

Mosquitoes, CSOs and Stable Isotopes

Where's the link?

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Outline

- ▶ CSO Introduction
 - ▶ Tanyard Creek
- ▶ *Cx. quinquefasciatus*
 - ▶ Stable Isotopes
- ▶ Ongoing Research
 - ▶ Conclusion



What is a CSO?

- ▶ Combined Sewage
Overflow
- ▶ Collect
 - Rainwater runoff
 - Domestic sewage
 - Industrial wastewater
- ▶ Combined Sewer
System (CSS)

▶ Atlanta has:

- 7 CSO facilities
 - Clear Creek
 - Custer Avenue
 - Greensferry
 - Intrenchment Creek
 - McDaniel Street
 - North Avenue
 - Tanyard Creek
- 2 CSO Regulators
 - Boulevard
 - Confederate Avenue

Combined Sewage =

Wastewater + Stormwater

What causes overflows?

▶ Dry weather



- All wastewater goes to WRC & is fully treated
- Returned to Atlanta water supply

▶ Wet weather



- Stormwater exceeds WRC capacity
- Combined sewage goes to CSO facilities for disinfection & screening

▶ Heavy rain



- Combined sewage bypasses CSO facility and flows directly into stream

Rain, rain....Go Away!!!

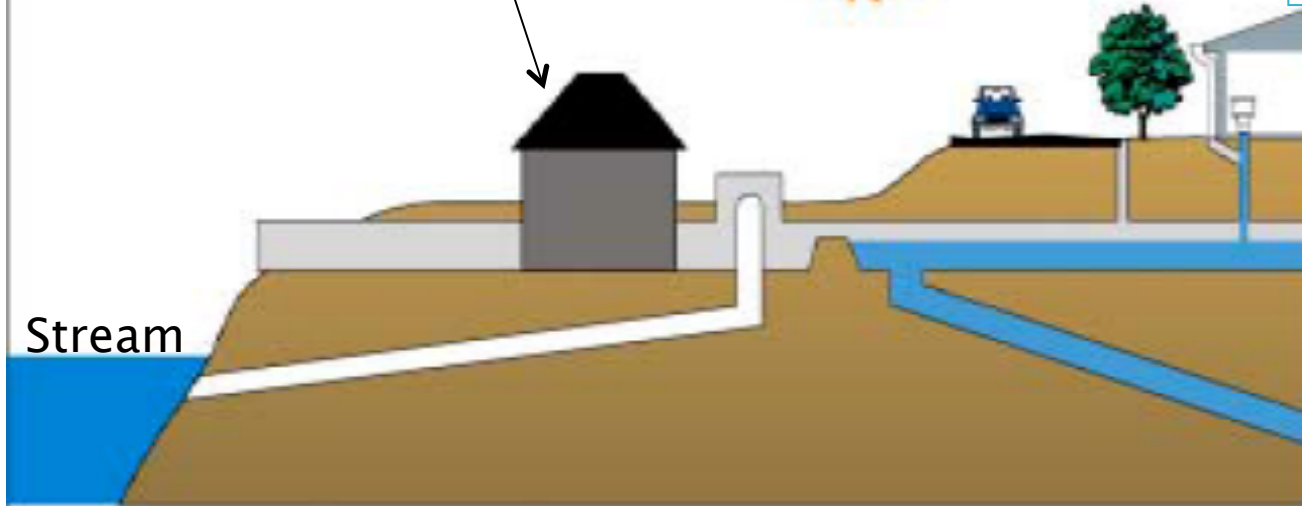
How's Atlanta's CSO System Works



During dry weather, combined sewage goes to WRC and is fully treated

CSO Facility (screening & disinfection)

Stream



During wet weather, combined sewage goes to a CSO Control Facility for treatment

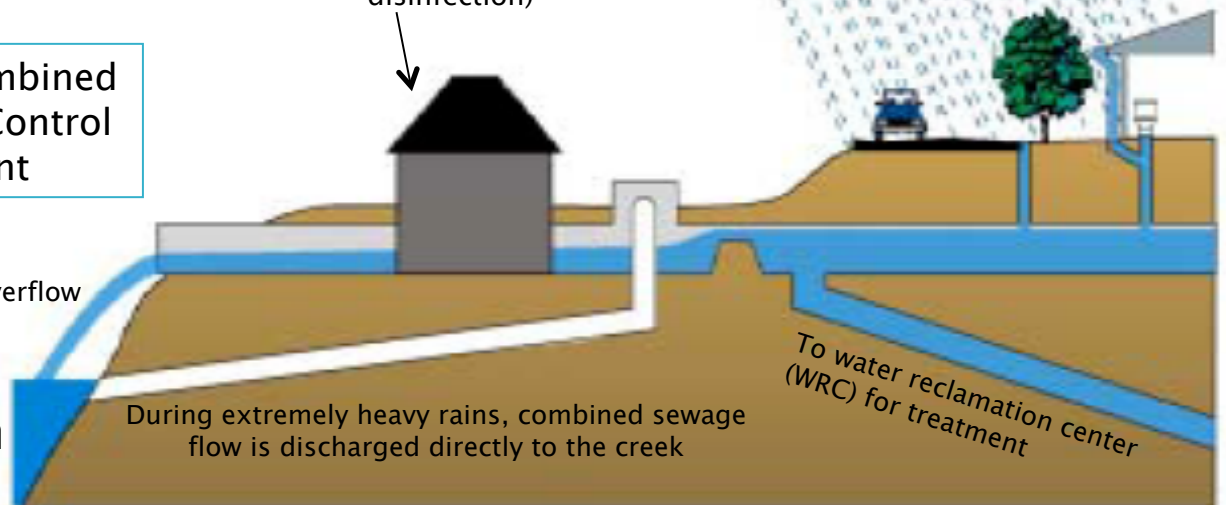
CSO Facility (screening & disinfection)

Combined sewer overflow

Stream

During extremely heavy rains, combined sewage flow is discharged directly to the creek

To water reclamation center (WRC) for treatment



Tanyard Creek CSO *-is unique-*

- ▶ Loring Heights residential area
- ▶ Serves West Atlanta combined sewershed
- ▶ 1,955 acres of urban area served
- ▶ Smallest volume capacity of all facilities
 - Maximum overflow capacity=3,600 mgd
- ▶ Primarily Treated?
 - Coarse screening
 - Remove large pollutants from street
 - Trash, basketballs, etc.
 - Fine screening
 - Remove solid sewage
 - Disinfection
 - Cl- injected
 - Kills some bacteria & pathogens

Paved Conveyance situated at headwater of urban stream.

Less than 1/10 in. of rain will cause Tanyard Creek facility to overflow.

Discharge at Tanyard Creek



How do overflows affect us?

- ▶ **Primarily disinfected sewage & rainwater runoff go directly into Tanyard Creek**

- ▶ Still contains some sewage solids & harmful bacteria

- ▶ Rainwater runoff contains organic & inorganic pollutants
 - Inorganics: oils, metals, and grease
- ▶ Sewage is a major source of excess Nitrogen
 - High organic content
 - Eutrophication
 - Algae deplete oxygen
 - Natural enemies such as fish cannot survive
 - Mosquito larvae thrive in anaerobic conditions

The good, the bad & the ugly

- ▶ Without overflow pipes sewage would backup into homes & streets
- ▶ Reconstruction in progress (reduce events)
- ▶ Tanyard Creek is used for many types of recreation
- ▶ CSO events can affect human health
- ▶ CDC/Emory Study shows correlation with *Culex* population & CSO events
- ▶ WNV+ surrounding Tanyard Creek CSO

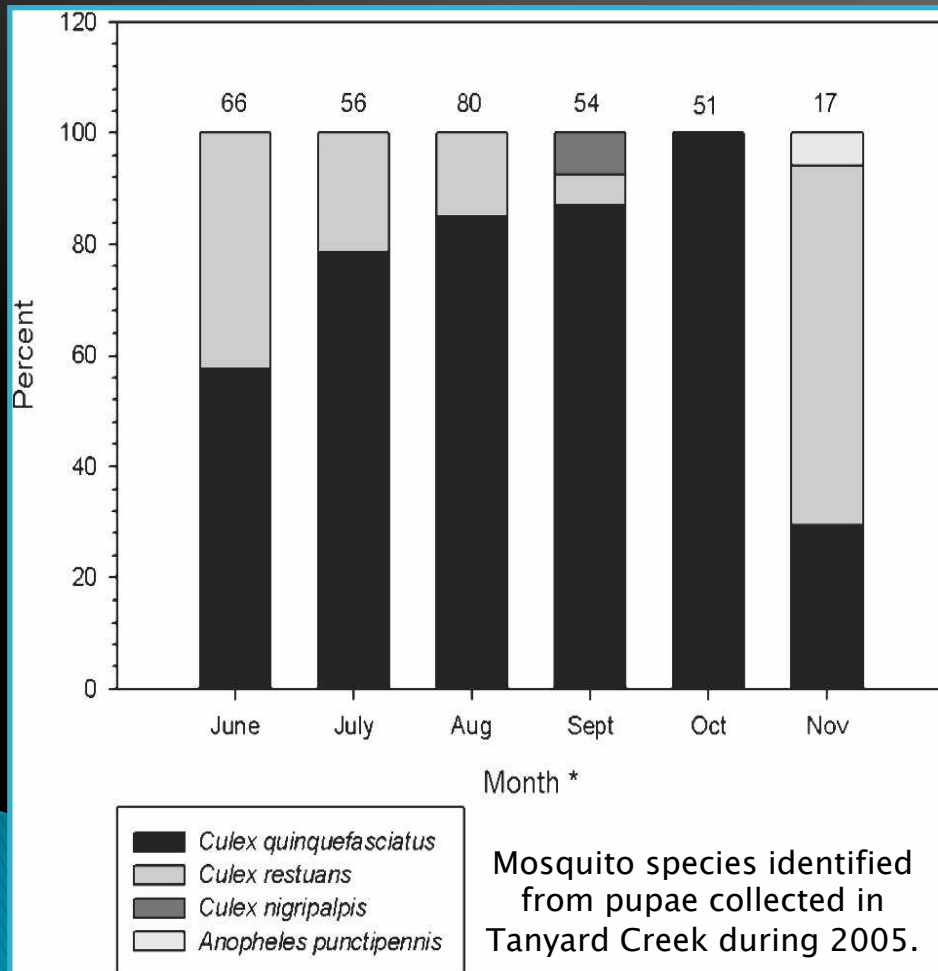


Combined Sewage Overflows (CSO) Are Major Urban Breeding Sites for *Culex quinquefasciatus* in Atlanta, Georgia

Lisa M. Calhoun, Melissa Avery, LeeAnn Jones, Karina Gunarto, Raymond King, Jacquelin Roberts, and Thomas R. Burkot*

Division of Parasitic Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

American Journal of Tropical Medicine and Hygiene, April 2007



- ▶ “The overall goal of this study is to define the role of CSO streams for WNV vector mosquito production in Atlanta, GA.”
- ▶ “An inverse relationship was found between the volume of water released in the previous 1–5 days and the prevalence of dips positive for any mosquito stage.”

Culex quinquefasciatus

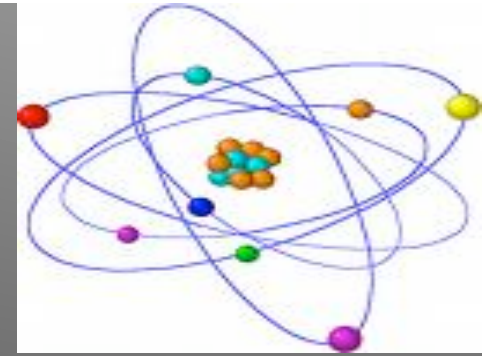
- ▶ Larvae can be found in bodies of water with a high degree of organic pollution
 - Drains, cesspits, polluted streams
 - CSO streams
- ▶ Close to human habitation
- ▶ Adults readily enter homes to bite humans at dawn and dusk



Southern House
Mosquito

- ▶ Blood meals:
 - Birds & mammals, especially humans
 - Contradicting data for % human blood meals
- ▶ Vector for
 - Lymphatic filariasis
 - MVE
 - RRV
 - Rift Valley Fever
 - SLE
 - Dog heart worm
 - Avian malaras
 - **WNV!!!!**

What is an isotope?



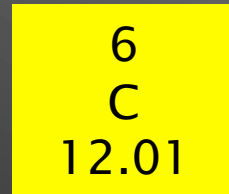
- ▶ Atoms of same element!
 - # neutrons in nucleus
 - Mass difference–separation
 - Example: ^1H and ^2H

1
H
1.00797

- ▶ Isotope analysis is determination of isotopic signature
 - Relative abundance of isotopes of given element in particular sample
- ▶ Stable isotopes are Non-Radioactive!
 - Share chemical characteristics

Stable Isotopes In Question

▶ Carbon



▶ ^{12}C

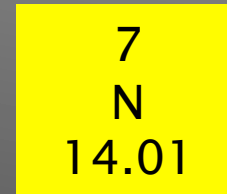
- 6 protons + 6 neutrons
- 98.89% natural abundance

▶ ^{13}C

- 6 protons + 7 neutrons
- 1.11% natural abundance

▶ Nutrient rich – ^{13}C

▶ Nitrogen



▶ ^{14}N

- 7 protons + 7 neutrons
- 99.63% natural abundance

▶ ^{15}N

- 7 protons + 8 neutrons
- 0.37% natural abundance

▶ Nutrient rich – ^{15}N

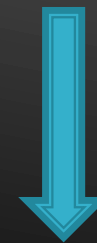
Stable Isotope Analysis

- ▶ Mass Spectrometry
 - Delta 15N vs. Air
 - Delta 13C vs. PDB

Preliminary Data 06/05/2008

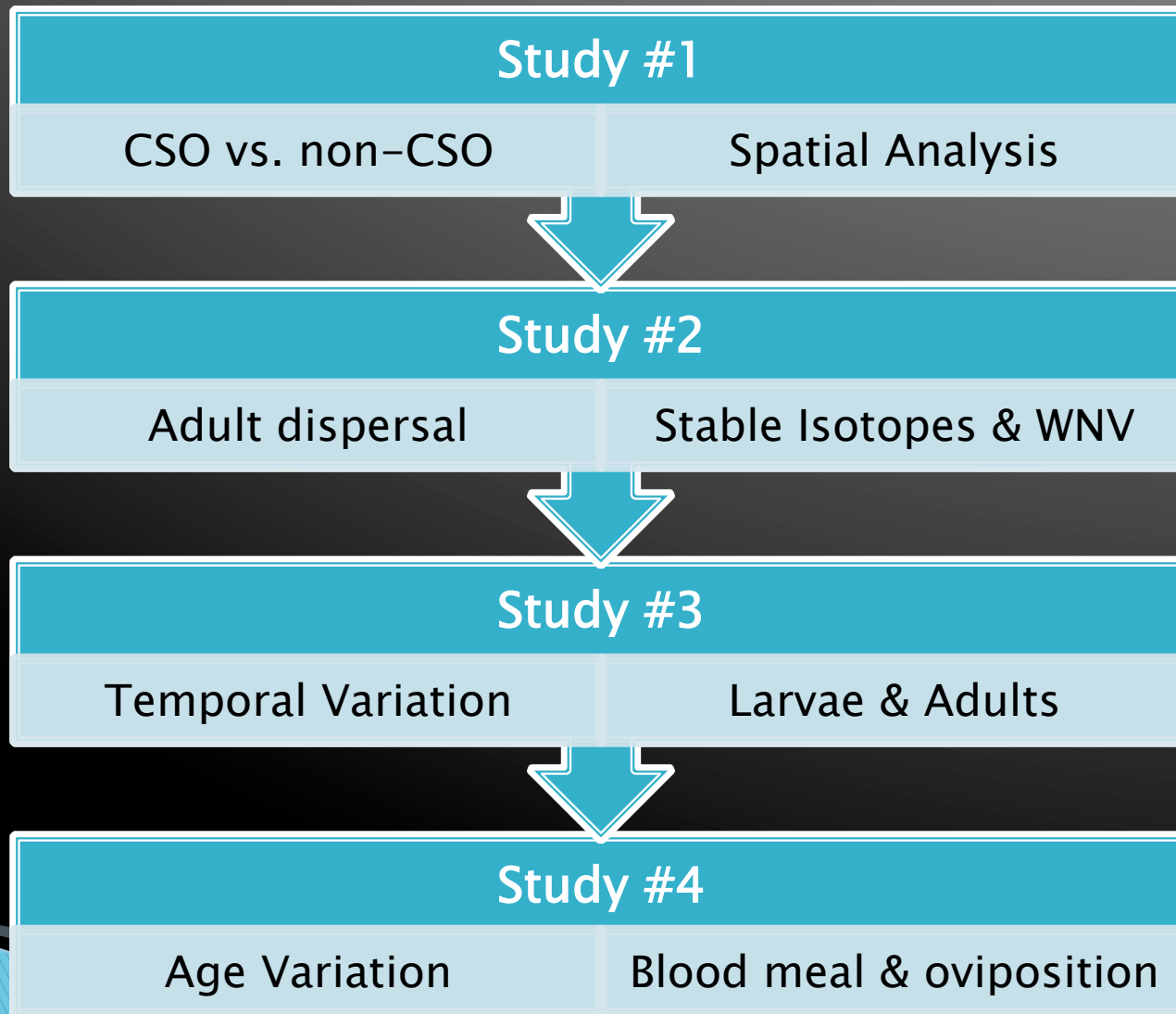
	Avg. Delta 15N vs Air	Avg. Delta 13C vs PDB
CSO	8.5	-21.7
Control	3.3	-29.2

- ▶ Statistical Analysis
 - SAS-ANOVA test



ANOVA 15N	ANOVA 13C
< .0001 significant	<.0001 significant

Ongoing Research



Study #1 Isotopic Analysis of Mosquito Larvae

▶ CSO vs. non-CSO

- IS THERE A DIFFERENCE???

▶ Fourth instar larvae & pupae reared to adult

- 10 females from each site analyzed
 - *Culex quinquefasciatus*
 - *Culex restuans*

▶ Control Site

- Problem → Created Control Site!

▶ Spatial variation

▶ Does signature change down stream?

- Sample sites along entire stream
 - 0m, 250m, 500m, 750m, 1000m, & ~2000m

Study #2 Isotopic Analysis of Adult Mosquitoes

▶ Adult Traps

- CO₂-baited Light Traps



- Gravid Traps



- ▶ *Culex* dispersal

- ▶ 2 Transects

- 0 km, ½ km, 1 km, 1½ km, & 2 km Westward

- ▶ Adults definitively from CSO stream?

Stable Isotopes & WNV

▶ Isotopic Signature

- Does the signature of captured adults relate to established CSO signature?

▶ WNV

- Are captured mosquitoes WNV+?
- Do WNV+ mosquitoes have same signature as larvae from CSO?
- Definitive?
 - What questions are left?
 - Temporal & Age variation

Study #3 Temporal Variation

- ▶ Does stable isotope signature for larval samples change over time?
- ▶ Larvae sampled throughout 2009
 - CSO
 - Control
- ▶ Does stable isotope signature for trapped adults change over time?
- ▶ Adult traps throughout WNV peak season
 - July–October

Study #4 Age Variation

- ▶ Does signature change after blood meal?
- ▶ Does signature change after oviposition?
- ▶ Larvae reared in breeders
- ▶ Females are fed blood meal
- ▶ Mated
- ▶ Allowed to oviposit
 - ▶ **10 FEMALES REMOVED FOR ANALYSIS**
- ▶ Females are fed second blood meal
- ▶ Allowed to oviposit a second time
 - ▶ **10 FEMALES REMOVED FOR ANALYSIS**

Conclusion

- ▶ It has been established that **CSO streams yield high populations** of immature mosquitoes
- ▶ WNV+ mosquito pools in **close proximity to CSO**
- ▶ WNV human cases in **close proximity to CSO**
- ▶ Stable Isotopic tracing
 - Problems with mark/release/re-capture
 - Can captured **adults be definitively tied to CSO stream larval habitat** through isotopic tracing?
- ▶ CSO input raises ^{13}C & ^{15}N levels in creek
 - *Unpublished data (Downey, et. al., 2008)*

Why is this important?

▶ **IF**

we can definitively correlate captured mosquitoes in residential areas to CSO streams...

▶ **THEN**

we can provide solid scientific evidence to support the need for mosquito control in these streams...
...starting with Atlanta and then 771 other cities...

Acknowledgements

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