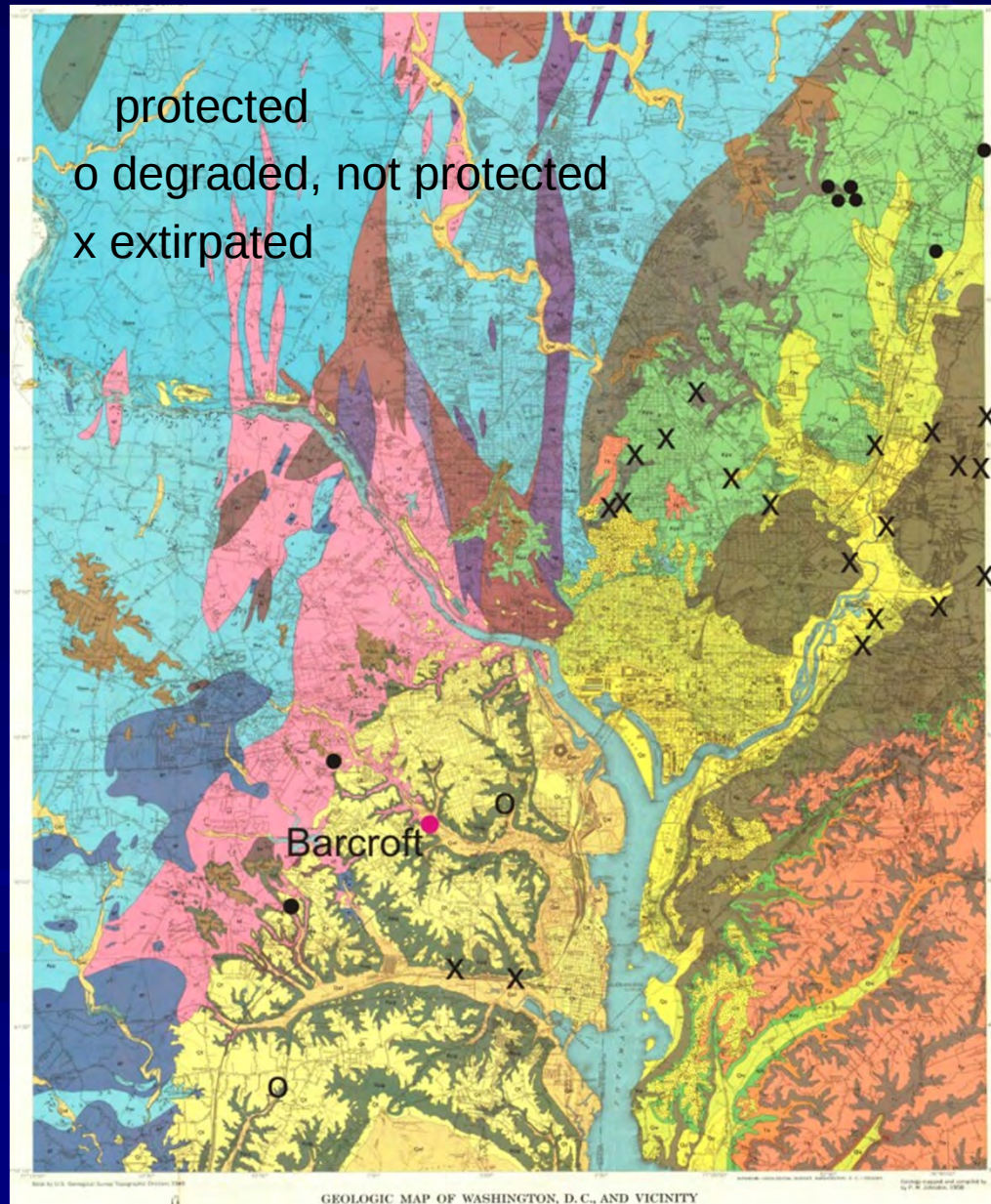


FALL LINE MAGNOLIA BOGS



The Fall Line, or 'Fall Zone', is a first order physiographic boundary between the Piedmont Plateau on the west and the Atlantic Coastal Plain to the east. It is defined by deeply-entrenched stream valleys that commonly form gorges, cascades, and small waterfalls.

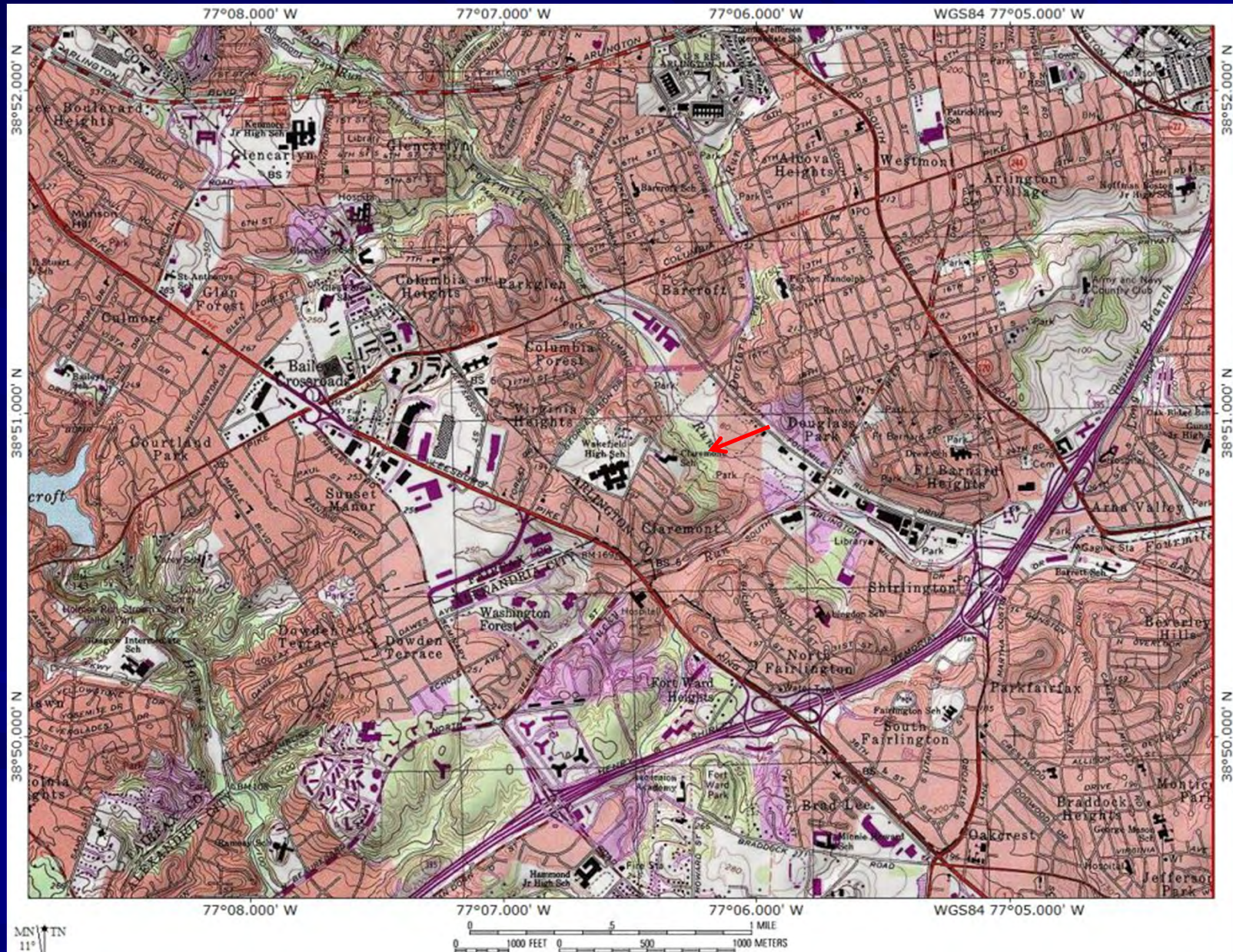
FALL LINE MAGNOLIA BOGS



- McAtee published first description of 'white sand and gravel bogs'
- Coined the name 'magnolia bogs'

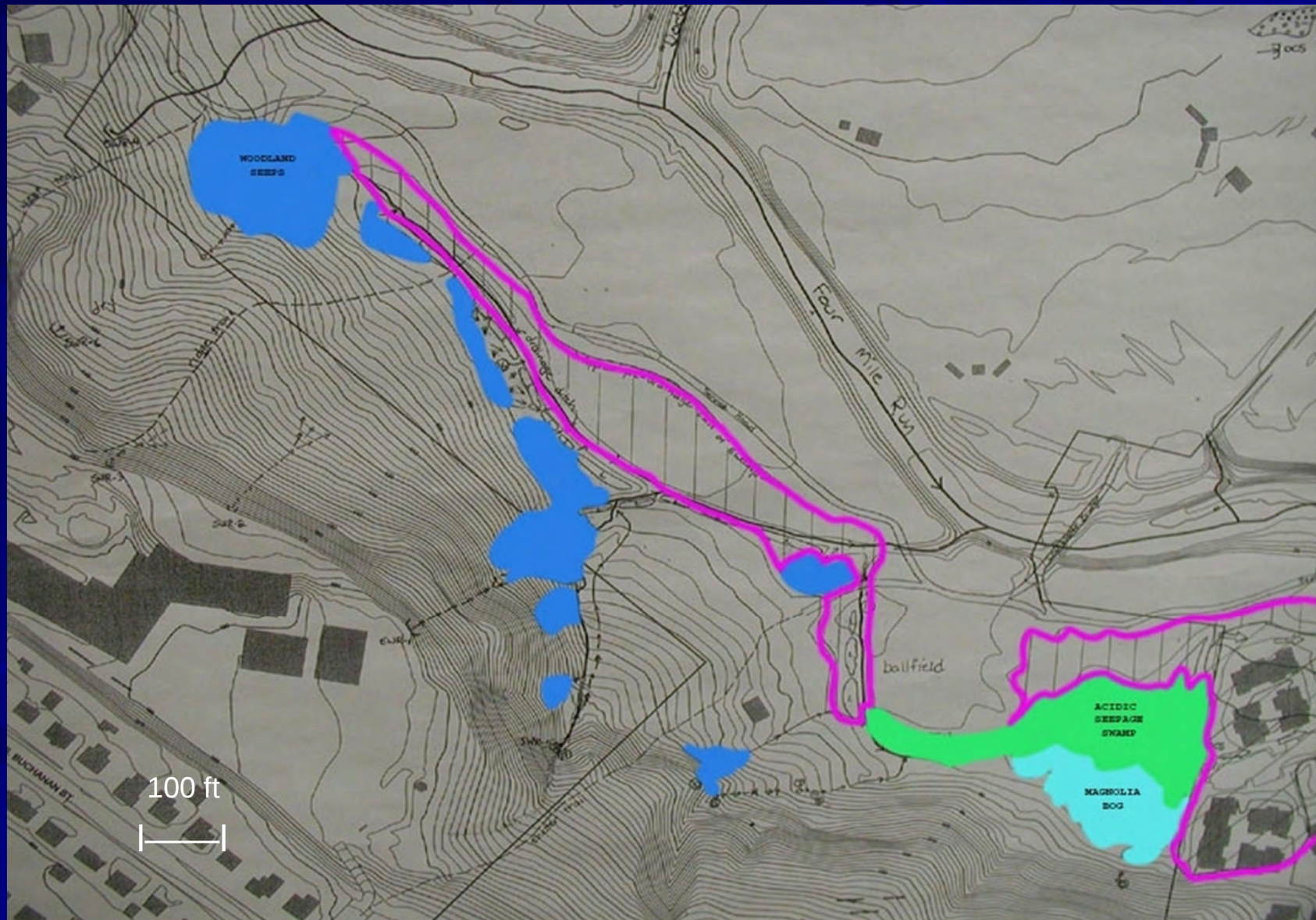
BARCROFT MAGNOLIA BOG

CULTURAL AND TOPOGRAPHIC SETTING



BARCROFT MAGNOLIA BOG

HISTORICAL EXTENT OF WETLANDS



BARCROFT MAGNOLIA BOG

FLORISTICALLY DISTINCTIVE



- Barcroft was one of the original sites described by McAtee in 1918
- The site was 'rediscovered' by ecologists in 2003, nearly a century later, almost by accident
- Contains many regionally rare plants: some 2 dozen county records have been found at the site: highbush blueberry, sweetbay magnolia, false hellebore, Turk's cap, sphagnum, slender wood oats, swamp haw, wood anemone, cinnamon fern, southern lady fern, and many others
- Supports the largest colonies of poison sumac and swamp azalea in northern VA

BARCROFT MAGNOLIA BOG

FLORISTICALLY DISTINCTIVE



- Many plants here are acidophiles, as well as obligate or facultative wetland plants
- Two main ecological communities are classified at the site:
 - Fall-line Terrace Gravel Magnolia Bog (G1), extant at less than 10 sites globally
 - Acidic Piedmont Seepage Swamp (G3), uncommon
- Ecological and historical evidence indicates that fire was an important factor in maintaining the openness of the bog community type
- Closest facsimile: NJ pine barrens

Ecological Processes



- Hummocky topography on bog floor

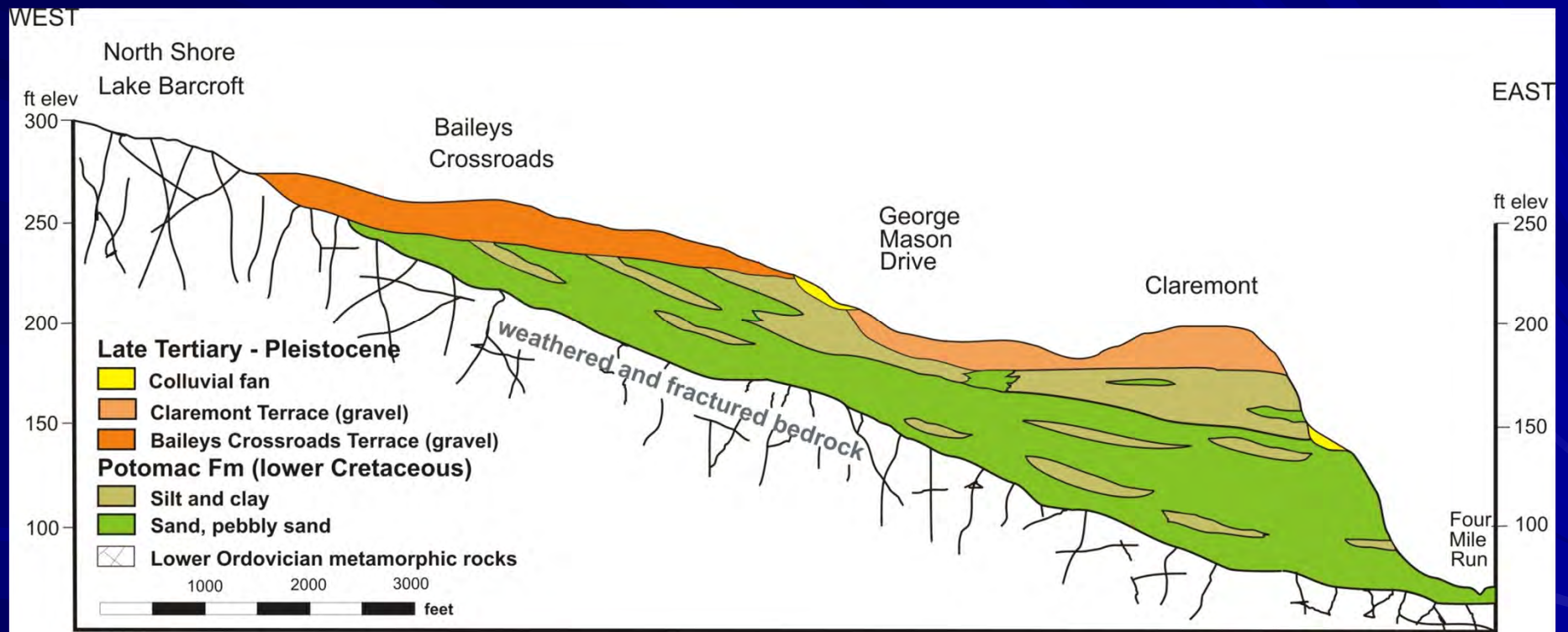
- Hydrogeologically-driven process



- Produced by growth of sphagnum mounds

- Eventually colonized by shrubs and trees

HYDROGEOLOGIC FRAMEWORK



HYDROGEOLOGIC FRAMEWORK



QTc-Terrace gravel

Potomac Formation

Kpc- Silty Clay (Lincolnia member)
beneath colluvial fans

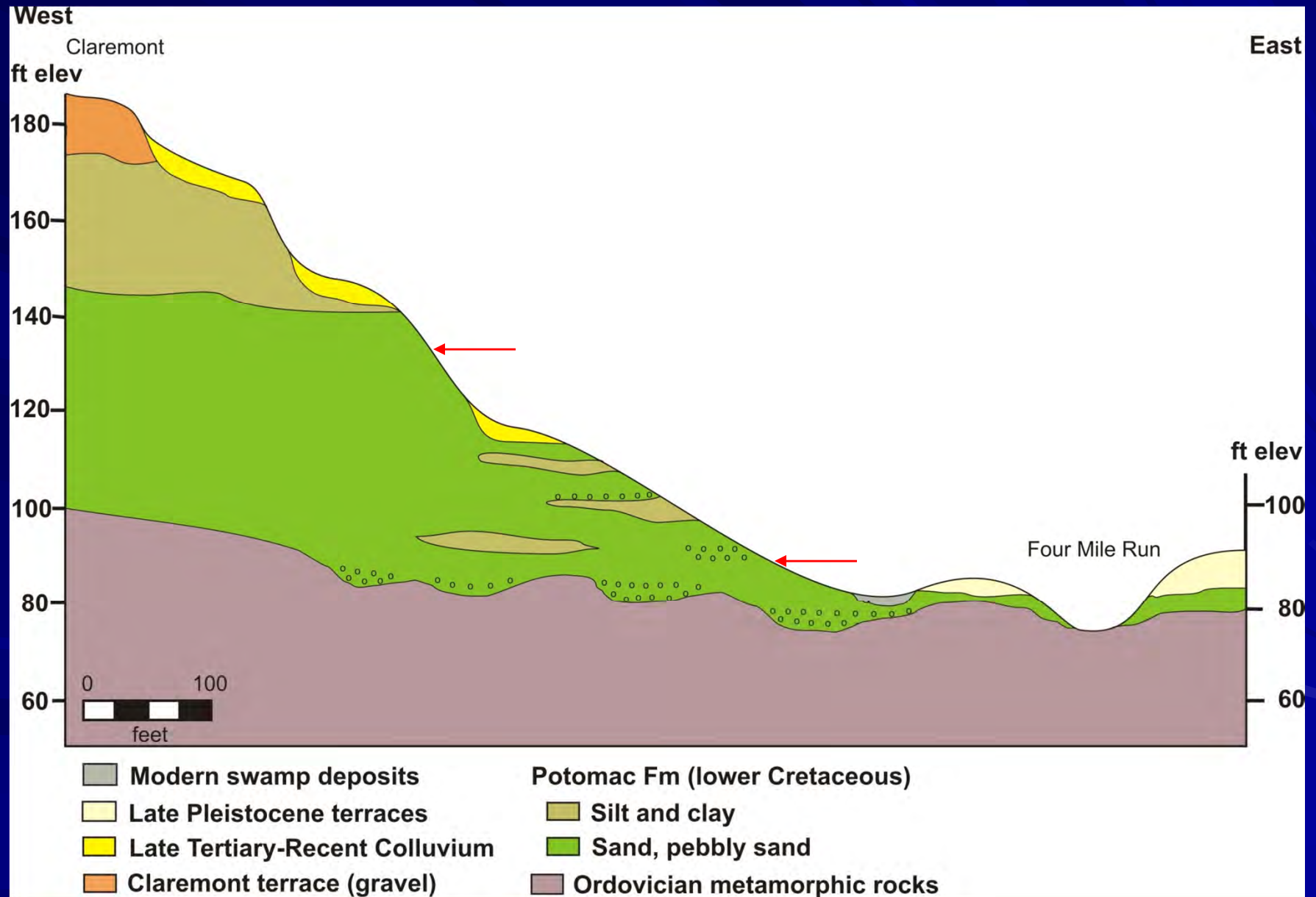


Kps-basal sand

Qs-modern swamp sediments over
Kps

HYDROGEOLOGIC FRAMEWORK

LOWER POTOMAC AQUIFER



HYDROGEOLOGIC FRAMEWORK

Potomac Formation-Basal Sand Aquifer



HYDROGEOLOGIC FRAMEWORK

Potomac Formation-Basal Sand Aquifer



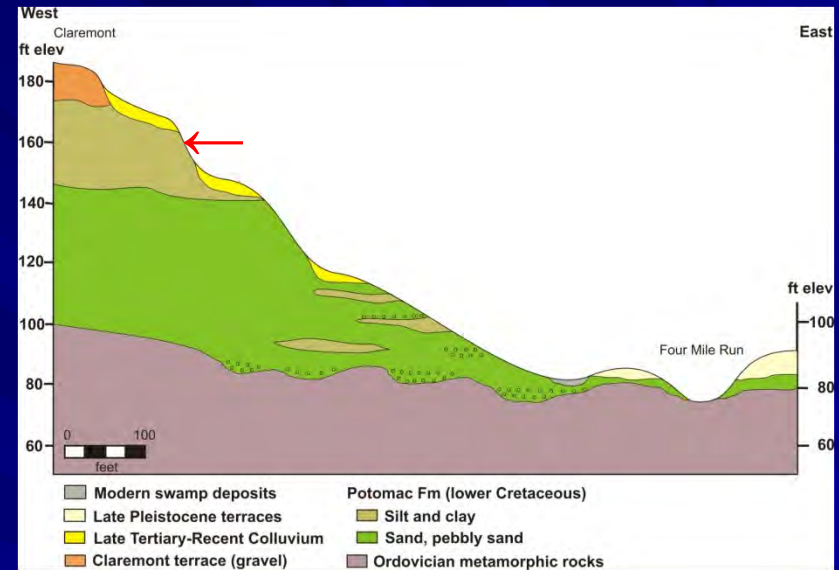
HYDROGEOLOGIC FRAMEWORK

Potomac Formation-Basal Sand Aquifer



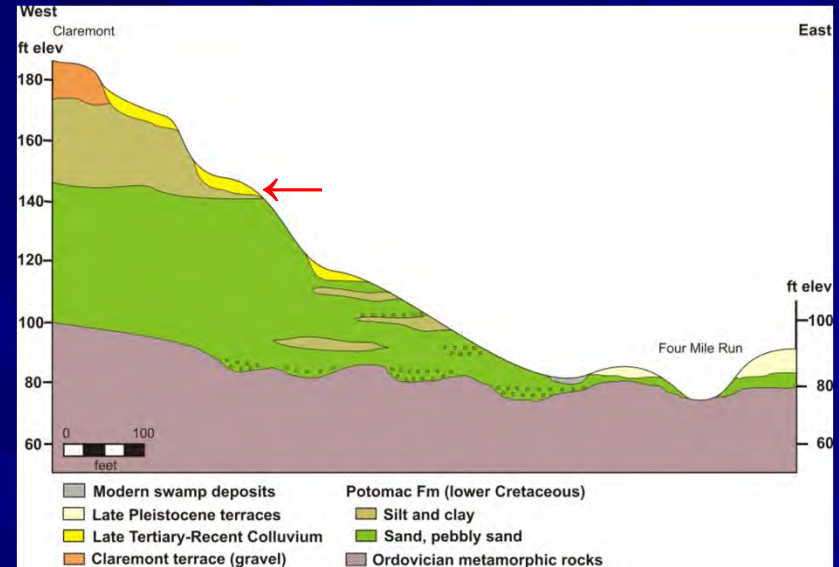
HYDROGEOLOGIC FRAMEWORK

Potomac Formation-Lincolnia Silty Clay



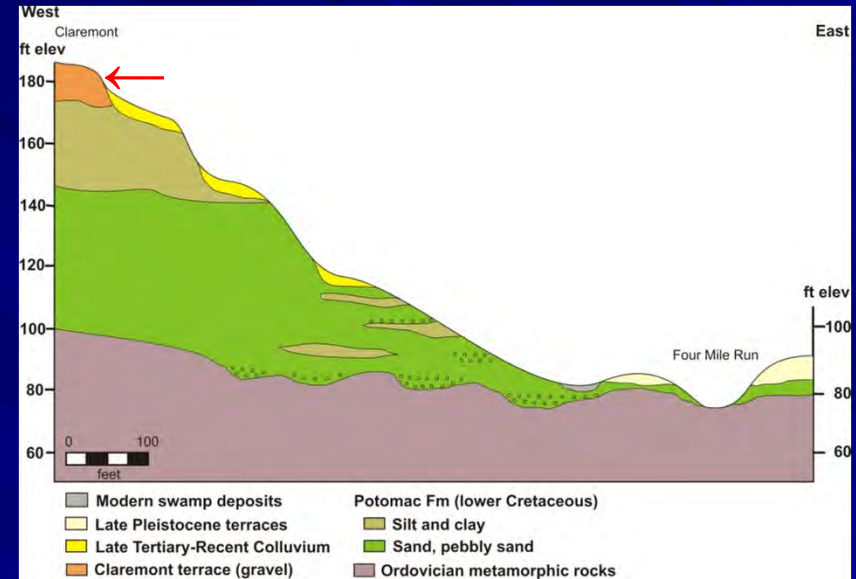
HYDROGEOLOGIC FRAMEWORK

Colluvial Fans



HYDROGEOLOGIC FRAMEWORK

Late Tertiary-Pleistocene Terrace Gravel



HYDROGEOLOGIC FRAMEWORK

Weathering and Geochemistry



- Strong Late Tertiary-Pleistocene weathering profiles preserved on uplands
- Depth of weathering locally >150 feet
- Extends into bedrock
- Thoroughly leached: no bases left
- Feldspars in Potomac Fm converted to kaolinite at depths >100 feet
- "Ghosts" of large siliceous clasts
- Sassafras-Neabsco-Croom Soils dominant on uplands
- Well developed ultisols on terrace gravel and Potomac Formation
- Acid: soil pH typically ≤ 5.0
- Thick fragipans common on level parts of terrace gravels (Neabsco Soils)
- Weathering profiles progressively truncated across regional slopes
- Toeslopes exhibit less colorful post-Pleistocene soil profiles, though still deeply weathered

HYDROGEOLOGIC FRAMEWORK

Ground-Water Geochemistry



Sources of Data

- This study: chemical analyses of two springs at Barcroft Magnolia Bog
- USGS WSP 1776: Samples from dozens of wells constructed before 1960. About 15 analyses are from the lower Potomac Formation aquifer, widely distributed in VA, DC, and MD
- Virginia Natural Heritage Database: Miscellaneous analyses of pH and temperature from magnolia bogs in Virginia, DC, and Maryland
- Visual and ecological: prominent acidophiles (sphagnum, azalea, magnolia, etc). Thriving population of iron bacteria

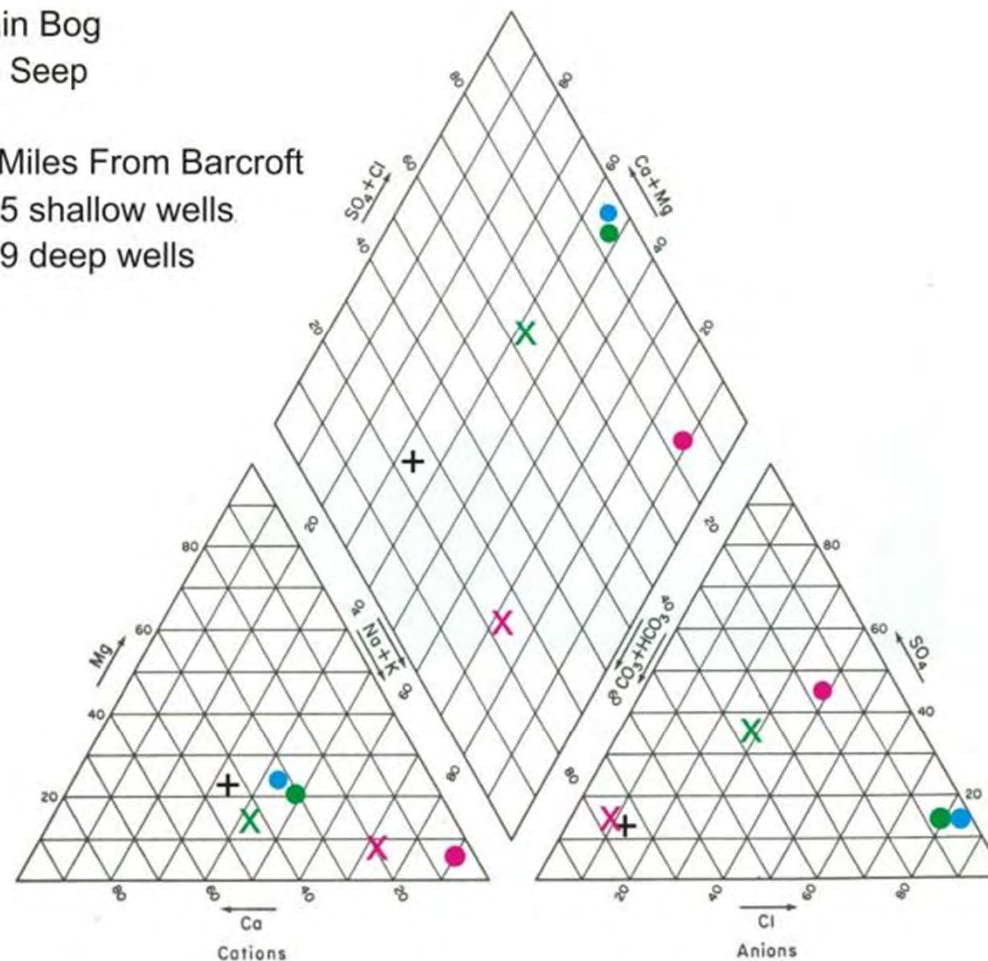
HYDROGEOLOGIC FRAMEWORK

Ground-Water Geochemistry at Barcroft Bog

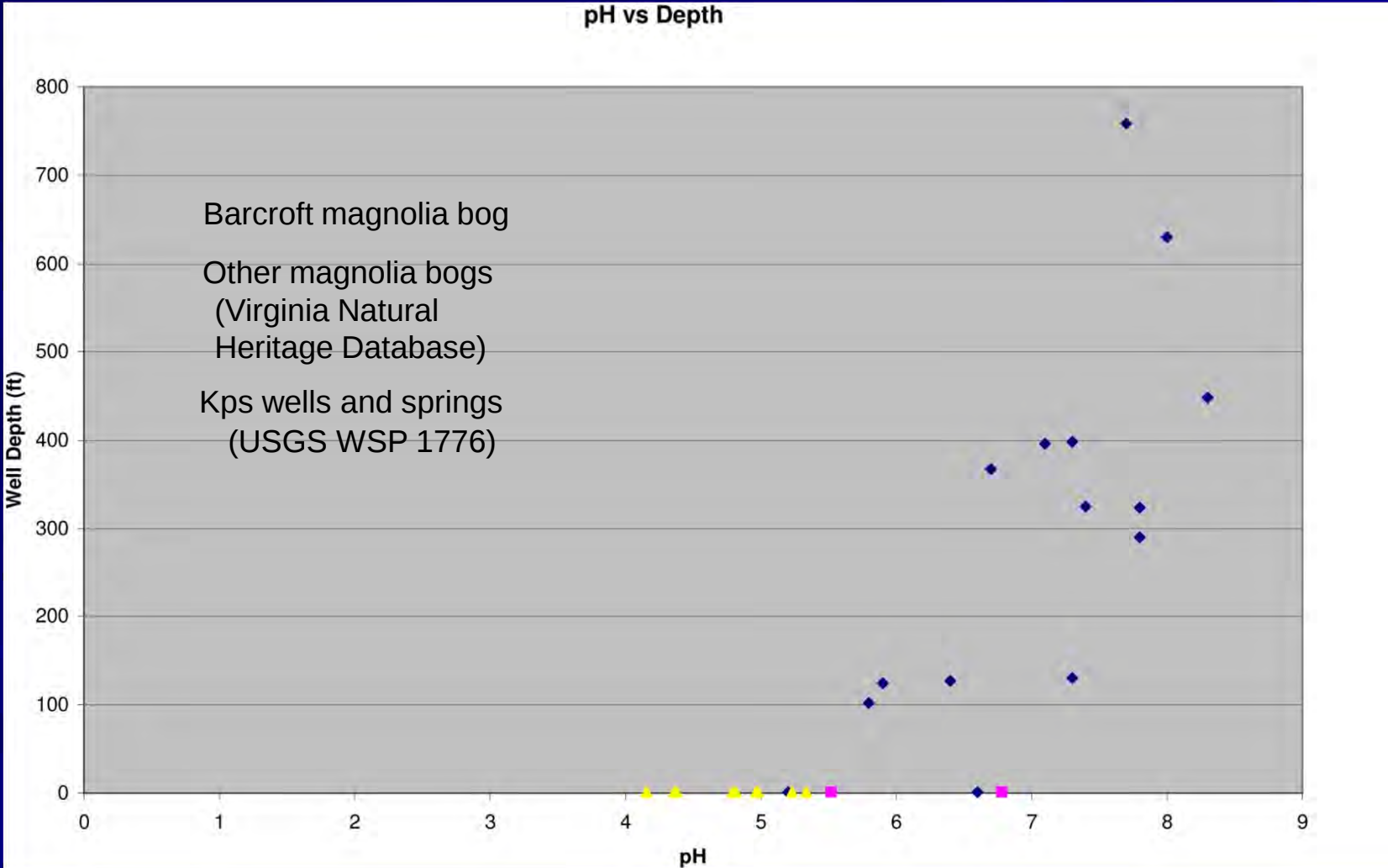
	Main Bog	Toe Seep
pH	6.78	5.52
TDS	102	116
Ca	7.6	9.2
Mg	5.4	5.8
K	3.9	4.4
Na	7.9	8.5
HCO ₃	2	1
SO ₄	7.4	7.6
Chl	40.5	40.8
NO ₃	1	1.4
PO ₄	<0.07	<0.07
B	<0.01	<0.01
Mn	5.4	5.8
Fe	0.8	0.7

Comparative Ground-Water Geochemistry Lower Aquifer of the Potomac Formation

- Barcroft Main Bog
- Barcroft Toe Seep
- Kps Springs
- + 130' Well 2 Miles From Barcroft
- X Average of 5 shallow wells
- X Average of 9 deep wells



Ground-Water Geochemistry



Geochemistry: Visual and Ecological Evidence



Observed Water Temperature Range

4.5 – 13° C (40 – 55° F)

Skunk Cabbage (*Symplocarpus foetidus*)



Hydrogeologically Adapted Thermophile



Ground Water Discharge Indicator

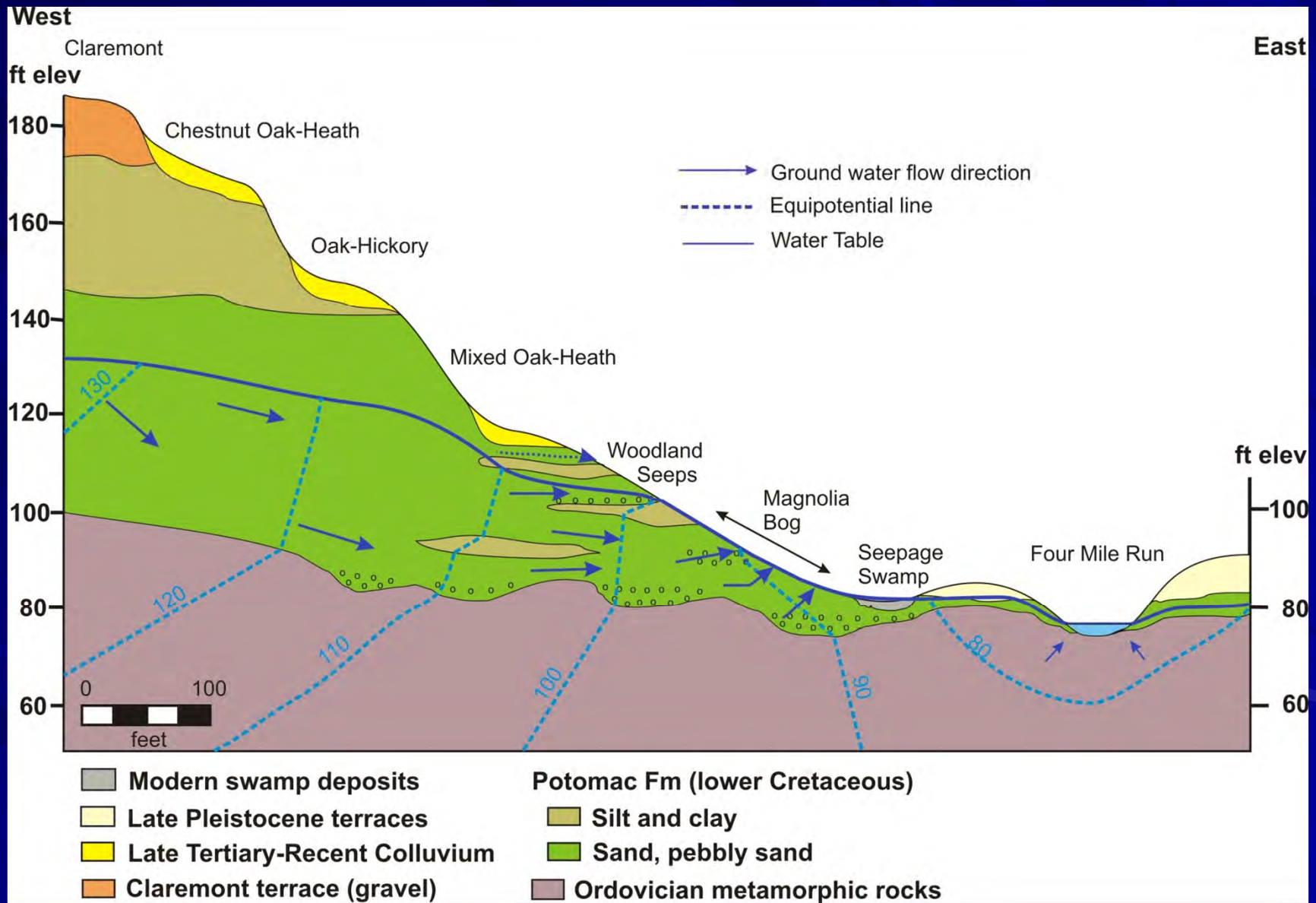
Ground Water Flow System

Well-Defined Discharge Area



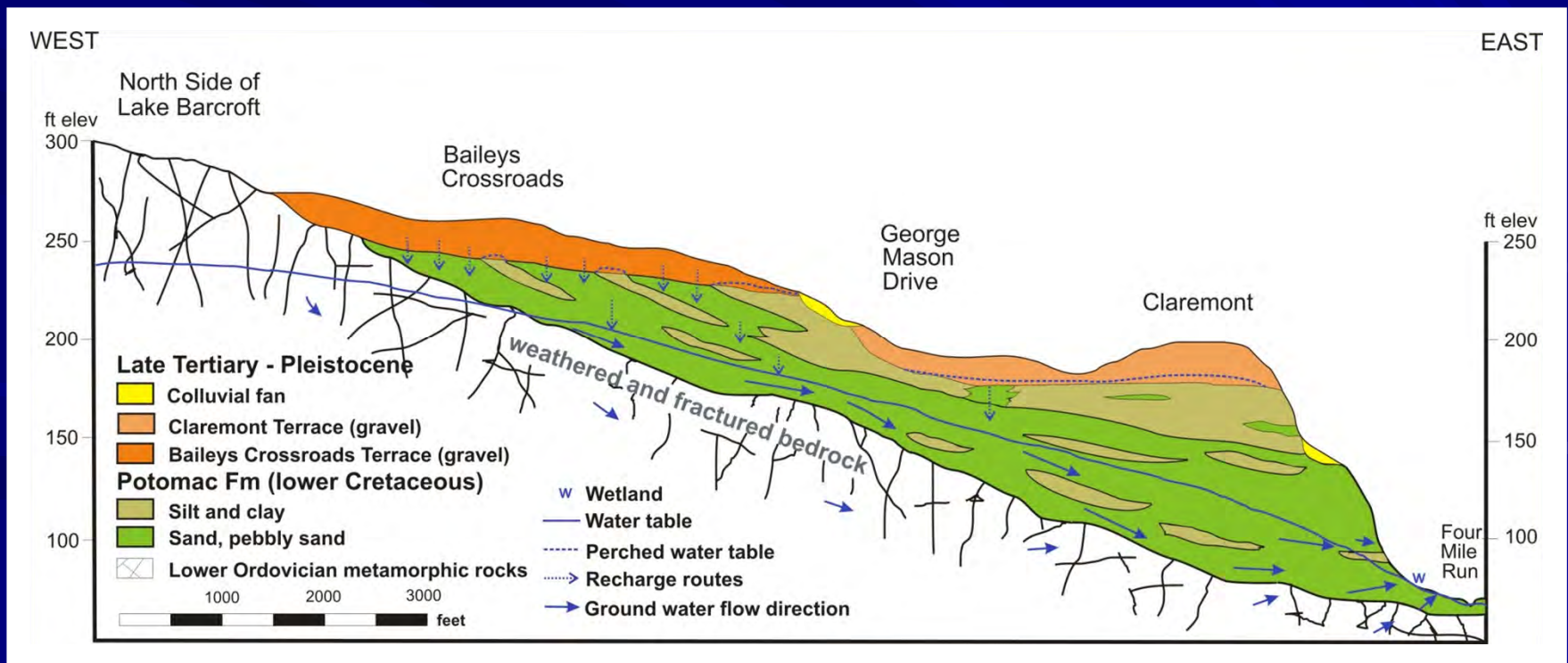
Ground Water Flow System

Where is the Recharge Area?



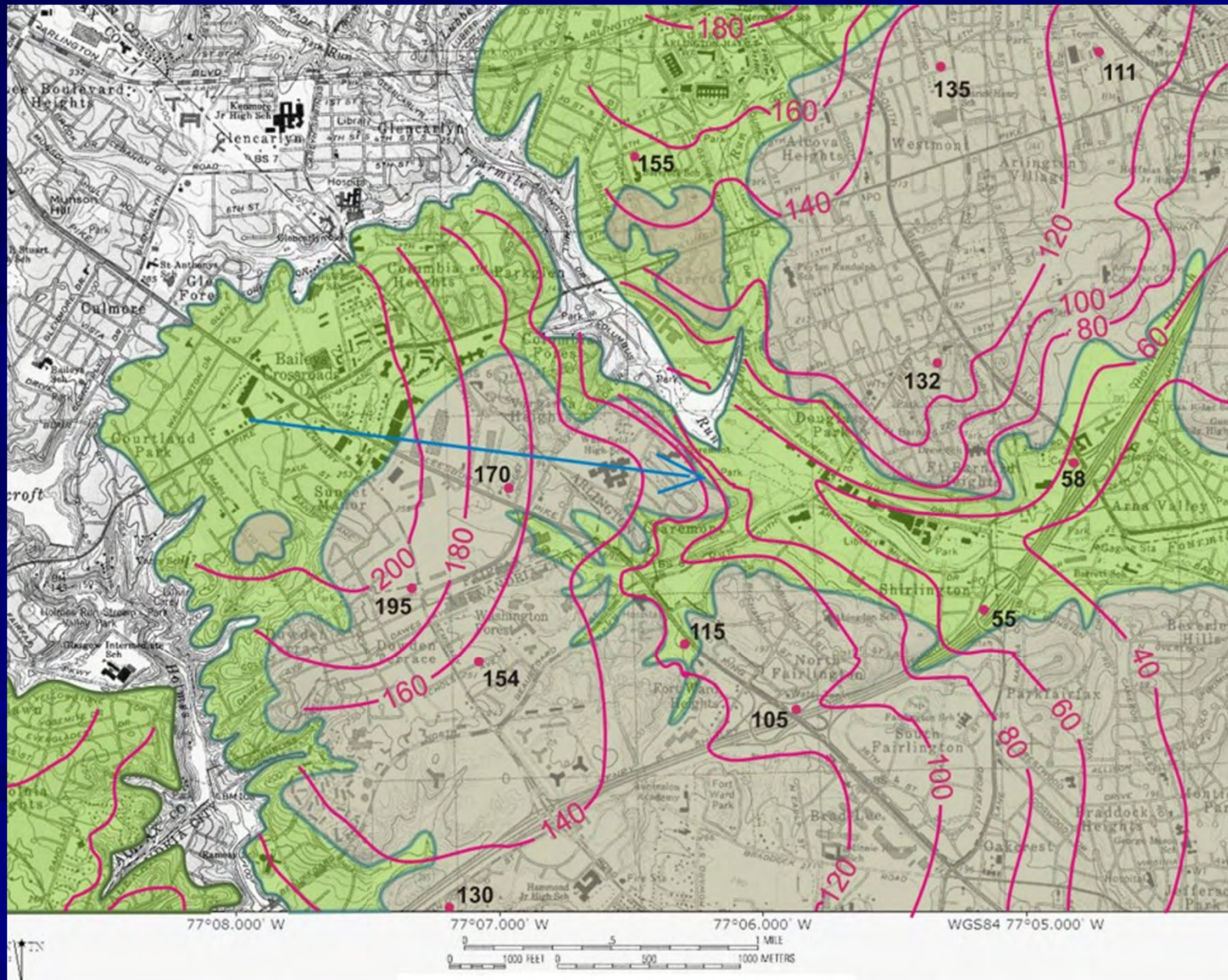
Ground Water Flow System

Local Cross-Section of the Basal Potomac Aquifer



Ground Water Flow System

Recharge Area-Subcrop of Aquifer



Ground Water Flow System

Discharge at Barcroft Natural Area: 300+ GPM

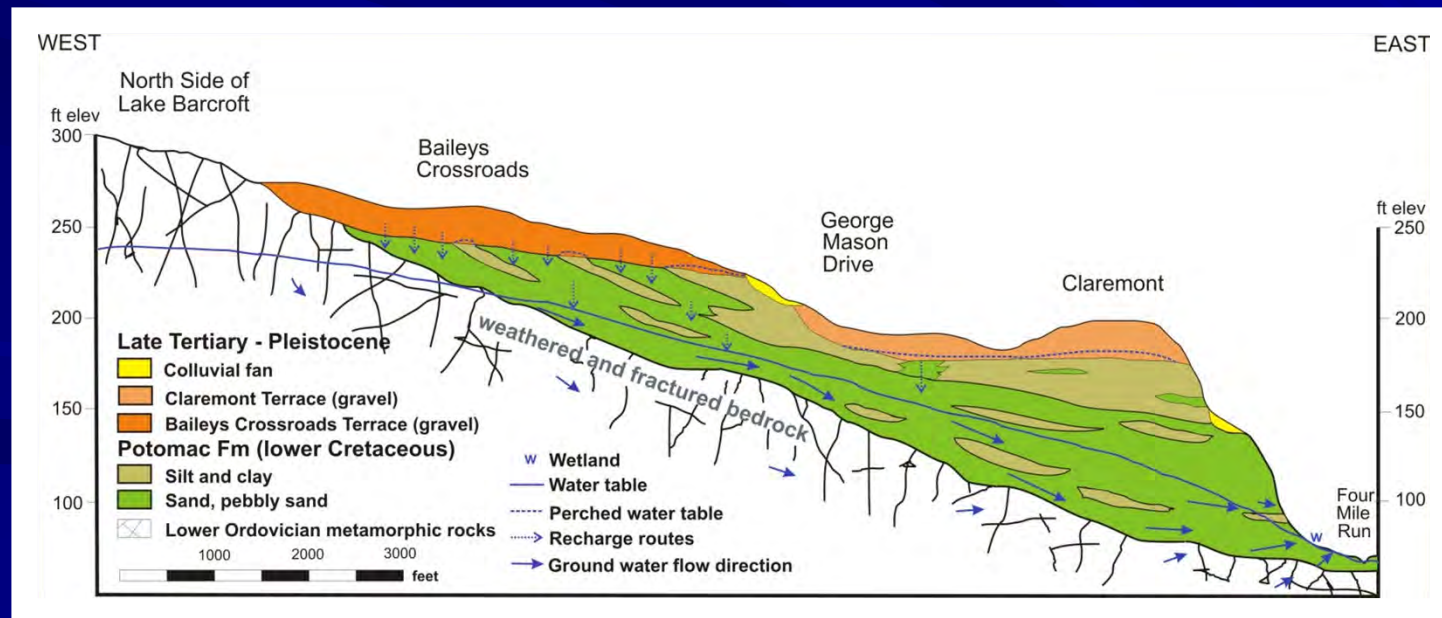
-Simple Empirical Calculation: $Q = K \times I \times A$

$K = 20+$ ft/day based on several long-term pump tests

$I = 0.1$ Hydraulic gradient below wetland

$A = 30,000$ sq ft (2,000 ft wide x 15 ft saturated thickness)

$Q = 60,000$ cubic feet per day, or about 312 gpm



Ground Water Flow System

Decadal Travel Time from Recharge Area to Wetland

Travel time = length (L) / seepage velocity (v)

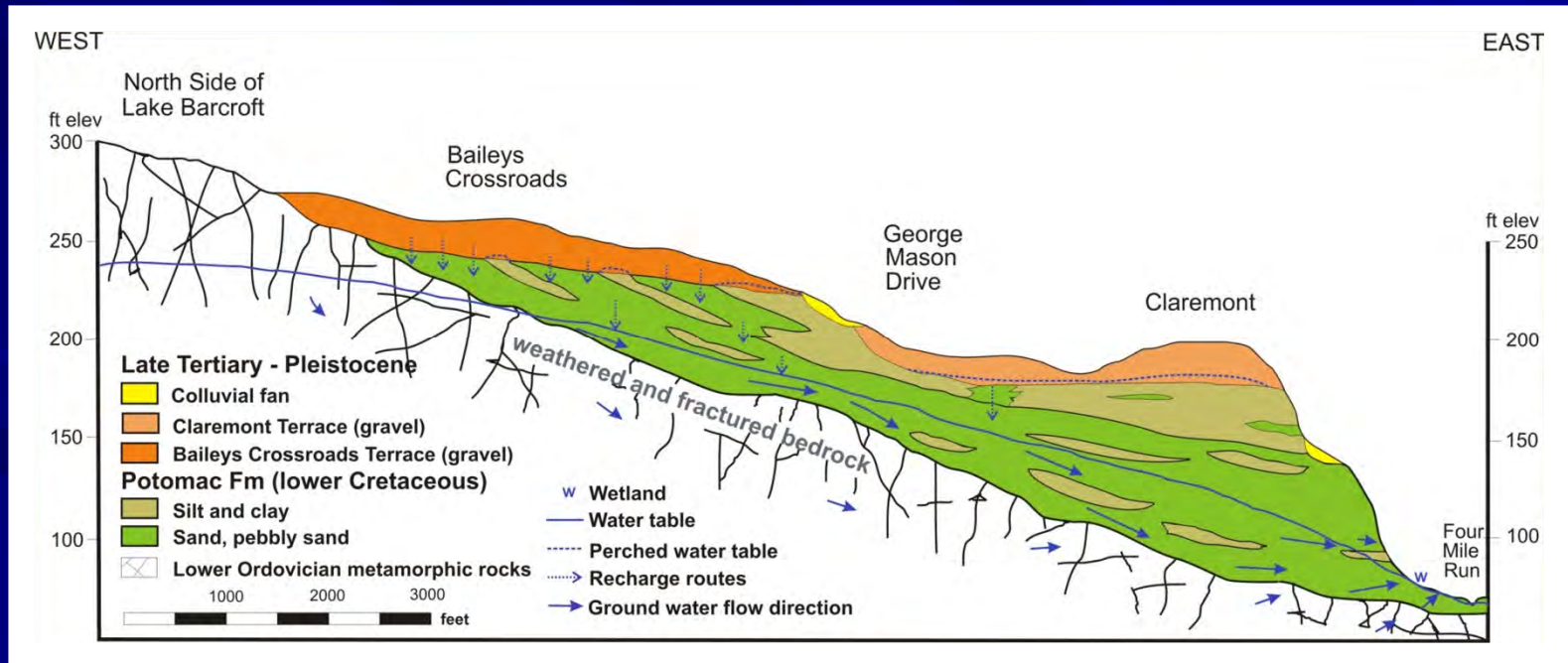
L = 8,000 feet, the distance from center of aquifer subcrop to wetland

$v = (K \times I)/n$ effective n assumed to be 25% for weathered sand

$I = 0.01$ Water table slope between recharge area and site (80 ft/8,000 ft)

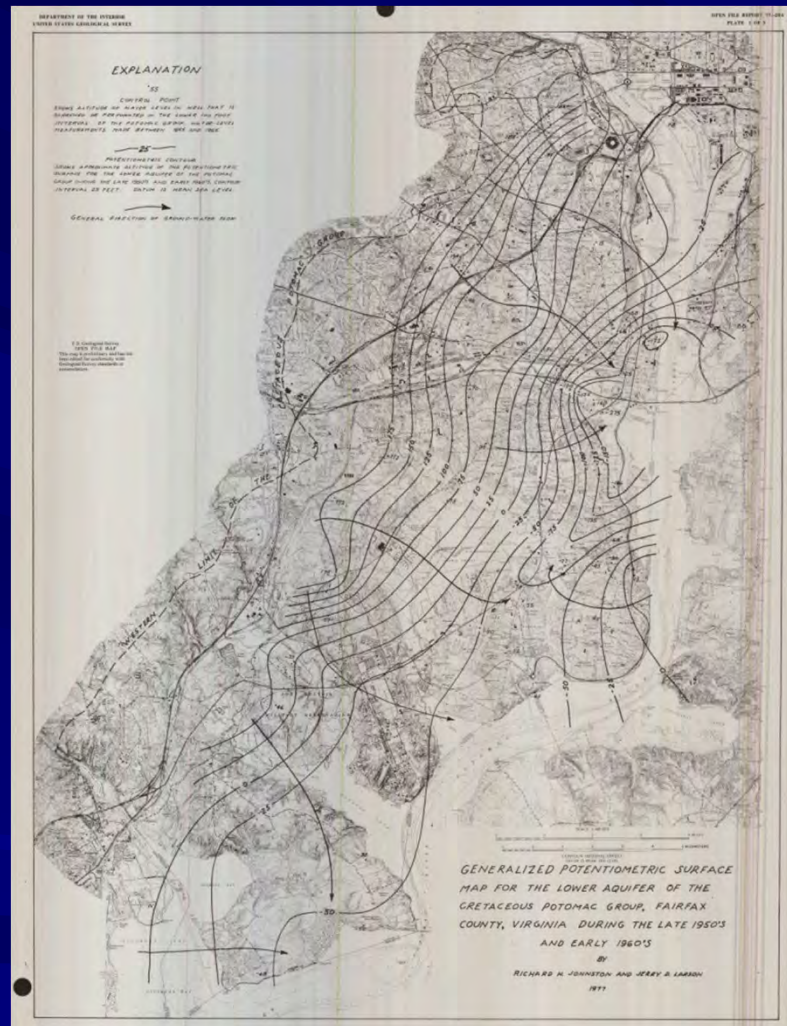
$v = (20 \text{ feet/day})(0.01)/0.25 = 0.8 \text{ feet/day}$

travel time = (8,000 feet)/(0.8 feet/day) = 10,000 days, or roughly 27 years

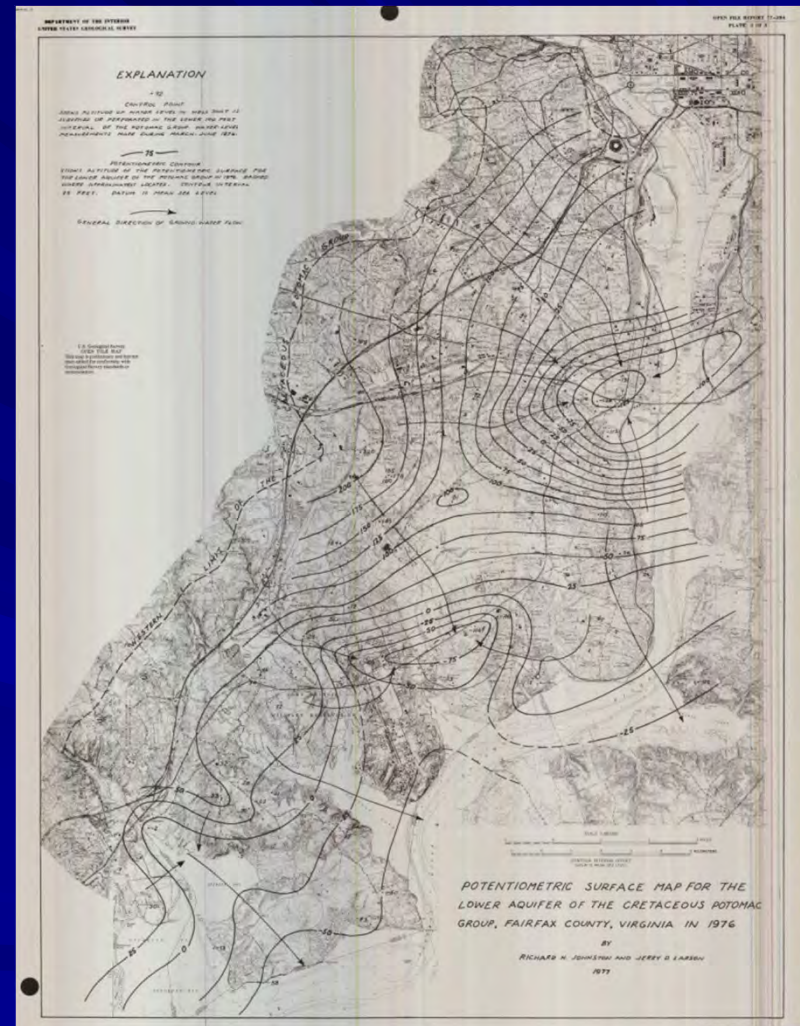


Management Issues

High-Capacity Wellfields: Dewatering of Aquifer



1960



1976

Management Issues

Urbanization



BARCROFT MAGNOLIA BOG

THEN AND NOW-URBANIZATION



1934

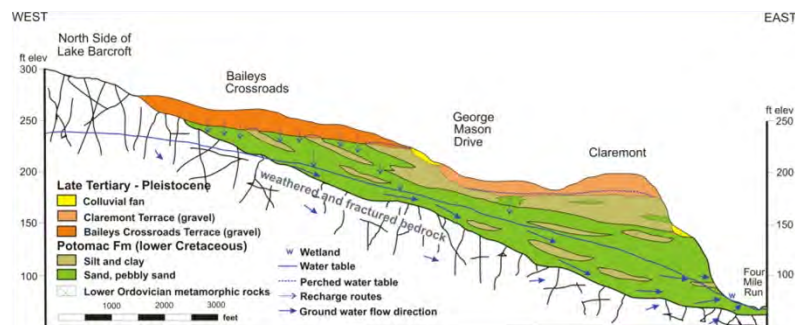


1980

Management Issues

Urbanization of Recharge Area

Byproduct: Geologic Opportunities!



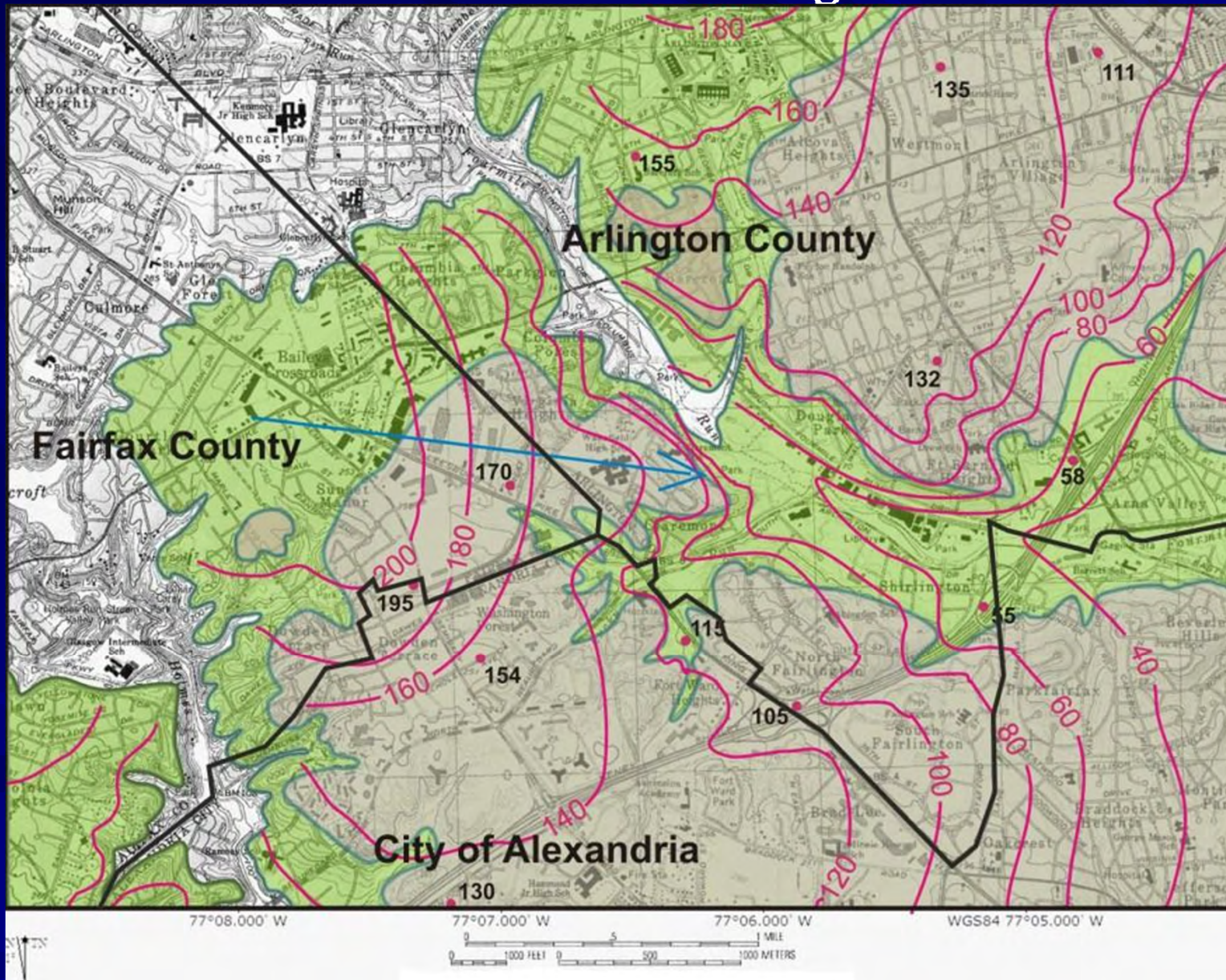
Management Issues

Urbanization of Recharge Area: 40-50% Impervious



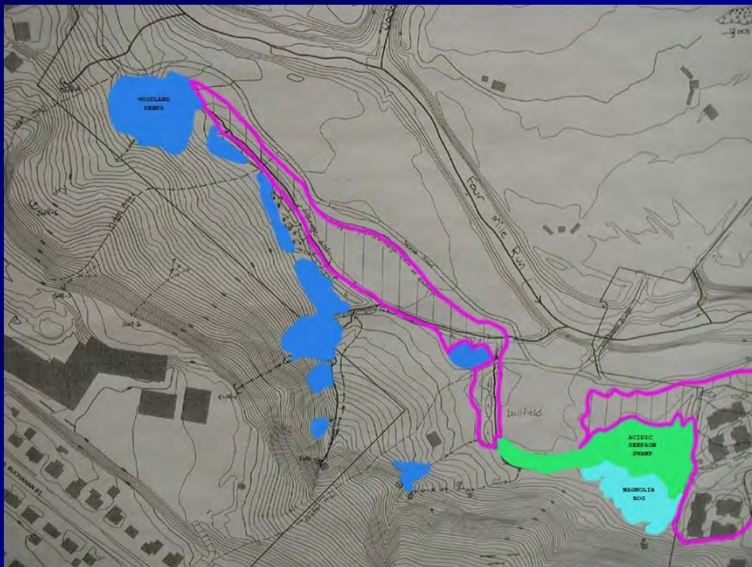
Management Issues

Urbanization of Recharge Area



Management Issues

Storm-Water Erosion and Sediment Deposition



Management Issues

Storm-Water Erosion and Sediment Deposition





Acknowledgments

- Greg Zell, Natural Resource Specialist, Arlington County Department of Parks, Recreation and Cultural Resources
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