An Approach to Evaluate the Effects of Septic Wastewater Treatment Systems on Stream Baseflow and Consumptive Use

August 7, 2008

U.S. Geological Survey
Georgia Water Science Center

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Preliminary Results. Subject to Revision.

U.S. Department of the Interior
U.S. Geological Survey

Background

>Over 26% of the Metro Atlanta region’s homes have Onsite Wastewater Septic Systems

>Consumptive Use of Septic Systems is undefined in State Water Plan and ACF negotiations

>Common perception in Georgia that Septic Systems are highly consumptive

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Georgia Comprehensive State-wide Water Management Plan

SECTION 9: WATER RETURN MANAGEMENT PRACTICES

Policy: On-Site Sewage Management Systems

(1) Properly sited, constructed, and maintained on-site sewage management systems are a cost-effective, long-term option for meeting public health and water quality goals, particularly in less densely populated areas.

(3) Managing the effect of on-site sewage management systems on the quantity of water returned to surface water sources may be a component of managing consumptive use. The significance of this component will vary with the condition of individual water sources and the characteristics of the uses of that source. This component of consumptive use is more important to manage in areas where the source of the water is surface water, and where consumptive use from that source is approaching its consumptive use assessment.

Implementation Actions

(1) The Division's guidance for regional planning written pursuant to section 14 of this plan may address region-specific benchmarks for return flows to individual water sources and mechanisms for meeting those benchmarks. This guidance will be based on the best available information on quantities and timing of surface water returns from on-site systems in different parts of the state. The guidance will recognize the factors that determine the relative significance

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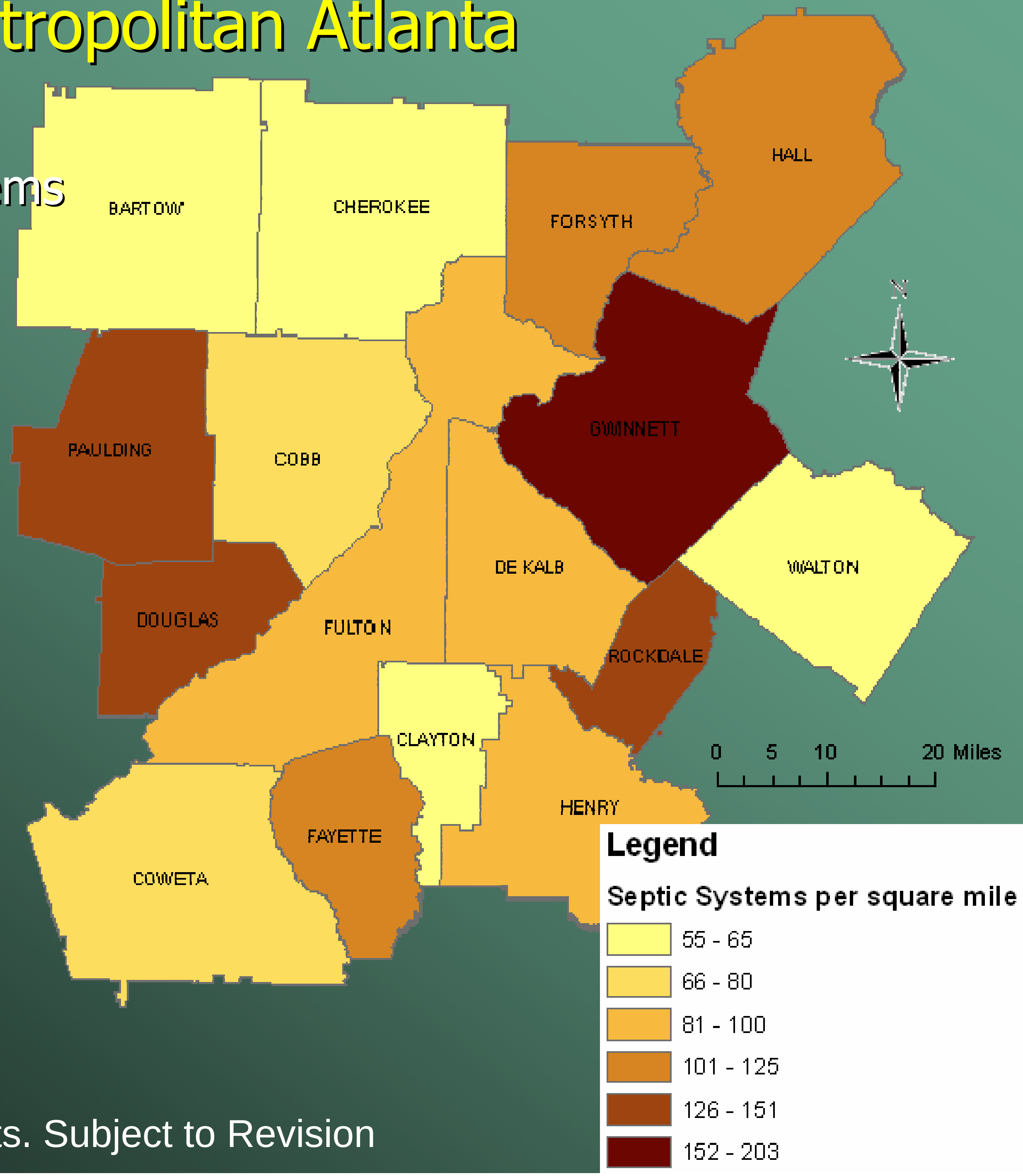
Background

Septic Systems in Metropolitan Atlanta

- An Estimated 526,000 Systems in 16-county area in 2005
- An Estimated 12,000 New Systems per Year
- About 26% of Residences



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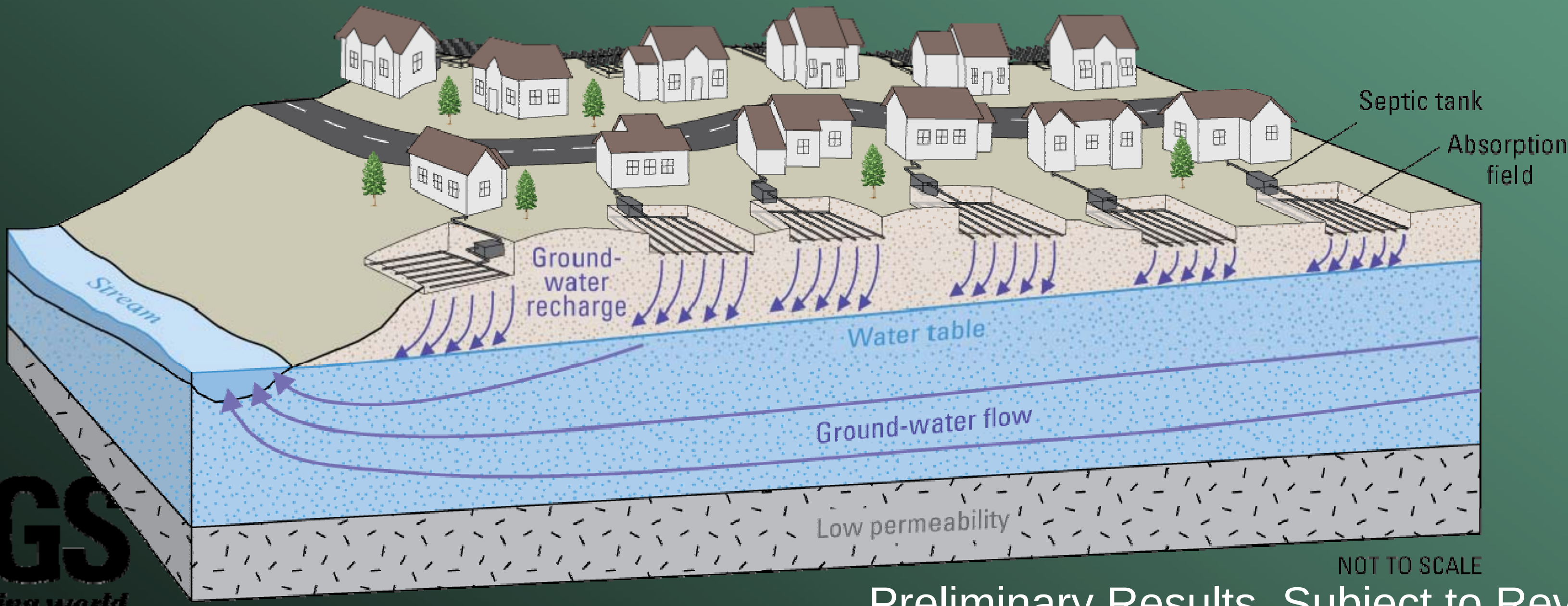
Background

Surface-water use is <u>consumptive</u> if water is removed from a source and is not returned to the source for reuse immediately downstream (Draper, 2006; USGS, 2002)

Surface-water resources treated in Septic onsite wastewater treatment systems are non-consumptive to the extent that they cause increased baseflow in the source watershed, in 'time' for the water to be reused.



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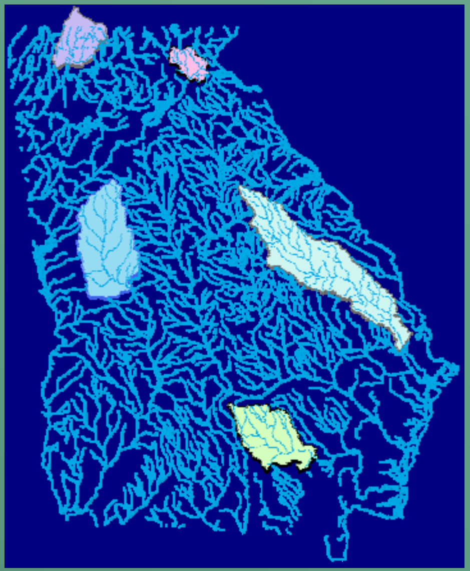
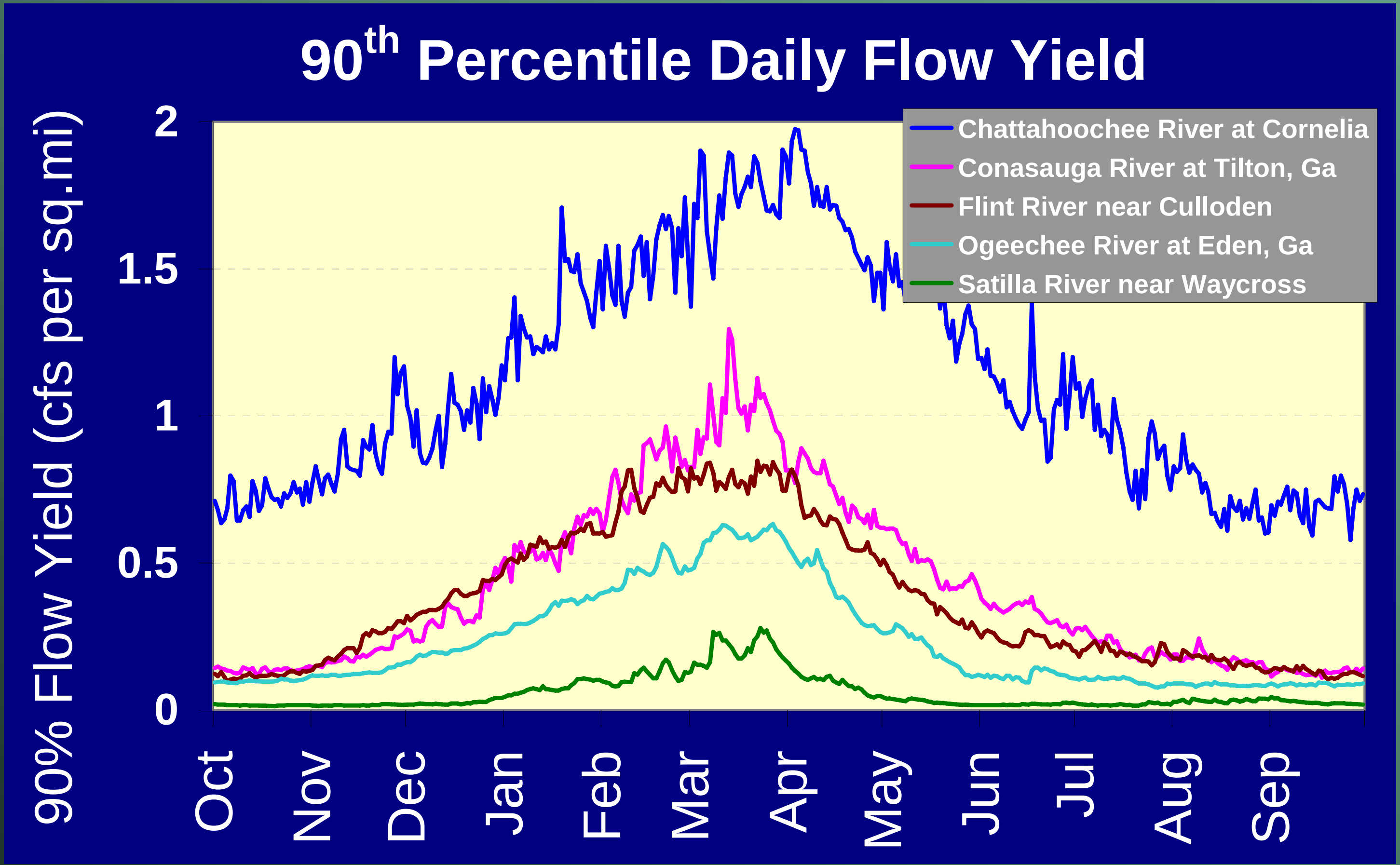
Natural GW Recharge and Baseflow

Stream Baseflow Varies by Several Hundred Percent with Geologic Setting and Climate Across Georgia



- Climate
- Geology/ soils
- Topography
- Vegetation
- Land Cover



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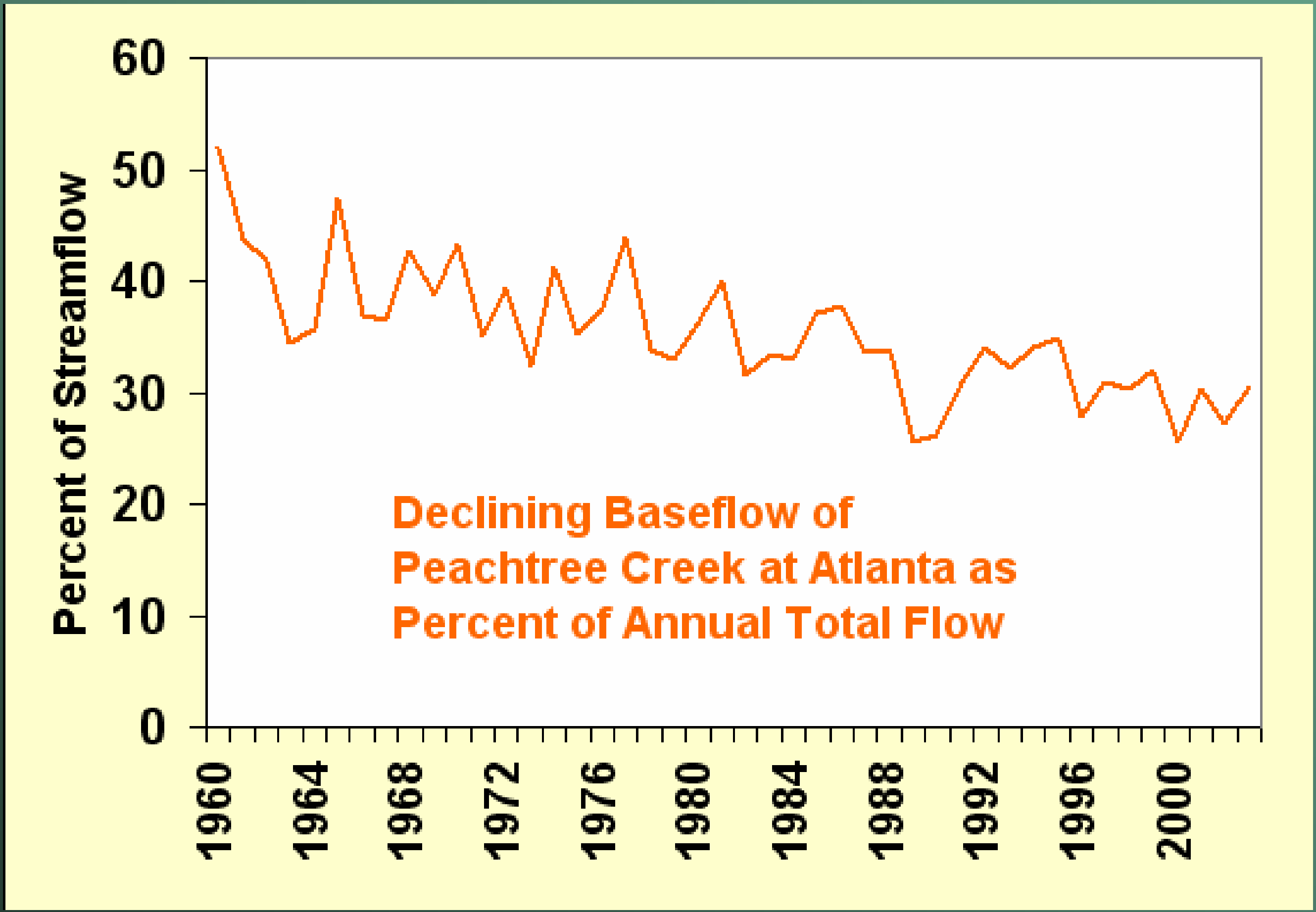
Urban factors potentially <u>decreasing</u> ground-water recharge and stream baseflow

- Impervious Surfaces
- Constructed Channels



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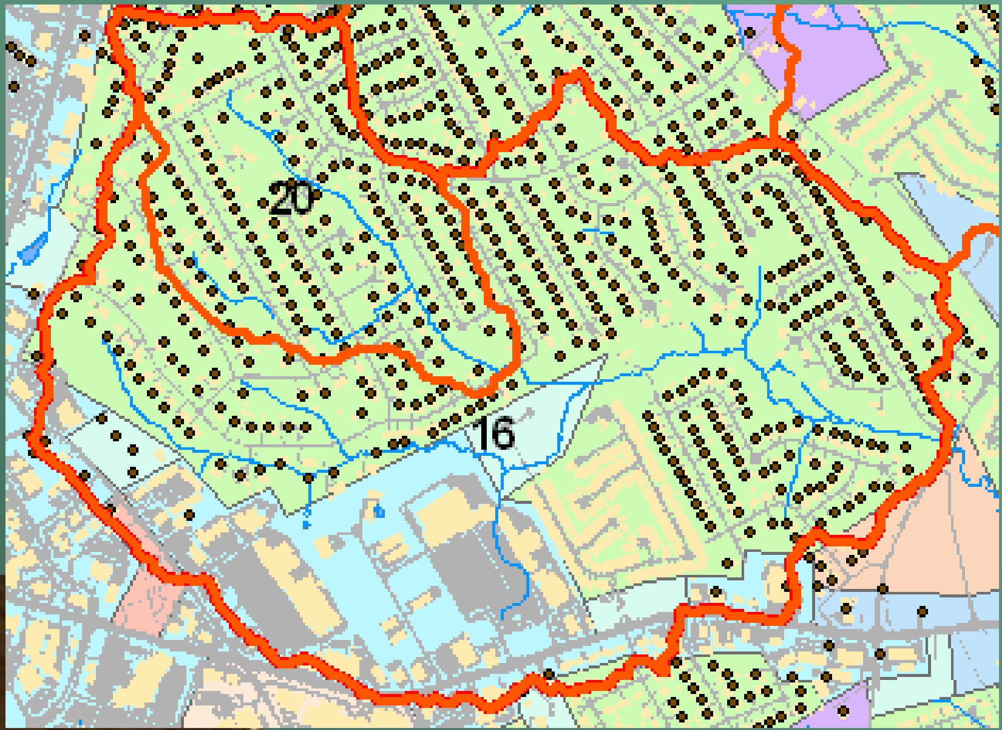
Urban factors potentially increasing ground-water recharge and baseflow

- Leaking Water Supply Mains
- Septic Systems Absorption Fields
- Excess Irrigation
- Infiltration Ponds
- Leaking Storm Sewer Systems
- Reduced Evapotranspiration



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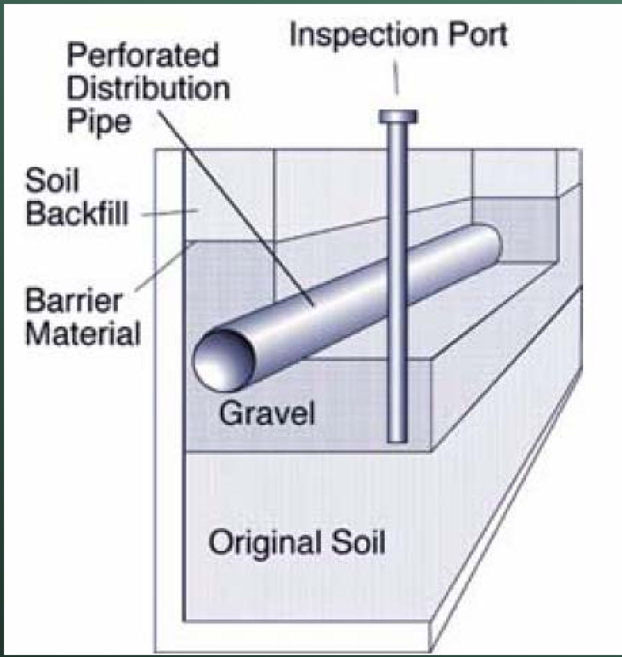
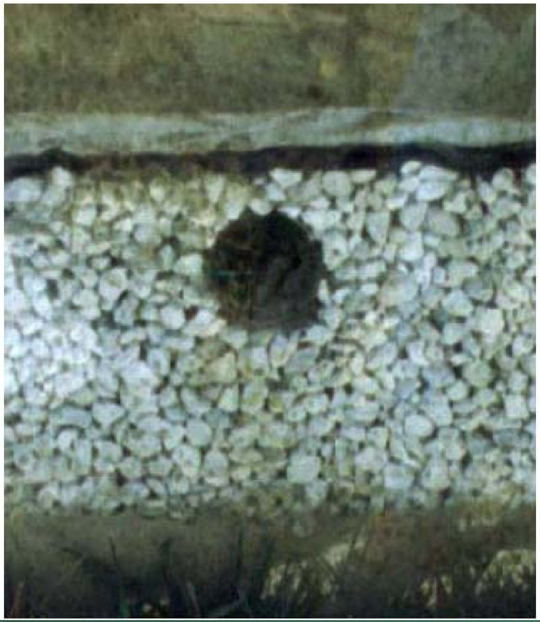
Hydrology of Septic System Absorption Fields

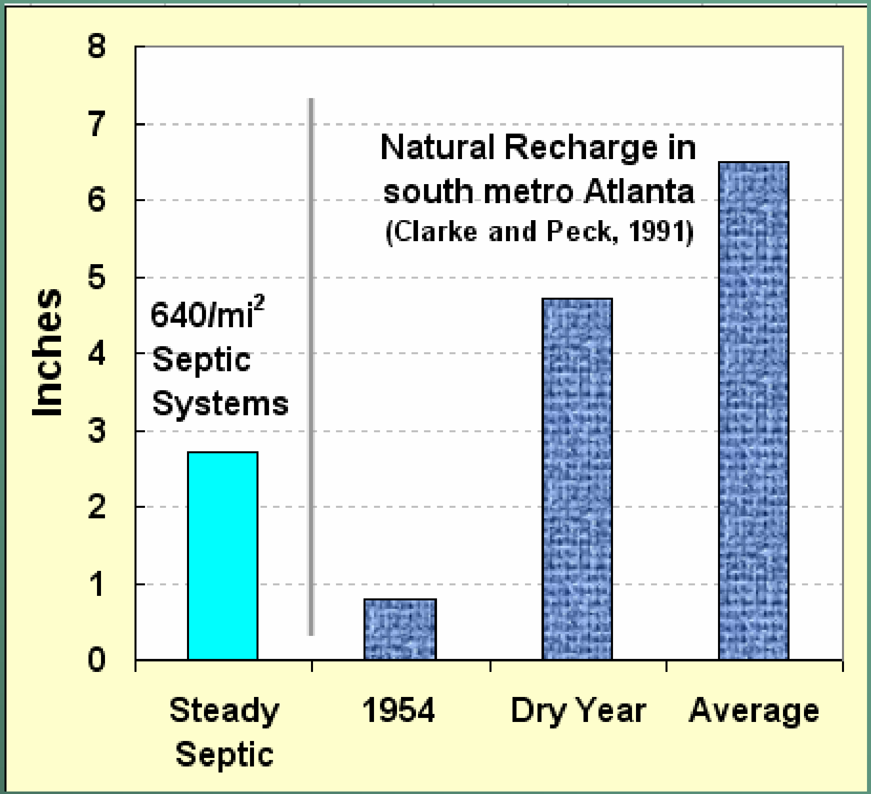
- In percolating soils with adequate transmissivity
- Generally not in root zone; relatively low ET
- Relatively level areas
- Steady Flow, relative to natural recharge sources

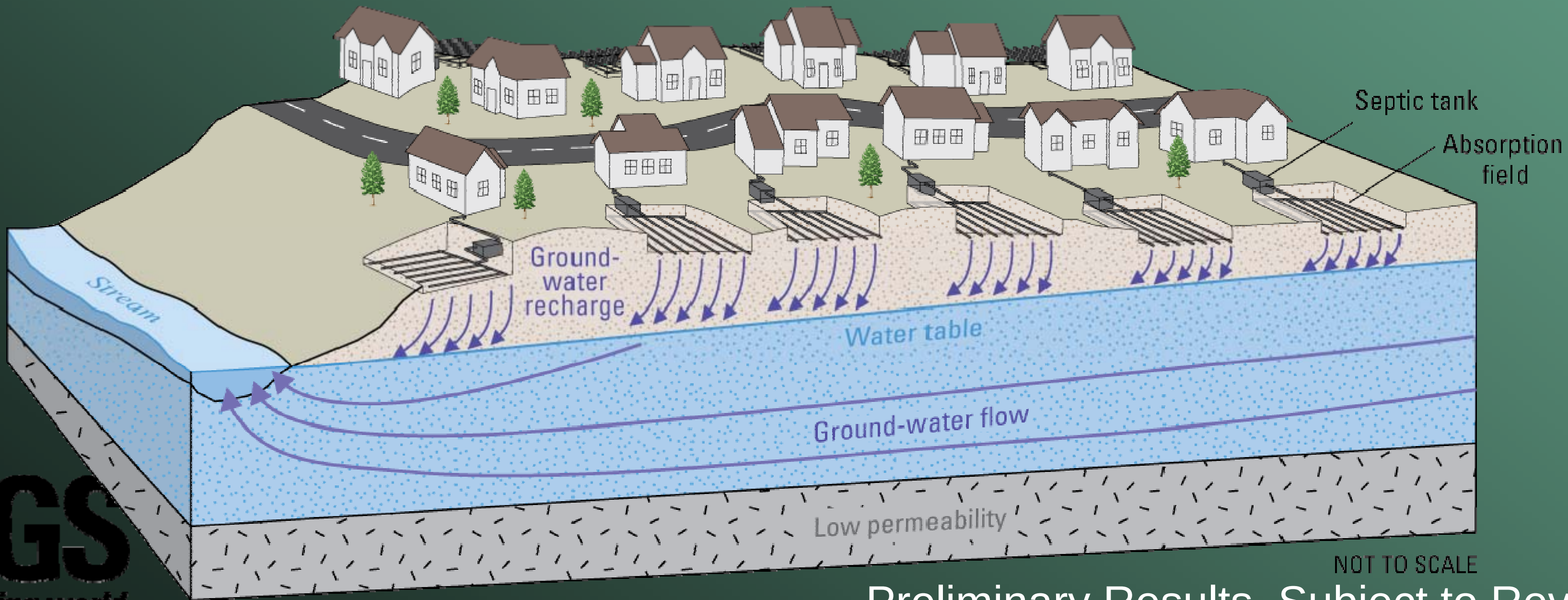




Hydrology of Septic System Absorption Fields

A hypothetical basin with 640 septic systems per square mile with 200gpd per system produces **2.7 inches** of ground-water inflow per year.





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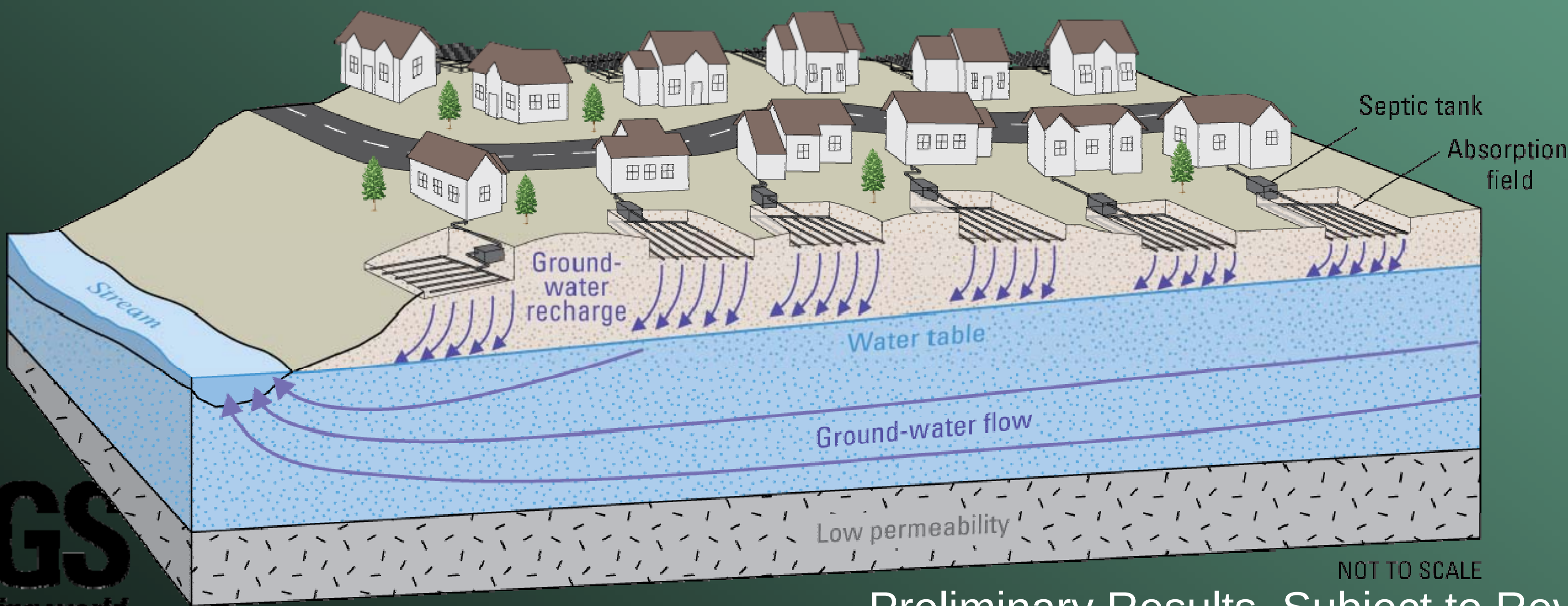
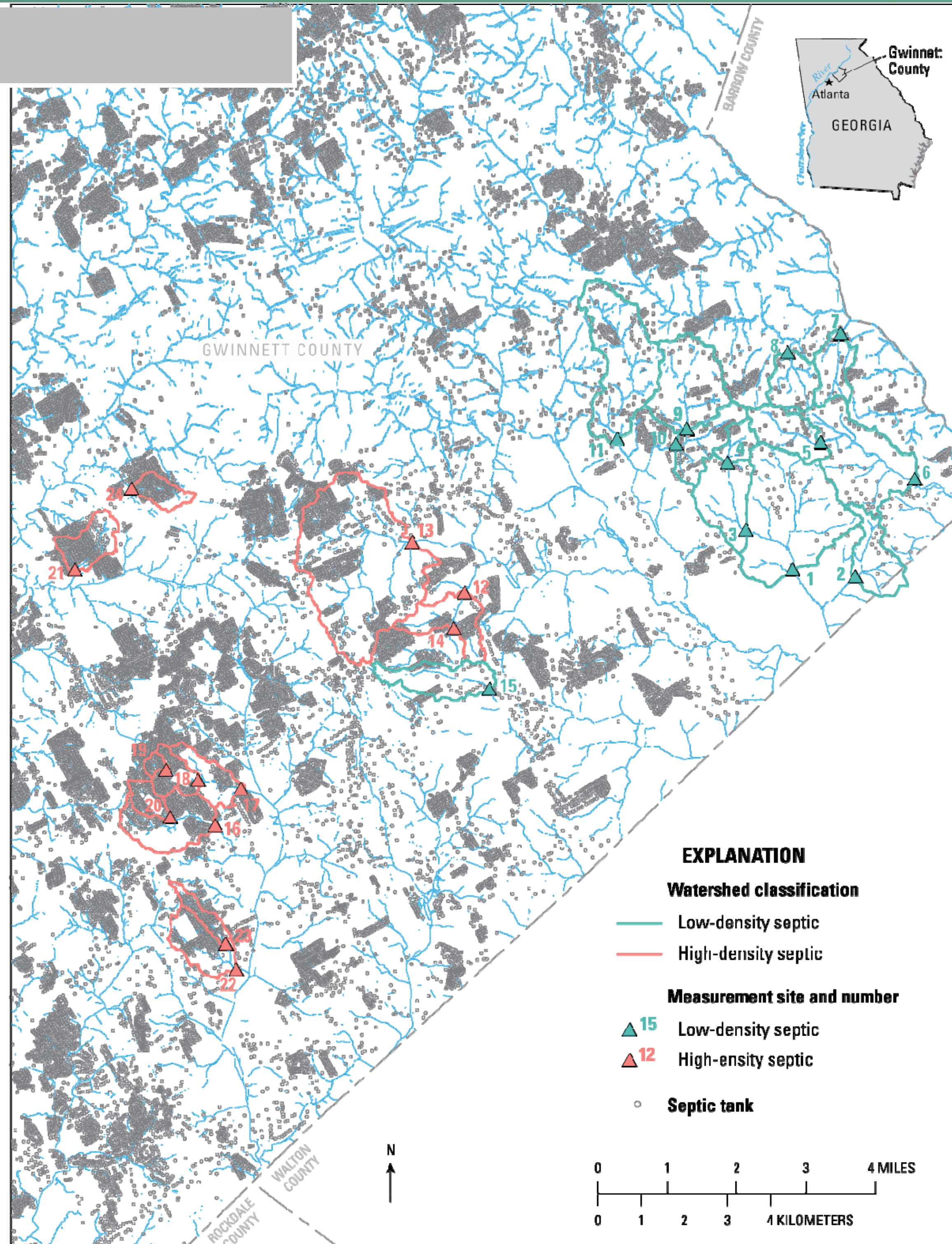
Hydrology of Septic System Absorption Fields

Stream baseflow will begin to increase when the 'head', the hydraulic slope of the ground-water table increases. The time required for this head increase depends on soil hydraulic conductivity and other factors and is variable.

The increase in hydraulic gradient and stream baseflow will occur before the actual water from septic systems reaches the stream.



Paired Watershed Approach



Watershed Selection Goals:

- Similar Geologic Setting
- Similar Climate
- Baseflow Conditions
- Accurate Measurement Sites
- Adequate Spatial Data
- High- & Low- Density of Septic Systems

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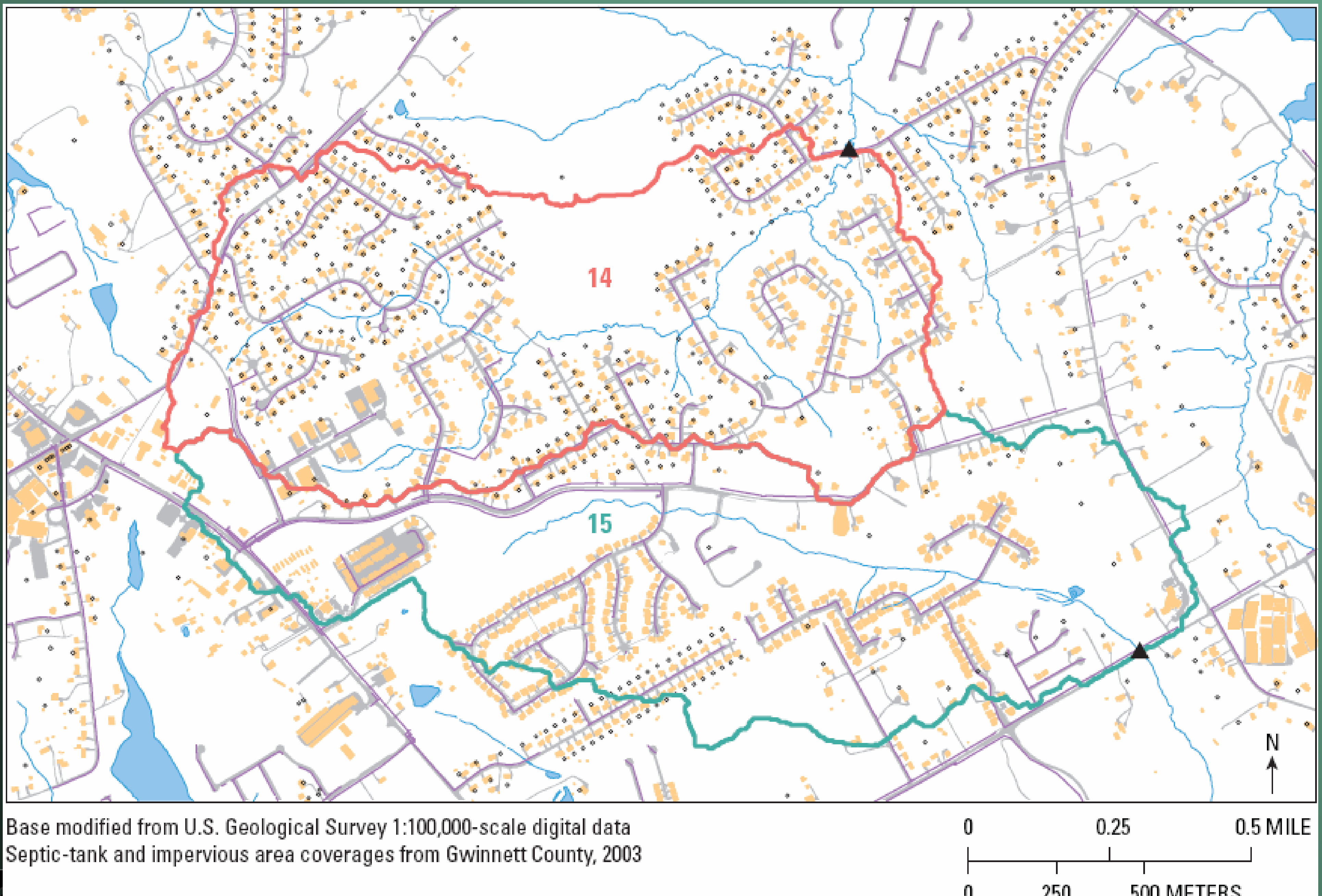
Paired Watershed Approach



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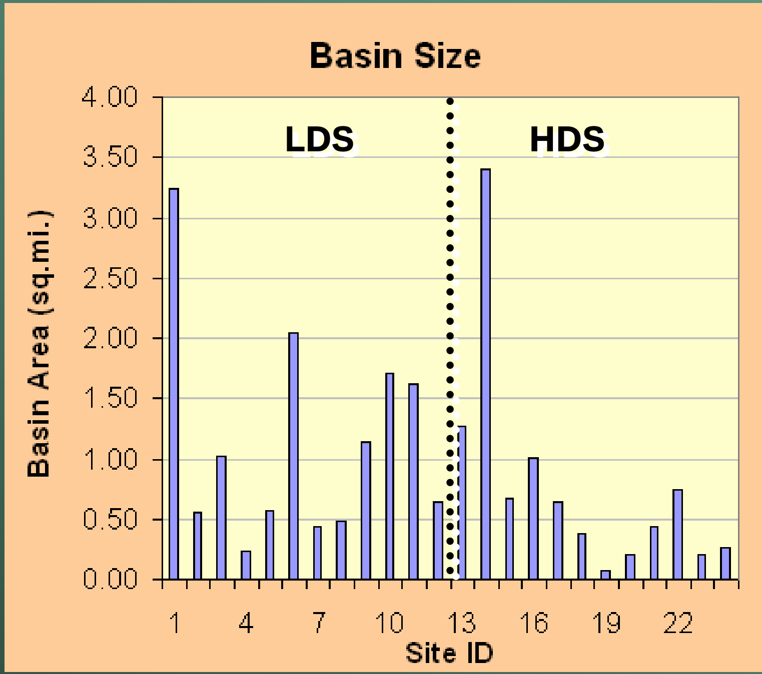
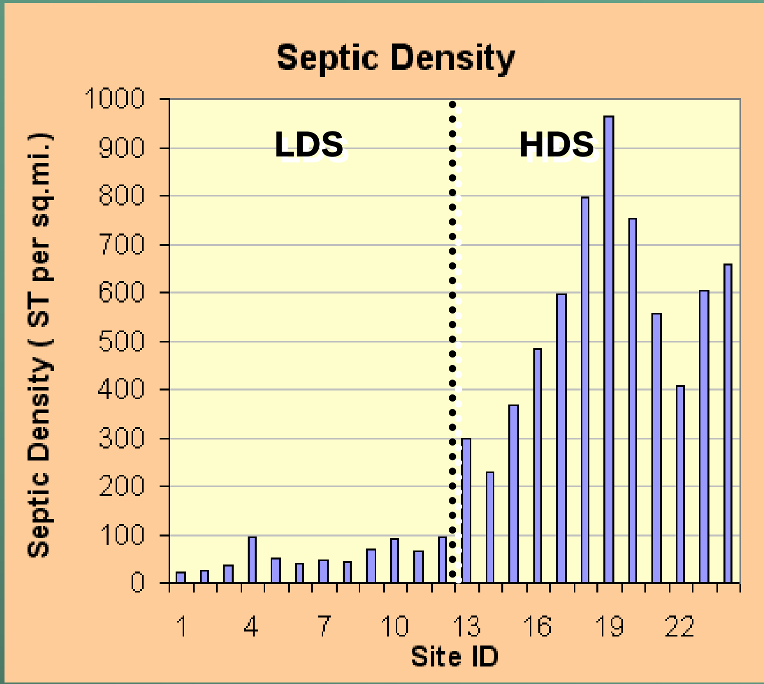
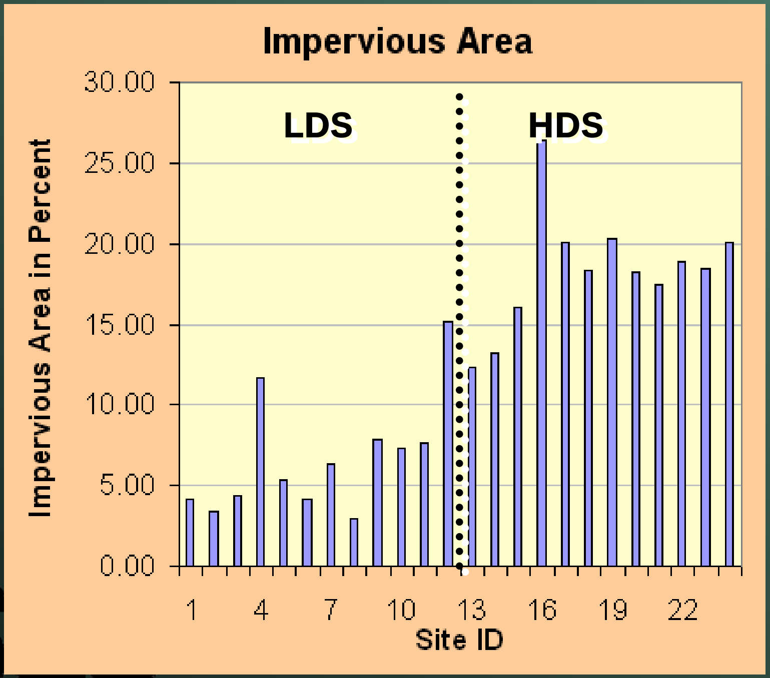
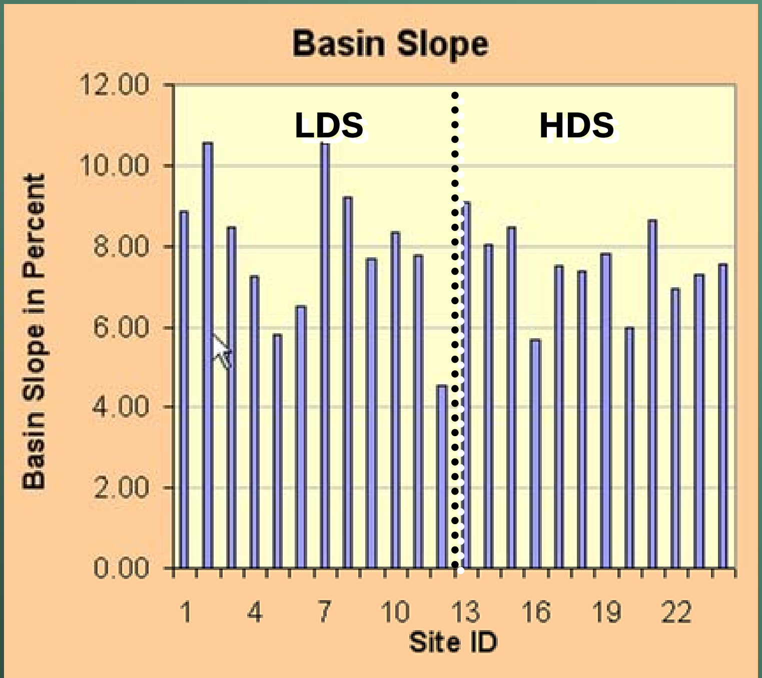
Paired Watershed Approach – Watershed Characteristics









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Paired Watershed Approach – Field Measurements

Parameters Measured:

Streamflow	Conductance
Turbidity	Fluorescence

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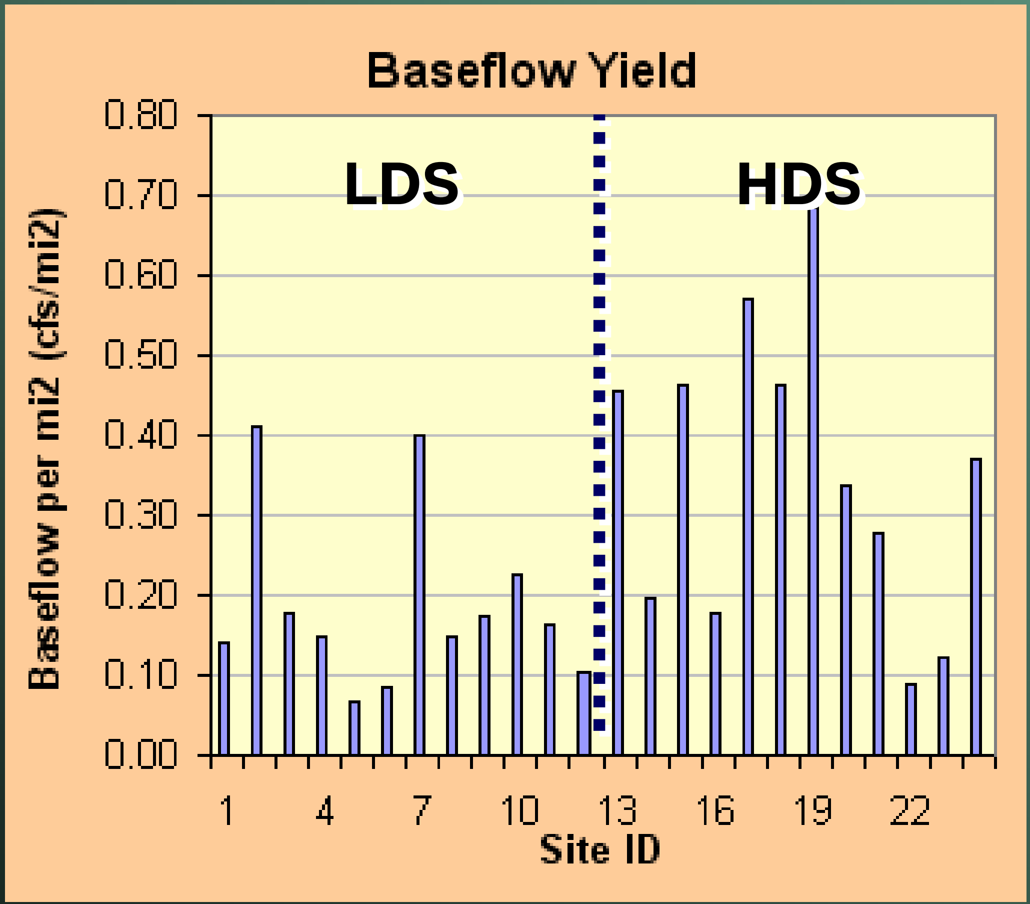
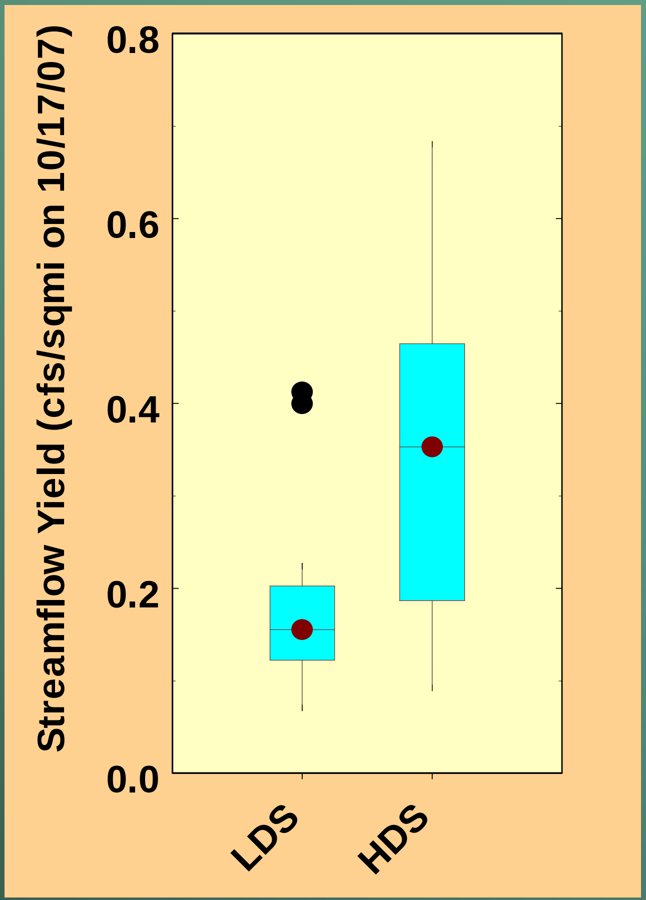
Paired Watershed Approach – Stream Baseflow Analysis

Measurement Summary: Baseflow Yield

*Median Baseflow Yield was about **100%** greater in High Density Septic Systems than Low Density Septic basins on Oct 16-17, 2007.*





Statistically significant increase (p-value <0.01)

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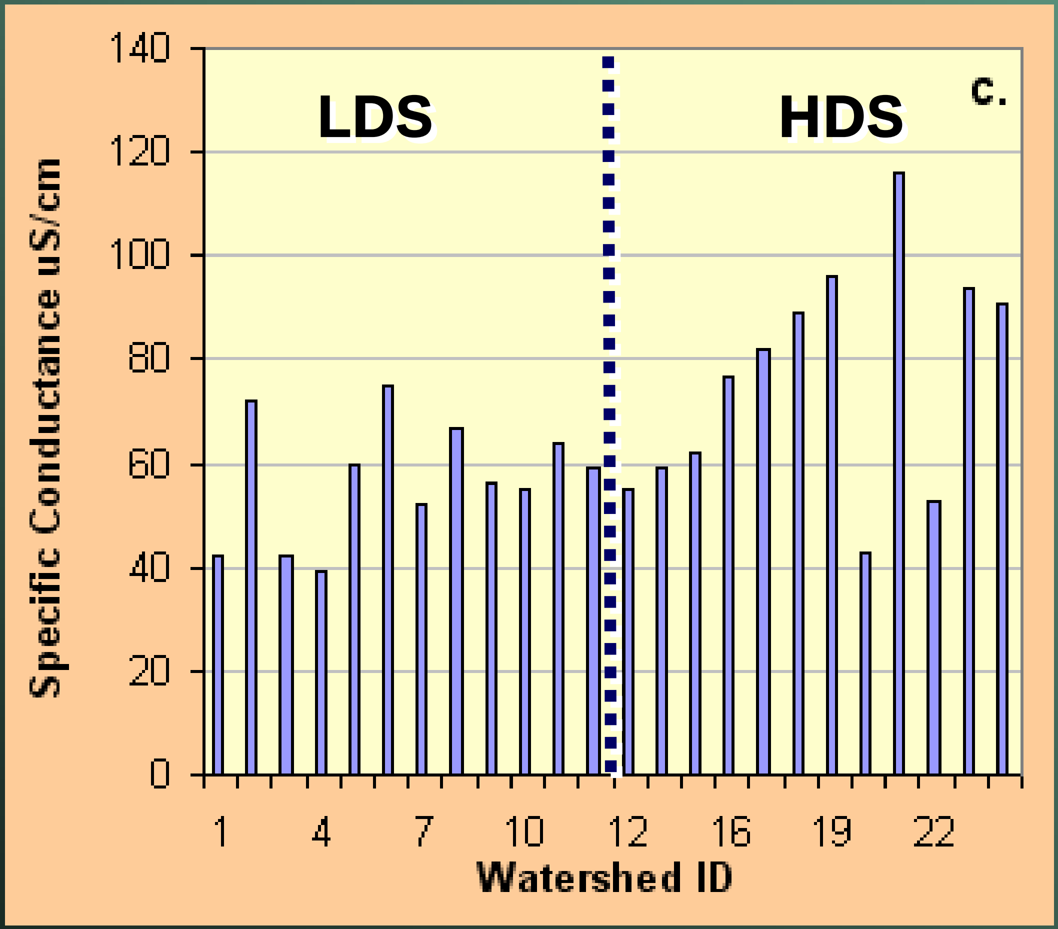
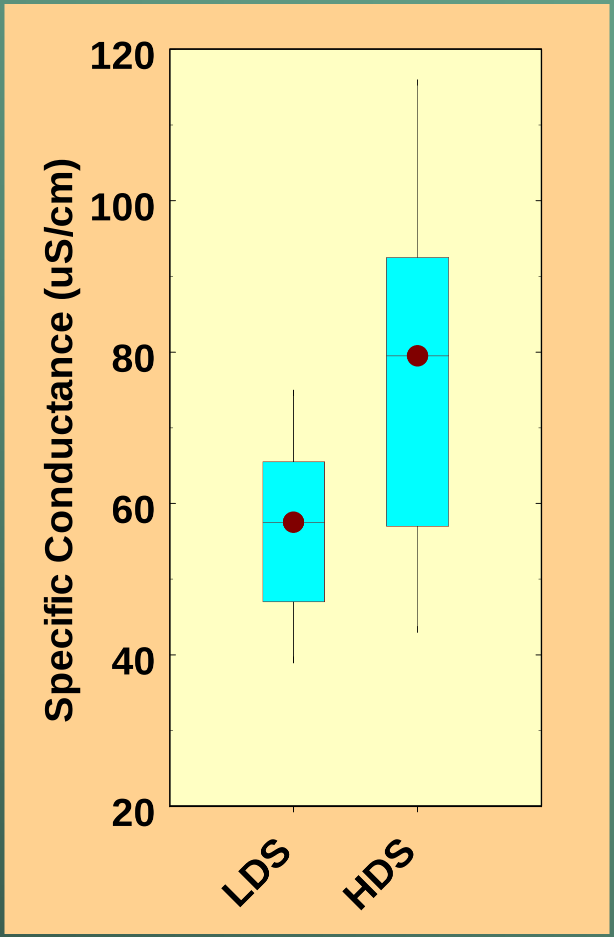
Measurement Summary: Specific Conductance

Specific Conductance was significantly greater in High Density Septic Systems than Low Density Septic basins on Oct 16-17, 2007.





Statistically significant increase (p-value <0.01)

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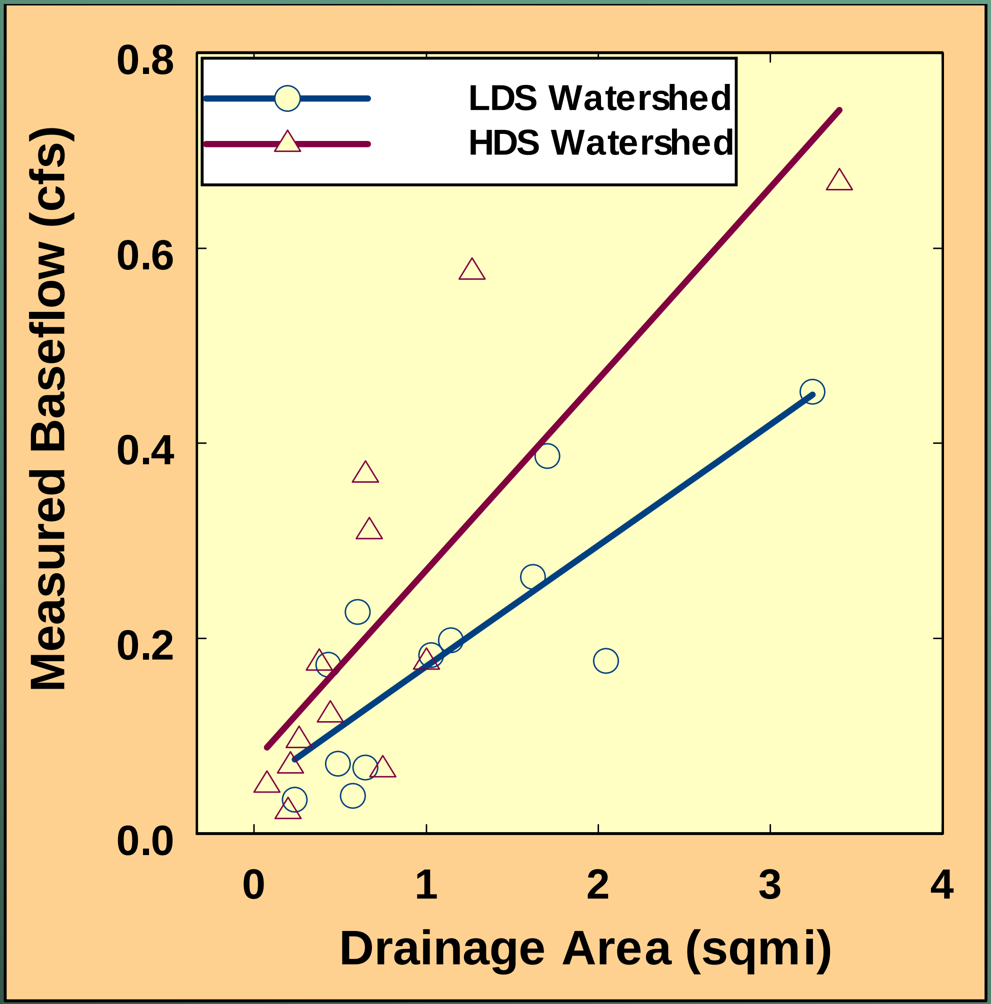
Analysis of Flow Differences

Q_{BSF} = function of
[drainage area, slope,
precipitation, geology,
evapotranspiration,
land cover,
excess irrigation,
withdrawals, returns,
impoundments,
water main leakage,
Septic System recharge]



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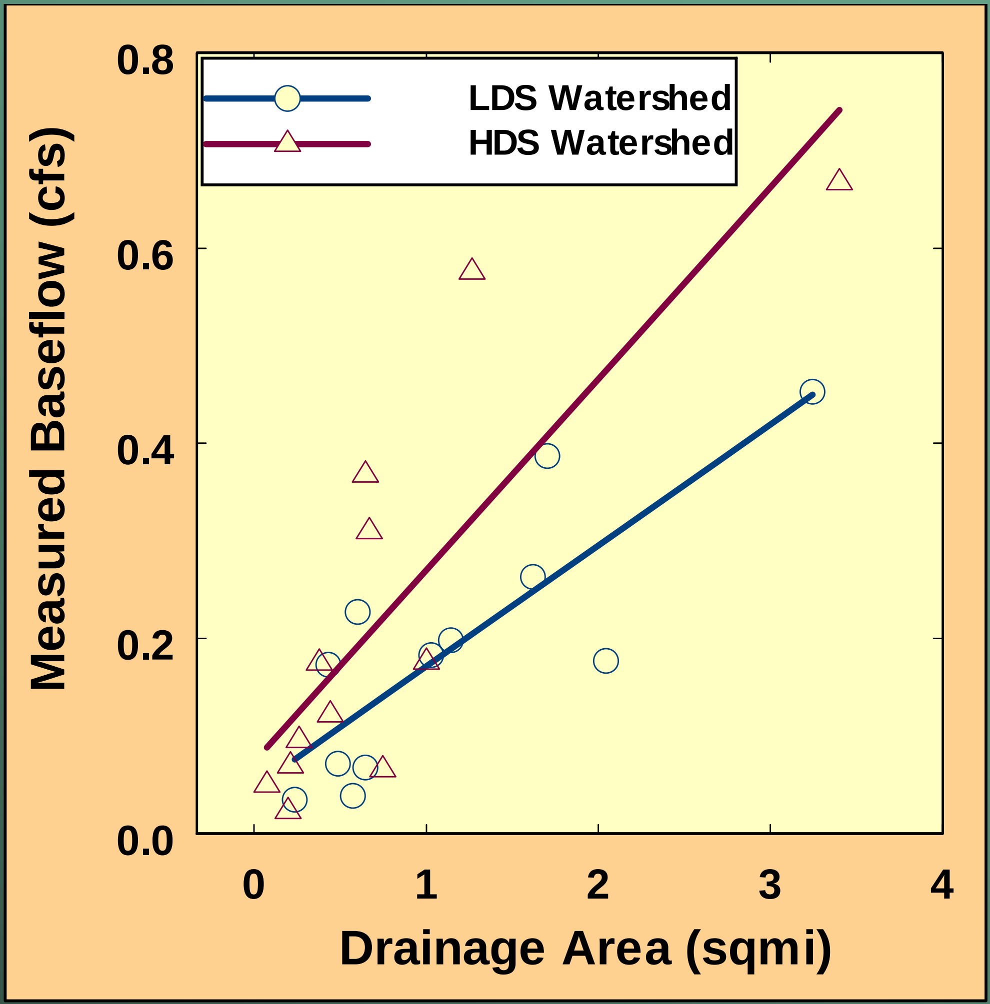

Residual Baseflow = Septic + ε

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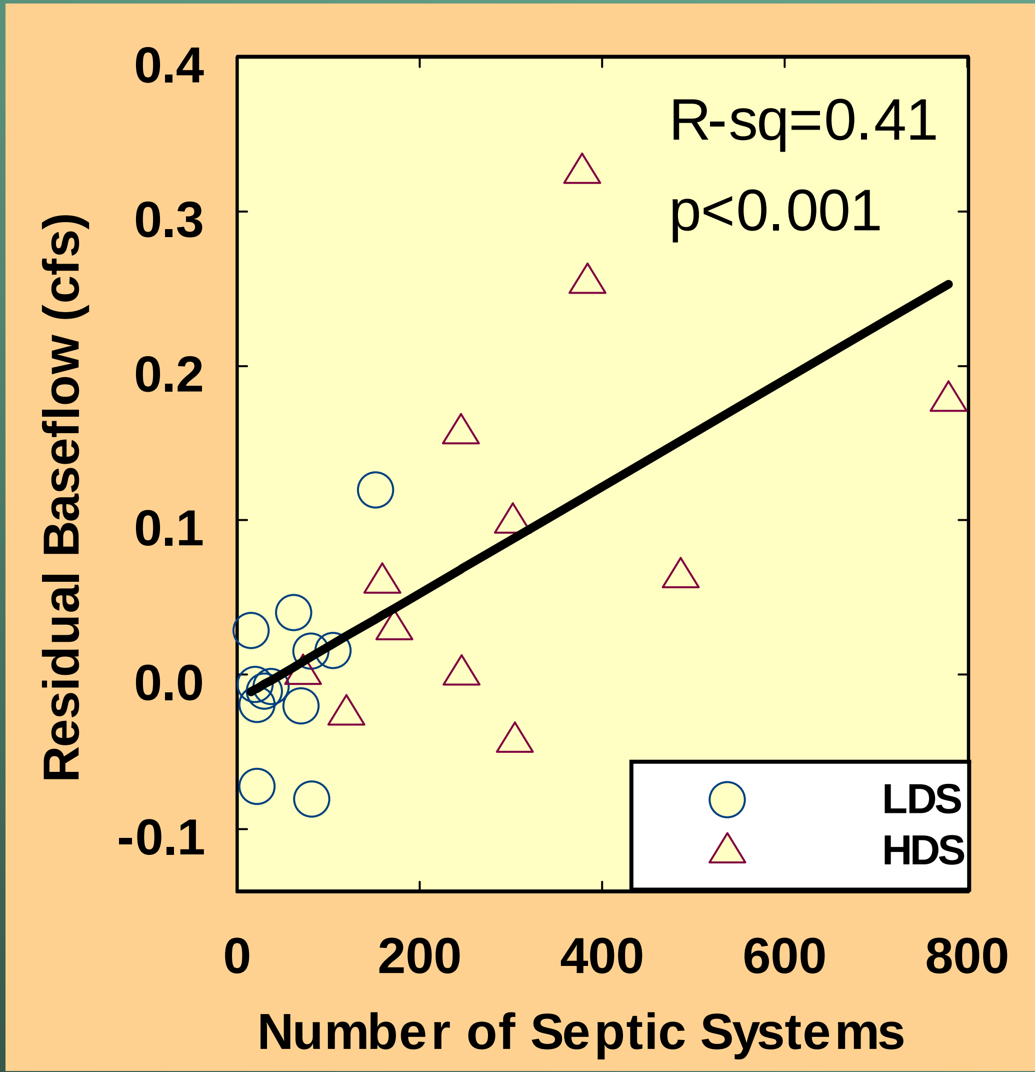
Effects of Septic Systems on Amount of Baseflow

Analysis of Flow Differences

$$\overline{\left(\frac{Q_{residual\_HDS}}{N_{septic\ systems}}\right)} = 166\,GPD/ST$$

StdErr of Mean = 62 *GPD/ST*

90% CI is 54 to 277 *GPD/ST*



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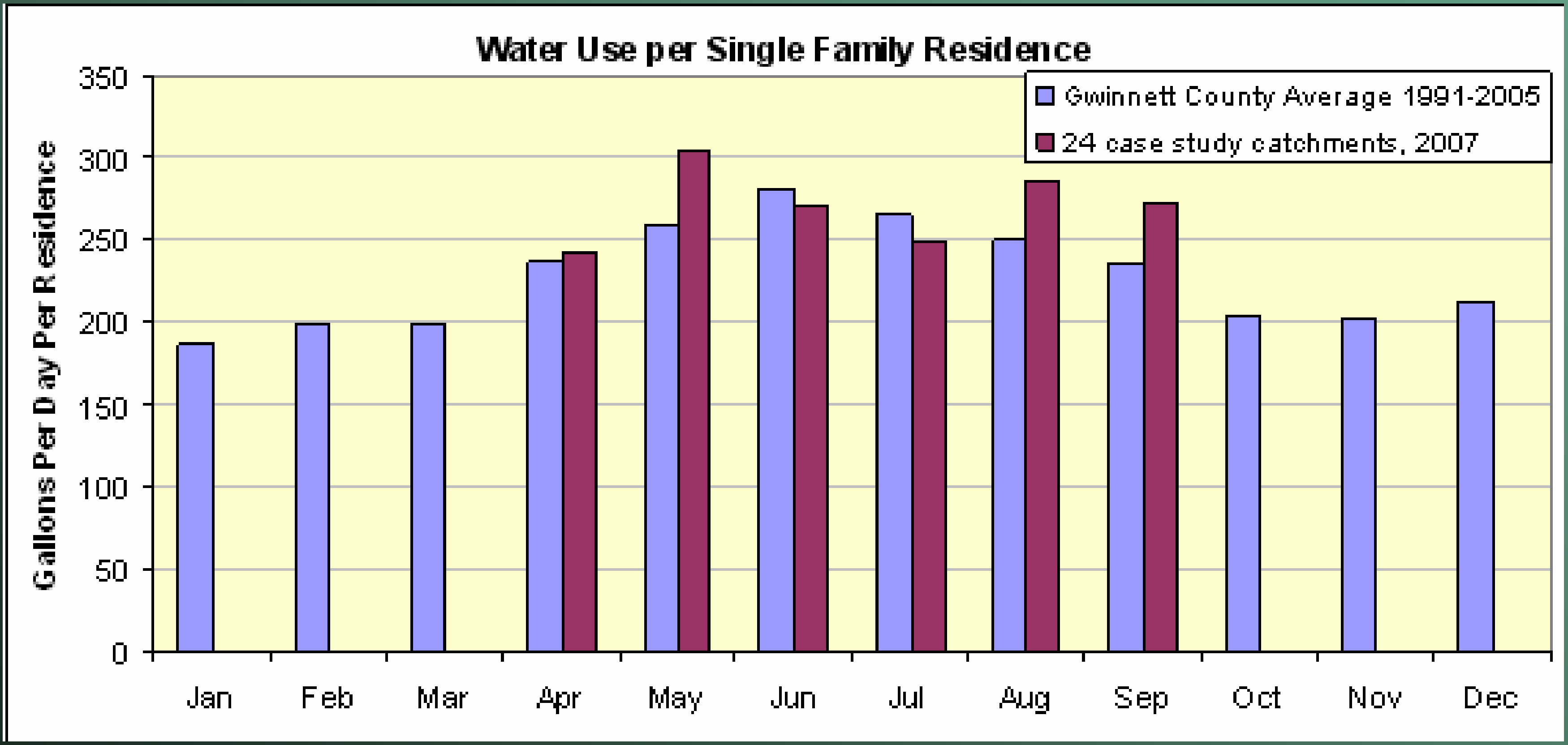
Water-Use Analysis

- Average per single family household water use 1991-2005 by month
- Per house indoor use has changed little 1991-2005
- Actual per household use for April – Sept 2007 greater due to watering, prior to total watering ban
- Indoor use estimated as average Dec-Feb use: 200 GPD/house



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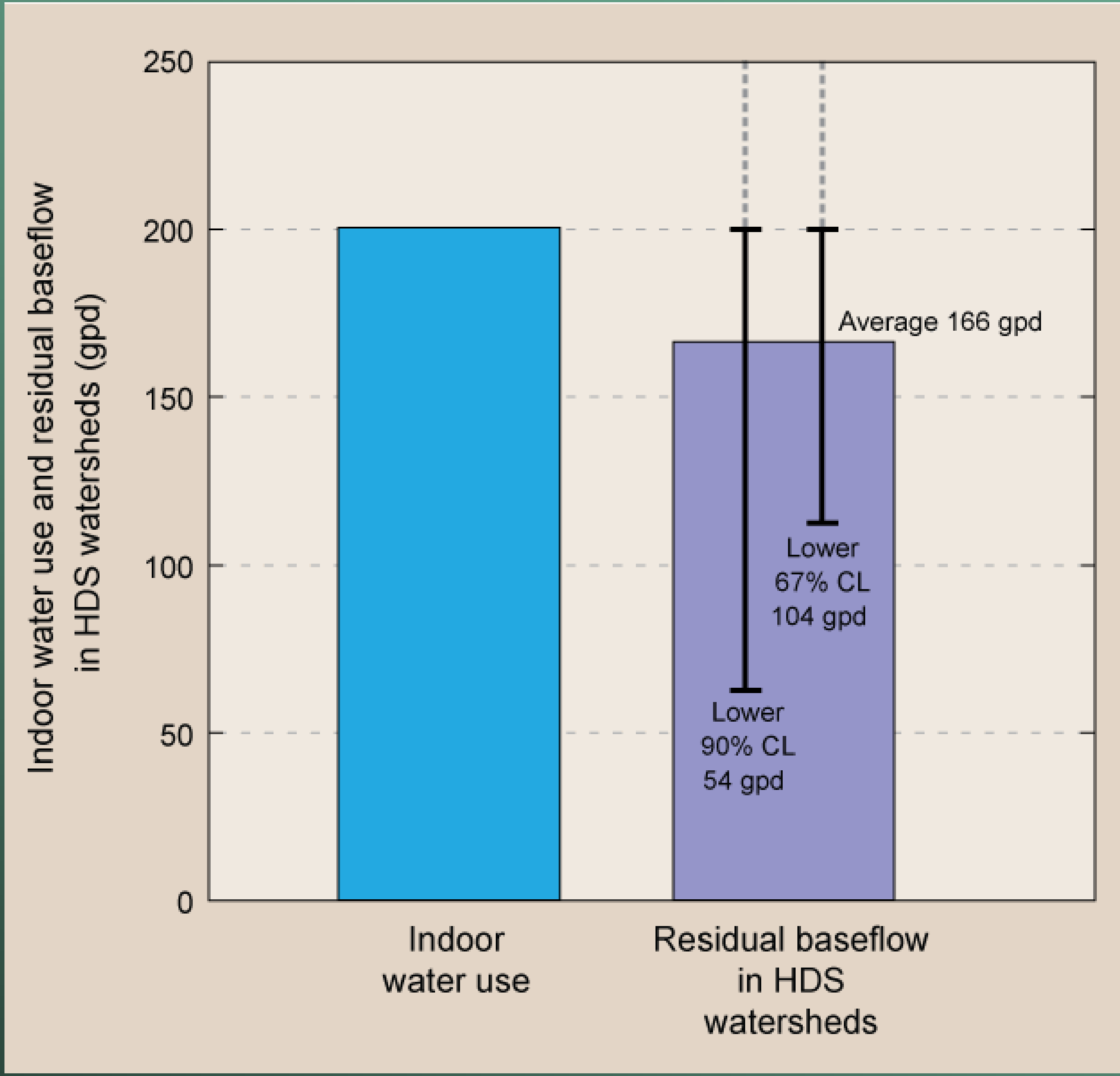
Consumptive Use of Septic Systems

*For this geologic setting, For the Fall of 2007, Consumptive Use is between **0%** and **73%** at the 90% Confidence Interval. The average is 17%; but this average has a high standard error.*

$$\left(\frac{200-166}{200}\right)=17\%$$

This estimate DOES NOT represent ANNUAL consumptive use, which is still unknown.



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Limitations and Need for further investigation

The results of this pilot study indicate that the approach works. However, the pilot study results do not provide the information needed for policy on consumptive use of on-site septic treatment systems. An adequate investigation will require the approach to be applied:

- In different geologies / soils
- In 4 seasons for an annual average consumptive use
- In additional land uses
- At different watershed Scales

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