Simple Tools for Estimating Loads and
Load Reduction: Load Duration
Curves and SELECT

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Flow Duration Curves (FDCs) &
Load Duration Curves (LDCs)
Flow Duration Curves (FDCs)

- **Flow Duration Curve**
  - A graph showing the flow rate versus the time
  - Time is illustrated as percentage of the year
  - Graph shows the relative percentage of the year that stream flow exceeded a designated flow level
  - Able to break up the flow rates into standard categories
    - Low flows
    - Dry conditions
    - Mid-range flows
    - Moist conditions
    - High flows

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Flow Duration Curve: Flow categories

- Can be the standard flow categories
  - High flows: 0 to 10% exceedance
  - Moist conditions: 10 to 40% exceedance
  - Mid-range flows: 40 to 60% exceedance
  - Dry conditions: 60 to 90% exceedance
  - Low flows: 90 to 100% exceedance
- Can develop your own flow categories based on the flow duration curve
  - Need measured or simulated daily continuous stream flow data over multiple years
  - Create flow breaks based on change in slope in FDC graph
Load Duration Curves (LDCs)

- Load Duration Curve
  - Combines concentrations of a pollutant with flow at the same time to develop a load
  - The LDC illustrates the load of a pollutant versus the time that a given load is exceeded
  - Time is illustrated as percentage of the year
  - Able to see if a stream is exceeding the standard in terms of load (flow and concentration)
  - Able to calculate a percent reduction based on flow categories

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E. Coli criterion of 126 cfu/100 ml
Load Duration Curve With Observed Loads During Different Flow Conditions

Load Regression Model on Load Duration Curve Plot
LDC Usefulness (source ID based on LDC)

Load Regression Curve: LOADEST

- Estimate load regression curve with USGS LOAD ESTimator (LOADEST) program
- Input matching flow and E. coli concentration data
- Apply regression models and choose which fits best
  - 1: $a_0 + a_1 \ln(Q)
  - 2: $a_0 + a_1 \ln(Q) + a_2 \ln(Q)^2$
- Have modified version of LOADEST that has E. coli constituent variables
- Calculate load regression curve from output variables and observed or simulated flow with equation:
  - 1: $\exp(a_0 + a_1 \times (\ln(Q) - \text{“center” of } \ln(Q)))$
  - 2: $\exp(a_0 + a_1 \times (\ln(Q) - \text{“center” of } \ln(Q)) + a_2 \times (\ln(Q) - \text{“center” of } \ln(Q))^2)$
Calculating Percent Reduction

- Percent Reduction calculated using formula:
  \[- \frac{(\text{Load}_{\text{est}} - \text{TMDL})}{\text{Load}_{\text{est}}} \times 100\]
- Percent reduction is calculated for each point and then points within a flow condition are averaged together to get the percent reduction for a flow condition.

Continuous flow nitrate LDC

Haberle Rd Load Duration Curve

Drinking water standard
10 mg/L nitrate-N

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### Developed Flow Conditions: Percent Reductions

<table>
<thead>
<tr>
<th>Flow Conditions</th>
<th>Percent Reduction</th>
<th>Flow Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Flows</td>
<td>82</td>
<td>0-10%</td>
</tr>
<tr>
<td>Mid-Range</td>
<td>83</td>
<td>10%-75%</td>
</tr>
<tr>
<td>Low Flows</td>
<td>85</td>
<td>75%-100%</td>
</tr>
</tbody>
</table>

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**Flow grab sample E. coli LDC**

![Graph showing flow grab sample E. coli LDC](image)
Advantages of Load Duration Curves

- Widely accepted and used in Texas
- Only moderate data requirements
- Ease of application
- Identifies allowable loading for all flow conditions
- When combined with monitoring data, identifies existing loading for all flow conditions and can provide percent reduction required
- Readily communicated to stakeholders

Disadvantages of Load Duration Curves

- Only identifies broad categories of sources (i.e., nonpoint source and point source) – not a problem if sources already well understood
- Does not quantitatively link sources to receiving water body quality
- Generally applicable only to non-tidal streams (selectively applicable in transition zones of reservoirs & in weakly tidal streams)
- Not readily applied in predictive mode (e.g., to evaluate control measures & BMPs)
Spatially Explicit Load Enrichment Calculation Tool (SELECT)

- GIS based tool
- Newly developed Visual Basic frontend for easier interface

Input Data

- Census Blocks (U.S. Census Bureau)
- Soils (USDA-NRCS)
- Digital Elevation Map (BASINS)
- Urban Areas (TCEQ)
- Sub-watersheds & stream network

- Livestock
  - Stakeholder input
  - Agricultural Statistics (USDA)
  - Poultry Operations within the watershed (TSSWCB)

- Wildlife
  - Stakeholder input
  - Wildlife experts input, Resource Management Unit data for Deer (TPWD)
Potential Sources

Range Cattle
- Density: 5 acres per animal
- Land Use
  - Rangeland
  - Mixed Forest
  - Riparian Forest

Pasture Cattle
- Density: 2 acres per animal
- Land Use
  - Managed Pasture

Deer
- Density: 37 acres per animal
- Land Use
  - Rangeland
  - Managed Pasture
  - Mixed Forest
  - Riparian Forest

Feral Hogs
- Density: 20 acres per animal
- Land Use
  - Rangeland
  - Managed Pasture
  - Mixed Forest
  - Riparian Forest

Septic
- 70 gallons per day per person
- $10^6$ CFU/100 mL
- Rural Population (1990 census)
  - Robertson County: 10379
  - Brazos County: 14203

Walnut Creek

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Walnut Creek – Land Use

Walnut Creek – Land Use Percentage

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>88395</td>
</tr>
<tr>
<td>Managed Pasture</td>
<td>35514</td>
</tr>
<tr>
<td>Rangeland</td>
<td>22452</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>12815</td>
</tr>
<tr>
<td>Riparian Forest</td>
<td>11902</td>
</tr>
<tr>
<td>Developed, Roads</td>
<td>3178</td>
</tr>
<tr>
<td>Barren Land</td>
<td>1201</td>
</tr>
<tr>
<td>Open Water</td>
<td>629</td>
</tr>
<tr>
<td>Developed, Low Intensity</td>
<td>592</td>
</tr>
<tr>
<td>Developed, Medium Intensity</td>
<td>72</td>
</tr>
<tr>
<td>Developed, High Intensity</td>
<td>39</td>
</tr>
</tbody>
</table>
Walnut Creek - Subwatersheds

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Walnut Creek - Potential E. coli loads

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Walnut Creek - **Total** Potential Daily *E. coli* load

<table>
<thead>
<tr>
<th>Total Potential E. coli Load (CFU/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.52e+012 - 5.50e+013</td>
</tr>
<tr>
<td>5.91e+013 - 1.13e+014</td>
</tr>
<tr>
<td>1.14e+014 - 1.51e+014</td>
</tr>
<tr>
<td>1.52e+014 - 2.74e+014</td>
</tr>
<tr>
<td>2.75e+014 - 3.45e+014</td>
</tr>
</tbody>
</table>

Streams: Orange, Subwatersheds: Green

Lampasas River Watershed

Copperas Cove

Cities: Lampasas

Streams: Blue, Roads: Red, County Boundaries: Black, Watershed Boundary: Green

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Septic System

- **E. coli Load** = Number of Systems * Failure Rate * People/home * Concentration * Discharge * Conversion Factors
  - Number of Systems:
    - Number of homes from 911 addresses that are classified as residential
    - Remove homes within CCN boundary
  - Failure Rate
    - Septic Drainfield Limitation Class – SSURGO soil
    - Very Limited (15%), Somewhat Limited (10%), Not Rated (15%)
  - People per Home
    - 2000 Census Blocks: Average Household Size
  - Concentration
    - Fecal Coliform $10^6/100$ mL = $5 \times 10^6$ E. coli/100 mL
  - Discharge
    - 60 gallons/person/day
Potential *E. coli* Load Resulting From Septic Systems

Dogs

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Dogs

- 1 dog per household
- Estimated Population: 10,775
  - From 911 addresses classified as residential
- *E. coli* Load per Dog
  - $5.0 \times 10^9$ Fecal Coliform = $2.5 \times 10^9$ *E. coli*

Potential *E. coli* loads resulting from Dogs
Wastewater Treatment Facilities

- Assume 126 CFU/100 mL
- Permitted Discharge
  - City of Lampasas: 1.457 MGD
  - City of Copperas Cove: 2.5 MGD
Potential *E. coli* loads resulting from Wastewater Treatment Facilities

Confined Animal Feeding Operations
Concentrated Animal Feeding Operations

- Used TCEQ permitted head of cattle
  - Dairy#1: 1598 head
  - Dairy#2: 1200 head
  - Feed Lot: 3815 head
- Assumed a treatment efficiency of 80%

Potential *E. coli* loads resulting from CAFOs
• Within the WMAs used the WMA density
• Outside of the WMAs applied a density of 100 deer per 1000 acres over the entire area of the watershed
• Estimated Population: 84,739
Potential *E. coli* loads resulting from Deer (WMA)

Geronimo Creek Watershed Map

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Watershed Segments

Land Use
Cattle

• Estimated Population: 2889
• Density:
  – Comal: 20 acres per animal
  – Guadalupe: 10 acres per animal
• Land Use
  – Rangeland
  – Forest
  – Managed Pasture

Suitable Areas for Cattle
Daily Potential *E. coli* loads resulting from Cattle

Urban Runoff

- PBS&J Report
  - Impervious Cover % = Total Subwatershed Area/Urban Area in Subwatershed
  - Conversion from Fecal Coliform to *E. coli* is 0.63
Urban Runoff

• Curve Number Approach
  – Calculate the area weighted curve number for each urban area within a subwatershed using land use
  – Assume a 2 yr, 24 hr storm event
  – P= 4 in/day
  – Use the curve number formulas to calculate runoff volume using the curve numbers for each urban area and P
  – E. coli Load = Runoff volume * E. coli

Potential *E. coli* loads resulting from Urban Runoff
Feral Hogs

- Density: 26 acres per animal
- Estimated Population: 1626
- Land Use
  - Forest
  - Rangeland
  - Managed Pasture
  - Cultivated Crops
  - 100 meter buffer
- Used perennial streams to calculate buffer

Suitable Areas for Feral Hogs
Daily Potential *E. coli* loads resulting from Feral Hogs

Advantages of SELECT

- Uses readily available data sources
- Relative ease of application
- Readily communicated to stakeholders
- When properly used can facilitate stakeholder input & interest (project buy-in)
- Can locate areas for control measure and BMP implementation
Disadvantages of SELECT

- Can evaluate only potential loadings and not actual loadings of pollutants
- Does not quantitatively link sources to receiving water body quality
- Not readily applied in predictive mode (e.g., to evaluate control measures & BMPs), but could be based on best professional judgment
- Present applications limited to bacteria, but should be adaptable to other pollutants

THANK YOU

Questions?