Double Bayou WPP: Tidal Mixing and Lower Watershed Load Reduction Goals

Double Bayou - CWP Meeting
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SAMPLING STATIONS

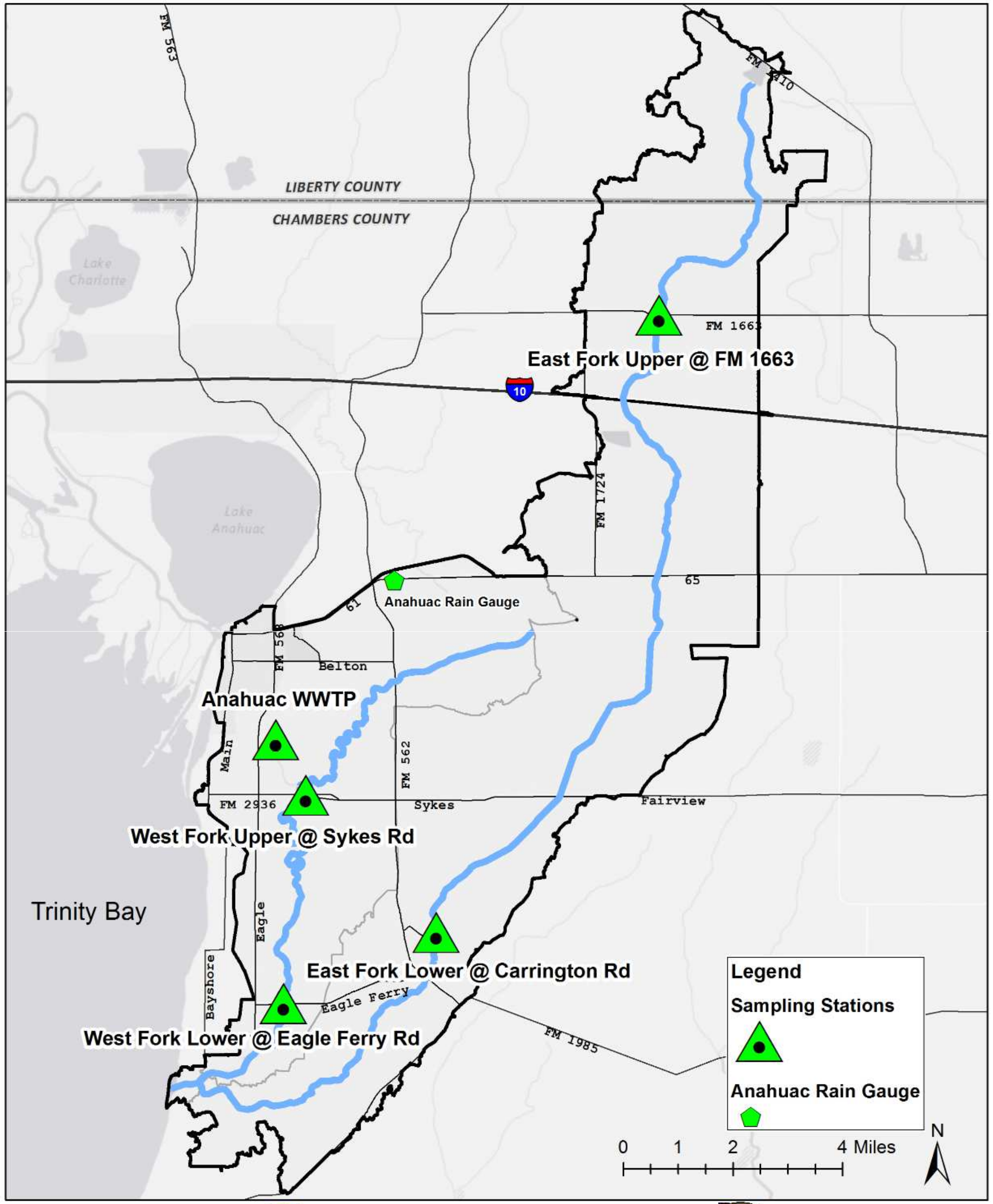
- Five Stations

  Two on each Fork,
  one at Anahuac
  WWTF

- Sampling results: October 22nd, 2013 –May 20th, 2015 (previous results 10/22/2013-8/12/2014)

- Sampling results include 30 to 31 routine events (sampling @ twice a month) and 7 targeted rain events at each station (189 total samples)

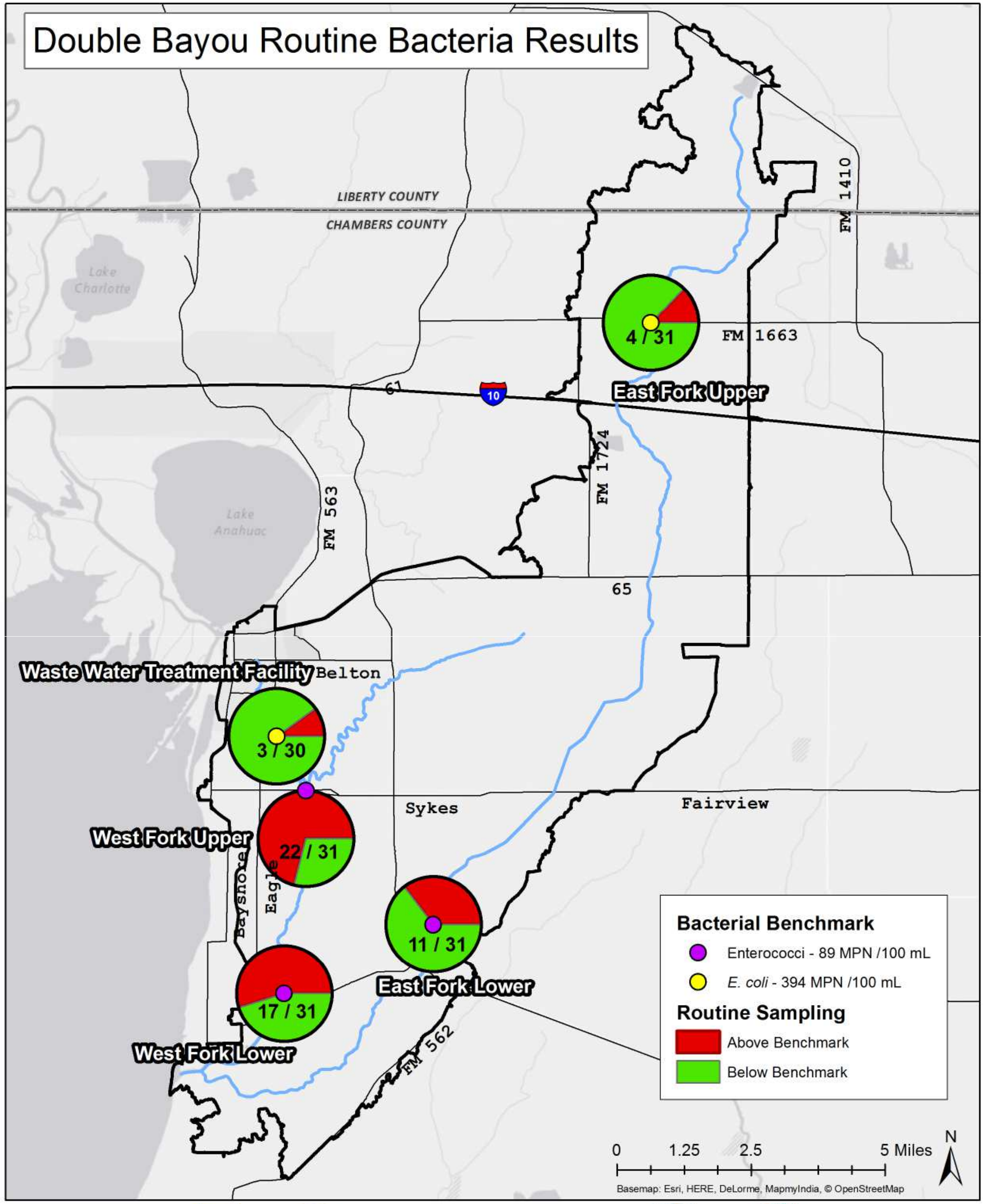
Double Bayou Watershed Sampling Stations



VARIATION IN BACTERIA BY SAMPLING STATION

•Routine Sampling 10/22/13-5/20/15

•Represents 17 total sampling events



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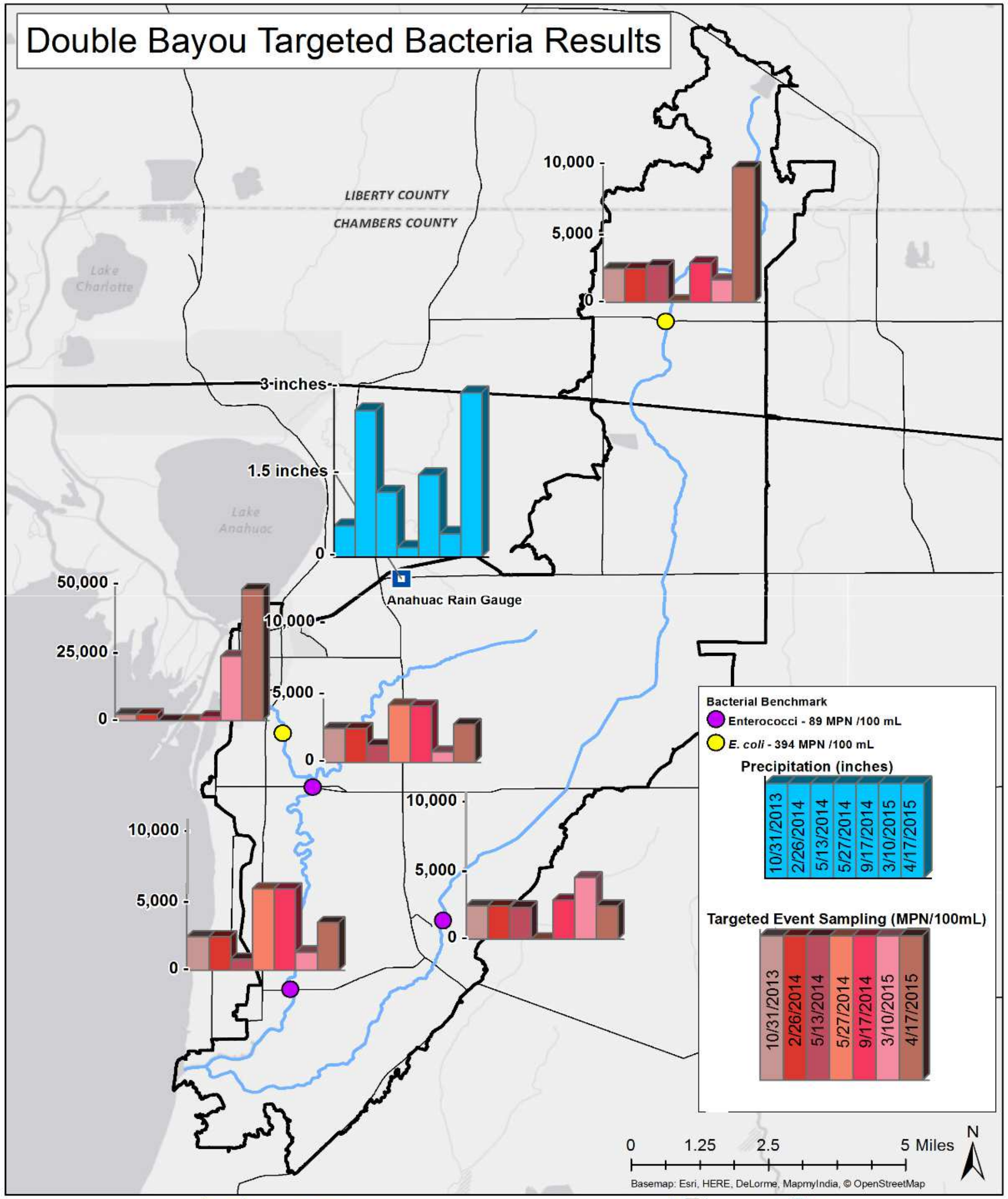
Double Bayou Watershed: Results of **Targeted** Rain Events 10/22/13-5/20/15

VARIATION IN BACTERIA BY SAMPLING STATION

- Targeted Rain Event Sampling
- Represents 7 total sampling events



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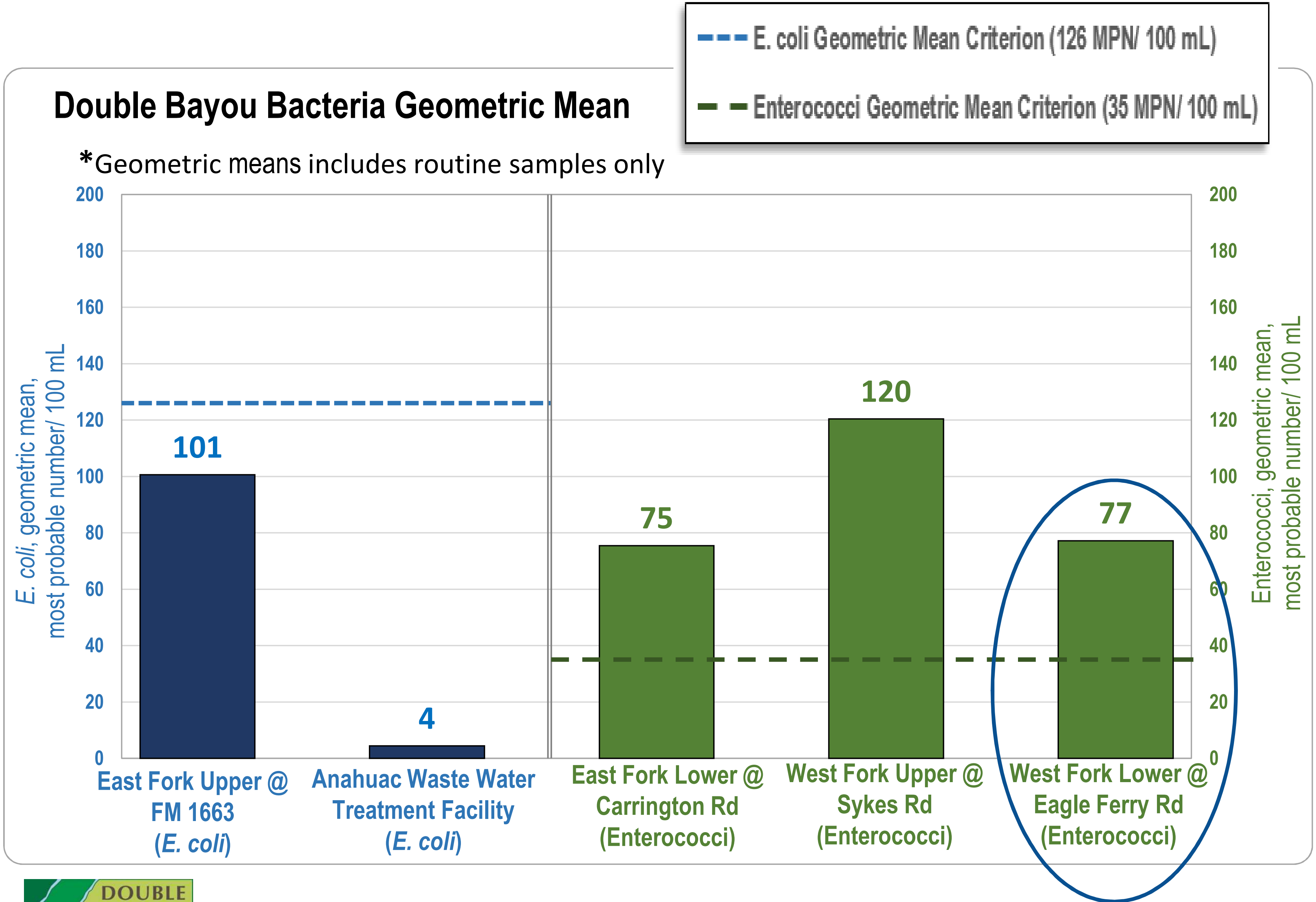

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TRINITY BAY

- Part of Galveston Bay Estuary System
- Relatively Shallow
  - 2 to 3 meters (6.6 to 9.8 feet)
- Largely enclosed
- Not heavily influenced by tides
- Winds significantly influence fluctuations and water levels

TRINITY BAY

- Tides in Galveston and Trinity Bay are both
  - **Diurnal** (one high and one low tide each day)
  - **Semidiurnal** (two high tides and two low tides each day)
- Winds are the dominating factor in circulation patterns
  - tides and freshwater inflows also influencing factors
- Trinity and San Jacinto rivers=majority of freshwater inflows
- Inflow seasonality
  - Spring rains = largest volume of freshwater inflows (April & May)
  - During this time, salinity in Trinity Bay can drop to 0 psu (practical salinity unit)
  - Normal conditions = @10 psu
  - Typical low-flow season @ July-October

DOUBLE BAYOU

- Trinity Bay's circulation patterns contribute to Double Bayou's flow patterns
- The tidal influence is relatively weak in this shallow estuary system, but there are tidal effects
- As the tide comes in (whether due to direct tidal flow or wind patterns), water flows up the bayous
- Strongest observed response at the lower West Fork sampling station (closest station to Trinity Bay)

FLOW

- West and East Forks of Double Bayou are very slow moving bayous
  - Typical river, such as the Trinity, can have daily average discharges anywhere from 12,000 to 160,000 cfs
  - Smaller streams can vary widely; typical average cfs might be 100 to 400 cfs or higher

Sample Flow Measurements During WPP Sampling Period

Flow, cfs	Min	Max	Average
EFU	-6	572	49
EFL	-49	1390	106
WFU	-70	940	71
WFL	-511	1020	71

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West Fork Lower – Tidal Mixing

- An Index Velocity Site Gauge (measures both positive and negative discharge (flows)) installed at the West Fork Lower station site
- Operates continuously, routinely measuring discharge (cubic feet per second (cfs)) every fifteen minutes
- “Positive discharge” = times at which the flow is occurring from upstream (north) towards downstream (south)
- “Negative discharge” = times at which the flow is occurring from downstream (south) towards upstream (north), as a result of tidal/wind influence from Trinity Bay.
- Gauge discharge data used for analysis were from February 24, 2012 – July 6, 2015.

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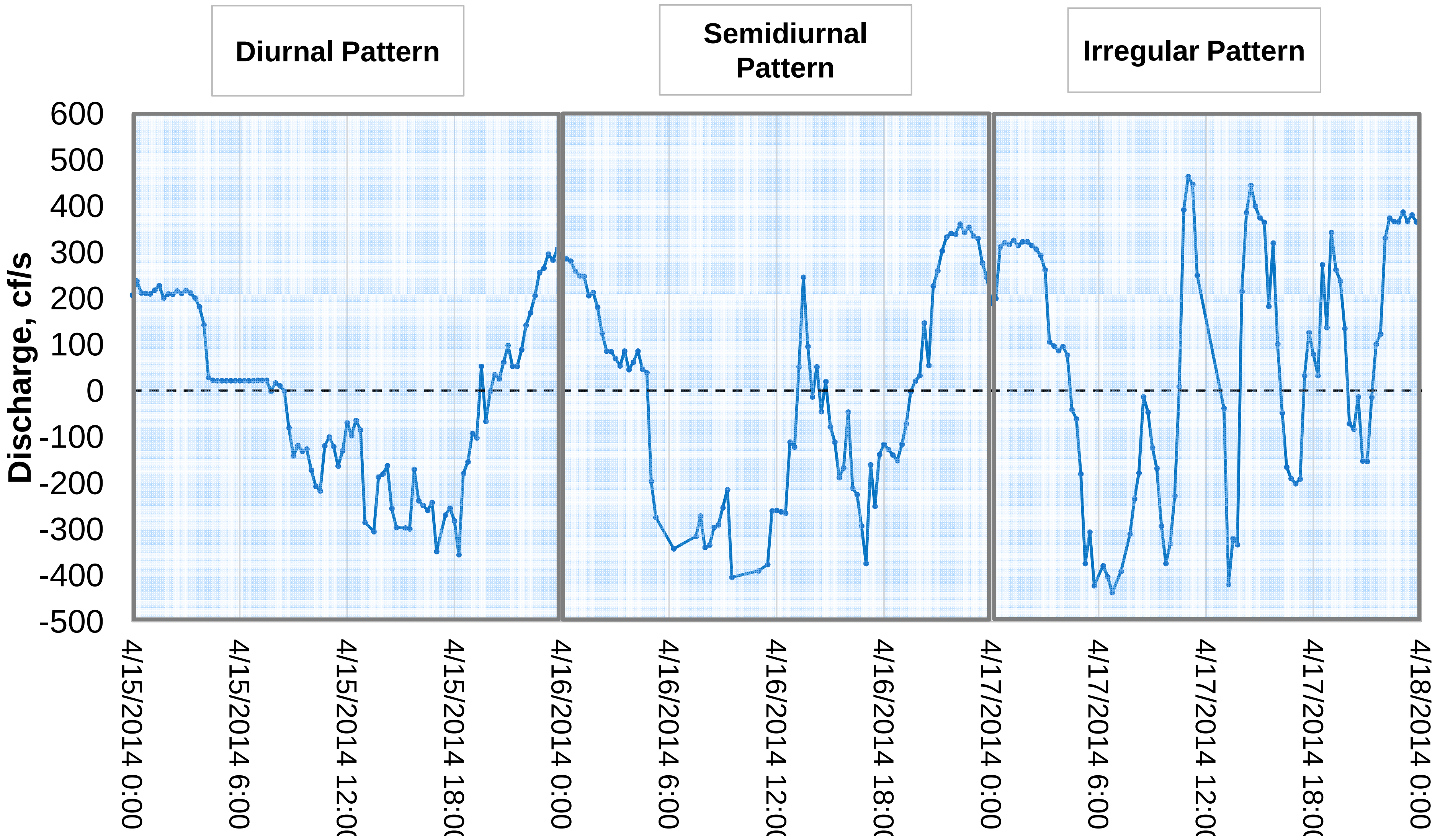
Flow Example: 3 Day Variance in Water Flow Patterns at West Fork Lower

- 24-hour data – irregularity of tidal, wind and other influences

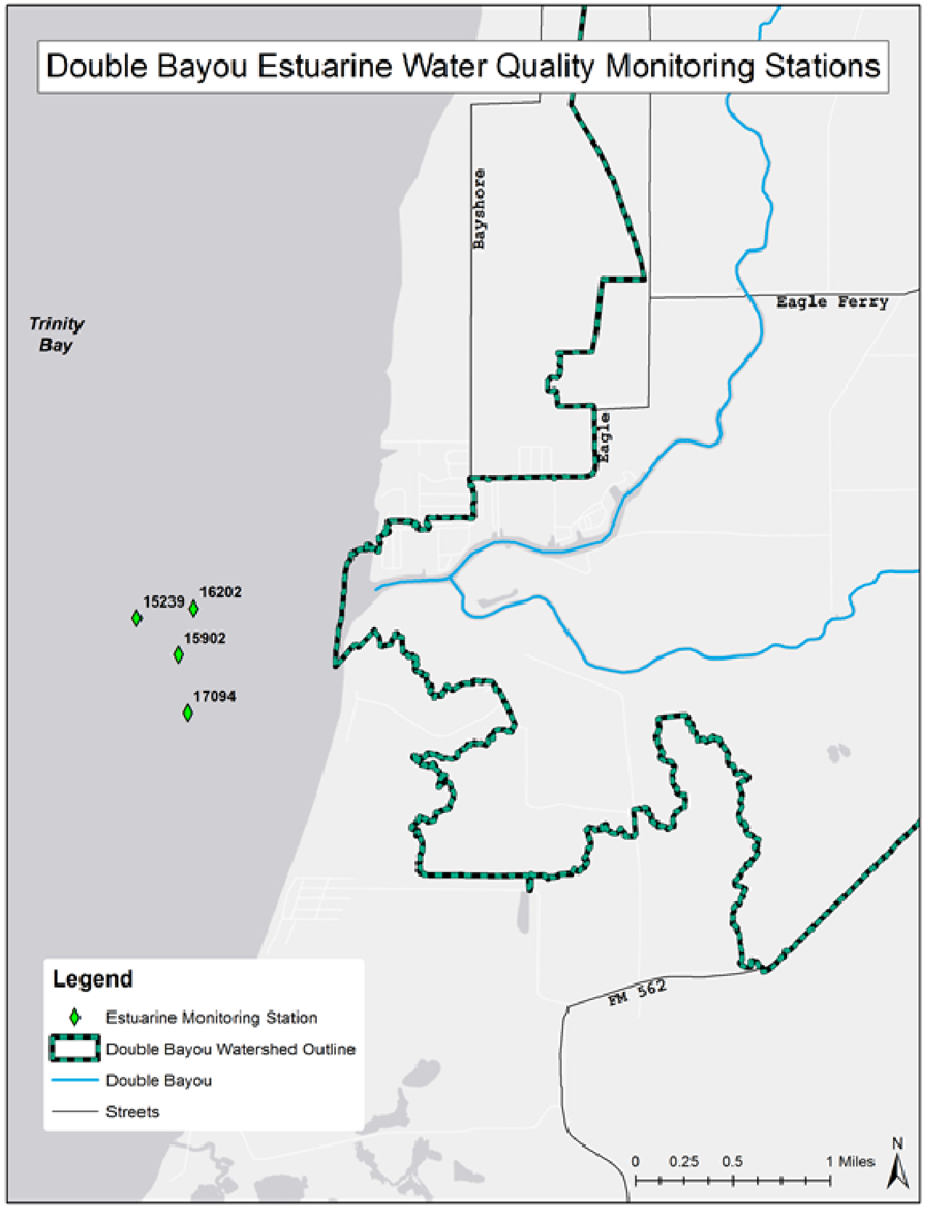


NEGATIVE DISCHARGE – TIDAL MIXING DILUTES BACTERIA

- Statistical analysis conducted on the bacteria samples in the categories of positive discharge and negative discharge
- Showed that the Enterococci levels of negative and positive flows at WFL are statistically different
- Negative flow samples' percent exceedance was **18%** and the positive flow samples' percent exceedance was **94%**
- Conclusion: tidal mixing dilutes the bacteria concentration and the resulting bacteria loads would not exceed the regulatory load, during negative flow sample periods.

Trinity Bay Bacteria Near Double Bayou

- Conclusion from previous slide is based on the assumption that the Bay is not a source of bacteria – which is true
- Analyzed bacteria data from the four stations in the figure, data from 2001-2014
- Geomean of the Enterococci from these years (46 samples) is **7.6**; of these, the most recent samples (20 of the 46) have a geomean of **6.6**



Water quality stations in Trinity Bay closest to the mouth of Double Bayou

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BACTERIA LOADINGS

- For Upper portion of Double Bayou watershed, we used an LDC analysis for estimating daily load and developing load reduction curves
- Typically, LDCs are calculated for nontidal stations due to the way the flow data are analyzed for this process
- Irregular flow pattern present at West Fork Lower→ LDC approach basing pollutant loadings on flow regimes would not work in this case
- Little correlation between positive discharge flow and bacteria concentration for West Fork Lower
  - Likely due to the wind-driven nature of the system – periods of intense rainfall will often be accompanied by high winds, causing erratic flow patterns.
- One note here – there is a strong connection between bacteria results for targeted rain events compared to non-rain event samples.
  - Targeted rainfall event samples: Enterococci had a 100% exceedance rate
  - It is the correlation between targeted rain events and flow itself that is relatively weak – some rain events had negative discharge or weak flow

BACTERIA LOADINGS

- Loadings for the West Fork Lower station were analyzed based on volumetric calculations
- Daily loads on bacteria sampling days were calculated by integrating the 15-minute volume increments into a day's worth of volume (units of cubic meters, or m^3)
  - Integrating the day's worth of 15 minute measurements resulted in final volume for the day
  - If you think of that cross section of the bayou as bowl, we are interested in all flow into that bowl during one day: total volume (V_t)

$$V_x = \int_{t=0}^{t_f} f(t)\Delta t$$

Where:

$V_x = V_b$ or V_s, depending on positive or negative designation of flow

$f(t)$ = flow at time t, expressed in cubic feet per second

Δt = change in time t; as stated our time steps were 15 minutes (every 900 seconds)

t_f = final time measurement

Bacteria Loadings

- Calculated daily load for each sample (units of cfu/day, total sample size for West Fork Lower was 46)
- Maximum allowable load was calculated in the same manner, using the Enterococci standard of 35 cfu/100 mL

Total amount of water accumulated in our "bowl" during the day

The bacteria grab sample concentration

Conversion factor for units

$$Daily\ Load\ (\frac{cfu}{day}) = V_t(\frac{m^3}{day}) * \mathrm{C}(\frac{cfu}{100\ mL}) * 1{,}000{,}000\ (\frac{mL}{m^3})$$

Where:

V_t = Daily total volume (m^3/day), which is defined as $V_b + V_s$

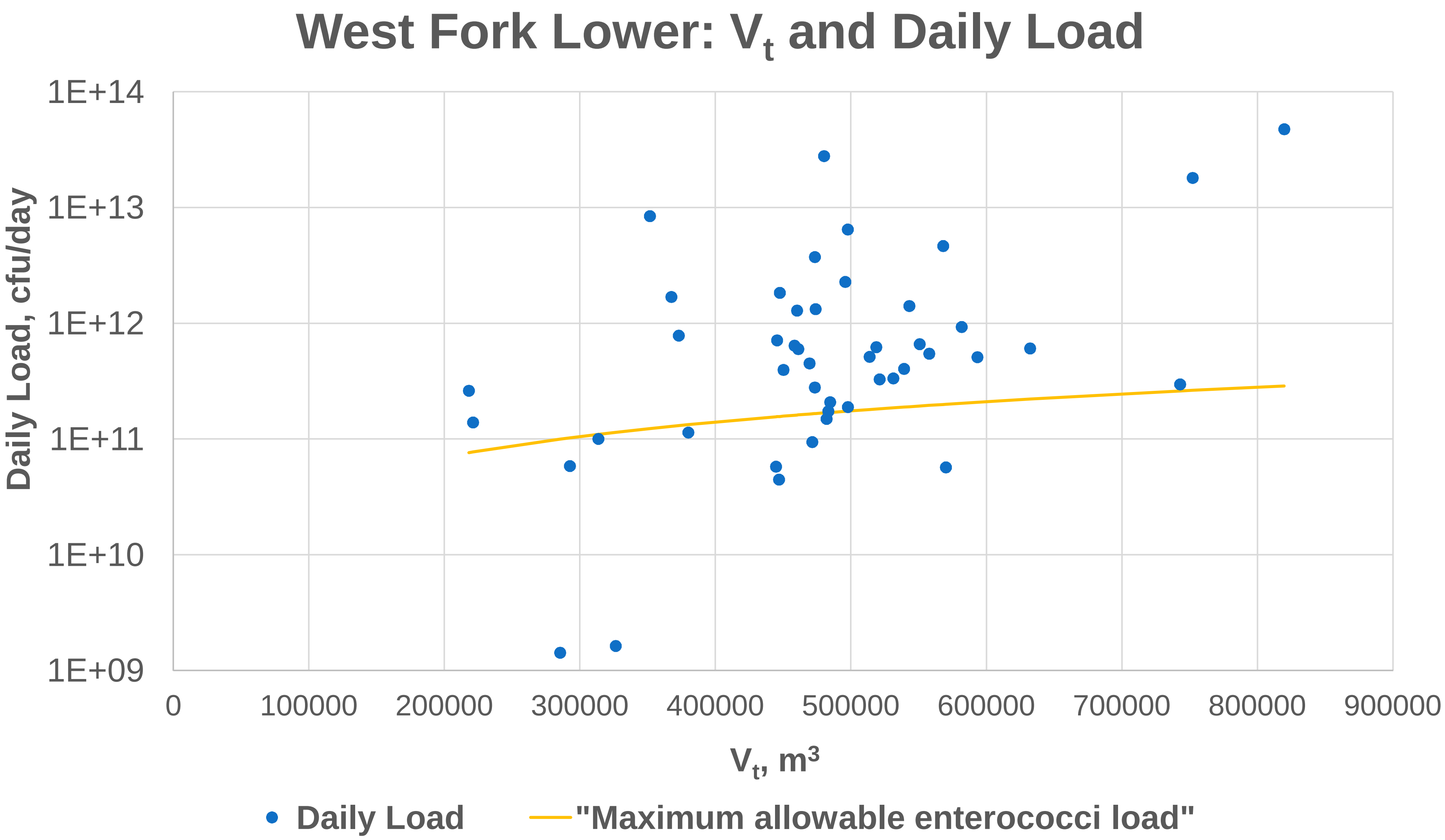
V_b = Volume of bayou water (m^3/day)

V_s = Volume of bay water (m^3/day)

C = Concentration of Enterococci (cfu/100 mL)

Bacteria Loadings

- Blue dots on or below the yellow line are meeting
- Blue dots above the line are exceeding



LOAD REDUCTION GOAL

- As with the percent reduction goal determined by LDC analysis, the percent exceedance categories were evaluated
- As opposed to categorizing by flow, such as with the LDC analysis, the focus was on the categories themselves and distribution of samples within each category
- Categories based on distribution frequency

Percent Exceedance Category	Number of % exceedances in each category	Percent Reduction
75-100%	17	90%
40-74%	**15**	**59%**
Under 0 (meeting criteria) - 39%	14	-1044%

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Load Duration Curves – Margin of Safety (MOS)

- A margin of safety (MOS) can be applied to the pollutant concentrations to account for variations in loading from potential sources, stream flow, management measures, etc.
  - Gives you more of a buffer for error if things go wrong
  - Gives the plan the capacity to plan for bigger loads
- Input on MOS:
  - TCEQ standard for *Enterococcus* - 35 cfu/100 mL
  - Options for more conservative thresholds for reduction goals
    - 5% MOS - 33.25 cfu/100 mL
    - 10% MOS - 31.5 cfu/100 mL

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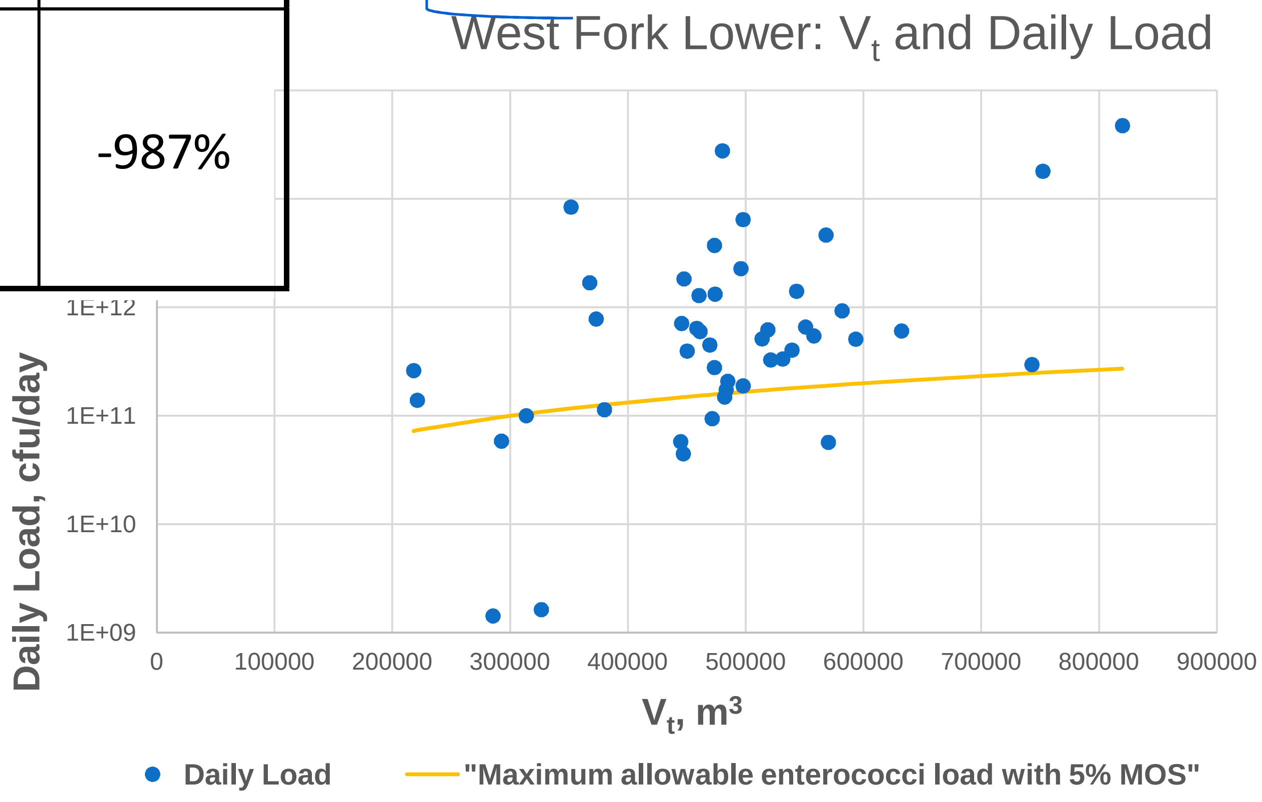
Load Reduction Goal – 5% MOS

Percent Exceedance Category	Number of % exceedances in each catergory	Percent Reduction
75-100%	17	91%
40-74%	15	61%
Under 0 (meeting criteria) - 39%	14	-987%

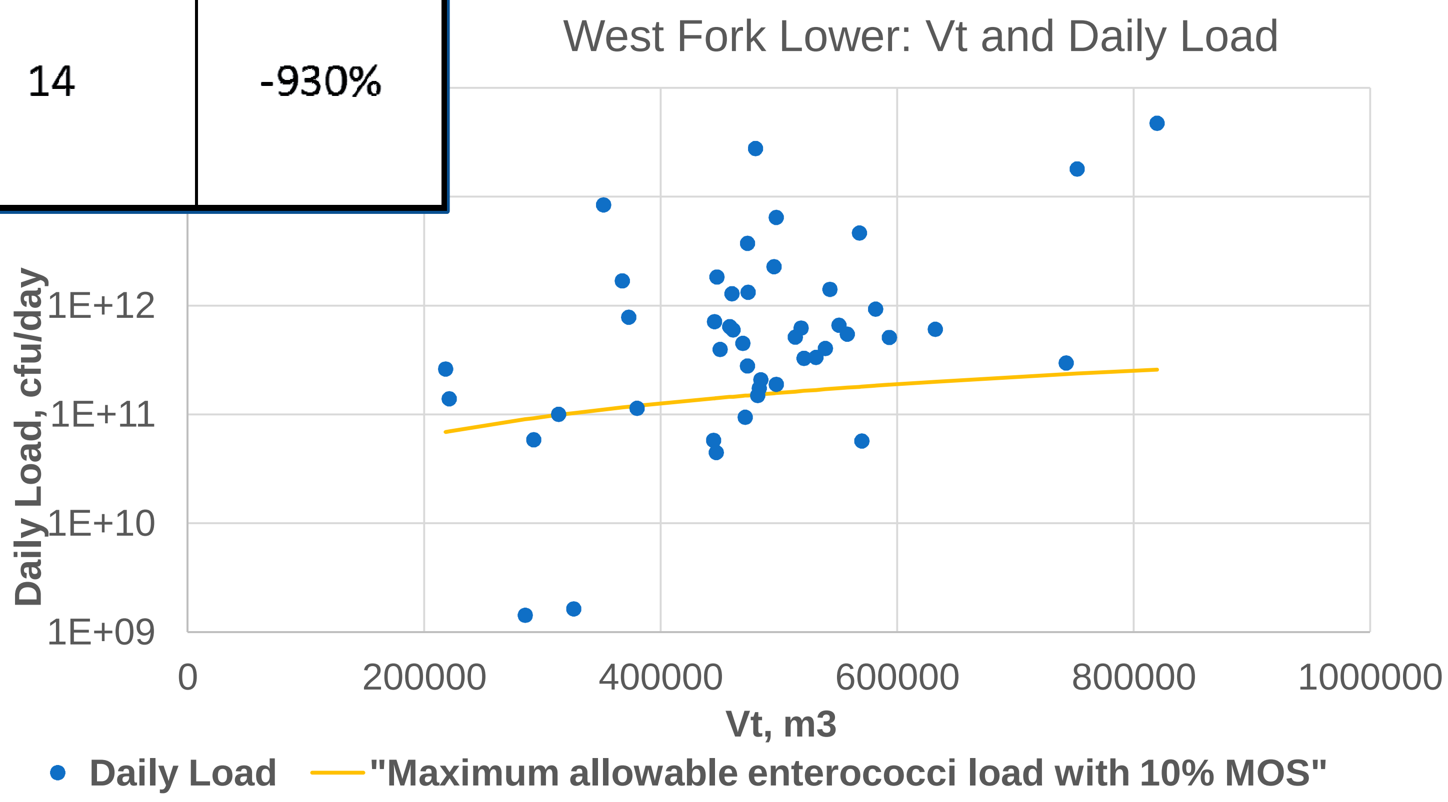
61% Load Reduction Goal at Mid-Range Conditions with 5% MOS



Load Reduction Goal – 10% MOS

Percent Exceedance Category	Number of % exceedances in each catergory	Percent Reduction
75-100%	18	90%
40-74%	14	62%
Under 0% (meeting criteria) - 39%	14	-930%

62% Load Reduction Goal at Mid-Range Conditions with 10% MOS



LOAD REDUCTION GOAL

- Plan generally for “mid-range” conditions
- MOS can be applied to the pollutant concentrations to account for variations in loading from potential sources, stream flow, management measures, etc.
- Input on MOS:
- No MOS – 35 cfu/100mL
  - Mid-range flow conditions **59%** reduction goal
- 5% MOS - 33.25 cfu/100 mL
  - Mid-range flow conditions **61%** reduction goal
- 10% MOS – 31.5 cfu/100 mL
  - Mid-range flow conditions **62%** reduction goal

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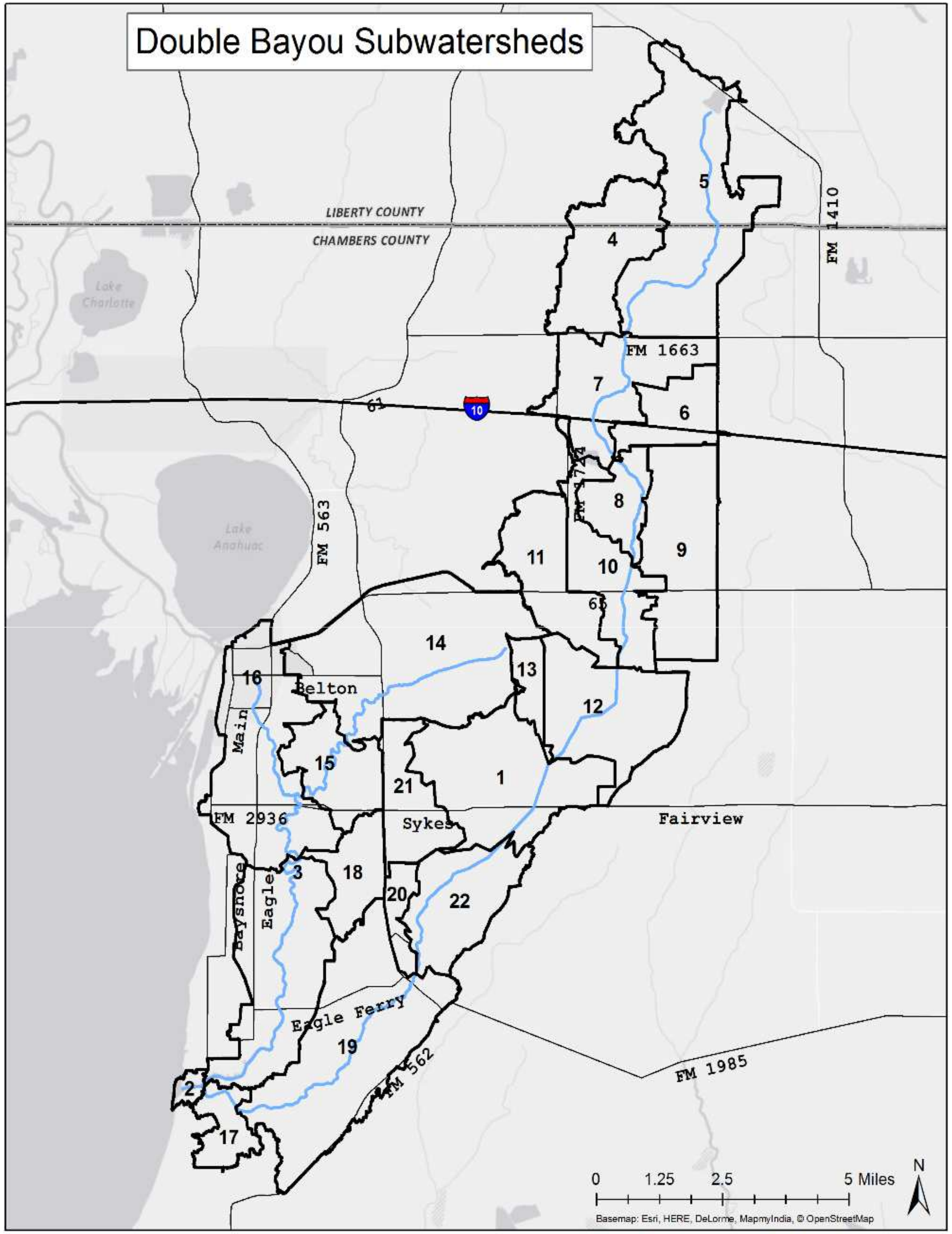
LOAD REDUCTION

- Previous meeting:
  - 38% reduction goal for upper watershed
  - (subwatersheds 4 and 5)
- This meeting XX% reduction goal for lower watershed
  - Rest of subwatersheds
- Load Reduction Goal?



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QUESTIONS

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TSSWCB Texas State Soil and Water Conservation Board

Shead Conservation Solutions

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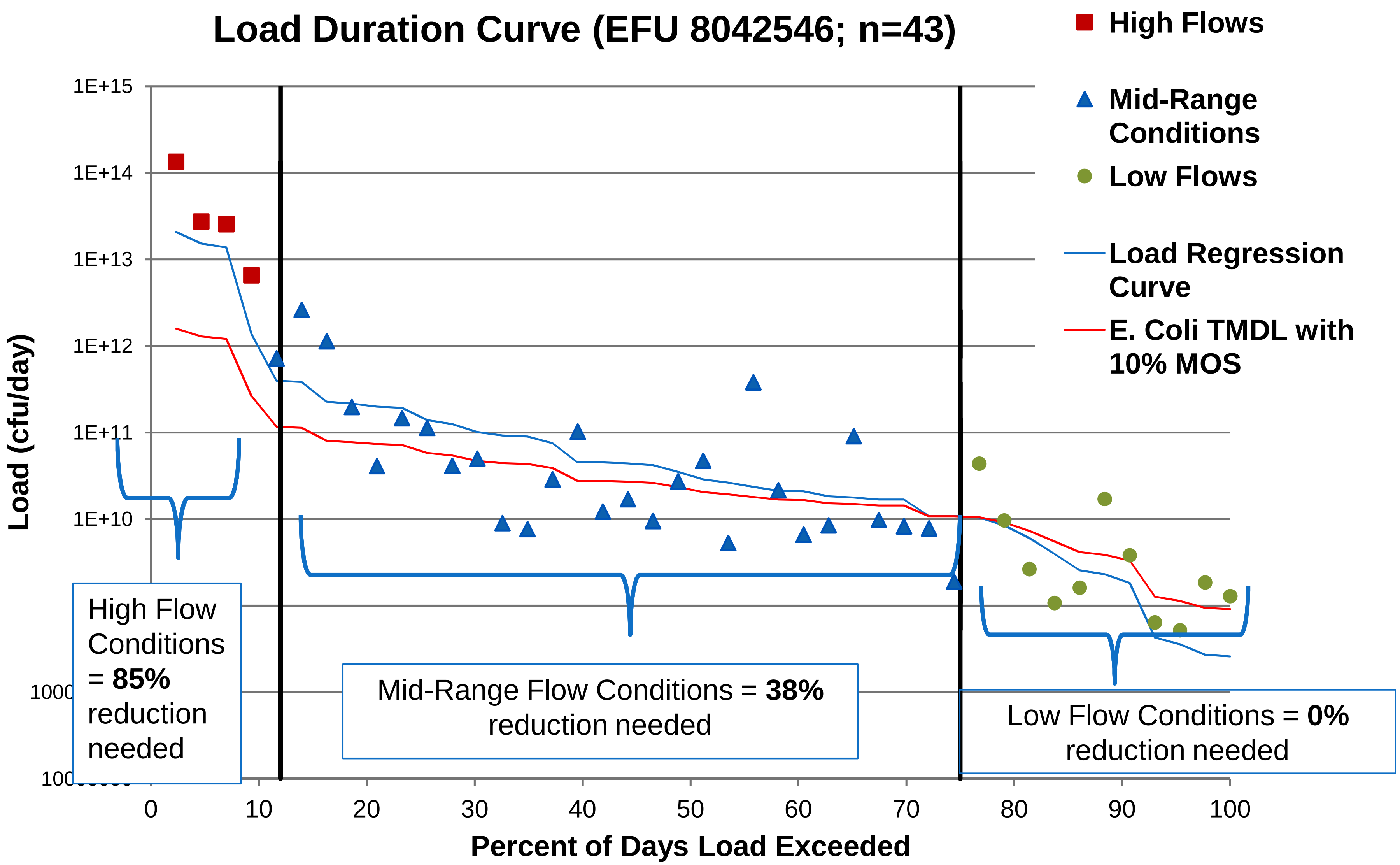
LDC – 10% MOS Estimate of Pollutant Loads



Load Reduction Goal

- Plan generally for “mid-range” conditions
- MOS can be applied to the pollutant concentrations to account for variations in loading from potential sources, stream flow, management measures, etc.
- Input on MOS:
- No MOS – 126 cfu/100mL
  - Mid-range flow conditions **30%** reduction goal
- 5% MOS - 120 cfu/100 mL
  - Mid-range flow conditions **34%** reduction goal
- 10% MOS - 113 cfu/100 mL
  - Mid-range flow conditions **38%** reduction goal

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