Sessom Creek Sediment Export Study
(EAHCP RFP: #160-17-TESS)

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Project Tasks:

1. Methodology Development
   1. Collect data on sediment/constituent loading
   2. Calculate sediment/constituent loading curves
   3. Examine the factors that contribute to sediment exports

2. Present Methodology to EAHCP Science Committee

3. Conduct Applied Research
Purpose of the Project

- Collect data required for developing stormwater TSS and nutrient export loading models from Sessom Creek into the San Marcos River
- Examine physical factors contributing to NPS loads
- Produce data and results that will be used to guide stream and riparian remediation and stormwater management efforts in the Sessom Creek watershed
- Generate baseline data that can be used to determine effectiveness of remediation and management efforts after implementation
Data collection methods

- Benjamin Schwartz
- Weston Nowlin
- Thom Hardy
- Gabrielle Timmins
- Victor Castillo
- Dalila Loiacomo

- Field data
- Lab data
- Digital data
Physical Parameters

• Discharge
  – Pressure transducer and state-discharge
  – New radar-based measurements

• TSS, NVSS, VSS
  – ISCO automatic water sampling across storm hydrographs
  – Filtration and combustion

• Nutrients
  – Total Nitrogen (TN) via second-derivative spectroscopy
  – Total Phosphorus (TP) ascorbic acid method

• Precipitation

• Water Quality data (Turbidity)
Discharge

- Pressure transducer and stage-discharge rating curve
- New radar-based discharge data from NOAA – National Severe Storms Lab
New NOAA radar-derived discharge

March 28-29 Sessom Creek Storm Events

Discharge [ft³/s]
Velocity and stage [ft]
Discharge [ft³/s]

v [ft/s]
h [ft]
Q [ft³/s]
USGS San Marcos River discharge

Sessom Creek flood pulses

Delayed Sink Creek flood pulses

--- Provisional Data Subject to Revision ---

△ Median daily statistic (23 years)  —  Discharge
TSS, NVSS, VSS

- Stormwater samples are filtered onto a weighed glass fiber filters, then dried, and then combusted.
- Difference between dry weight and filter weight = TSS
- Combusted weight allows calculation of NVSS and VSS
Field Duplicate Sampling
Preliminary Sediment Data

Sediment Concentrations in Sessom Creek

- TSS (mg/L)
- VSS (mg/L)
- NVSS (mg/L)
Nutrients

- Splits of stormwater samples are acidified within 48 hours of collection.
- Whole samples are digested and analyzed for total nutrient concentrations (N and P).
Precipitation and Weather Data

• Raingauges will record precipitation at 2–3 sites in the watershed at high temporal resolution

• Rainfall data for historical (2011–2012) data will be obtained from archived data sources, to allow inclusion of those data in models.

• Antecedent conditions will be calculated using publicly available daily weather data (T, RH, Wind Speed, Solar Radiation, etc)
Water Quality Data

- EAA has installed a real-time WQ Monitoring Station at the Freeman Aquatic Building
- After some initial datalogging issues, we also have deployed a YSI sonde as a duplicate instrument.
Questions and comments about data collection methods?
SESSOM CREEK SEDIMENT EXPORT STUDY:
Sediment Discharge Determination Methods

June Wolfe III - Associate Research Scientist
Jaehak Jeong – Associate Professor

Blackland Research and Extension Center
Water Science Laboratory
Temple, Texas
Definitions

• **Concentration:** Amount dissolved, or suspended (within a given amount of water)
  – Expressed as:
    • Mass of per unit volume (e.g., mg/L)

• **Load:** Amount transported (by water), over a given time
  – Types: dissolved, **suspended**, bed
  – Expressed as:
    • Volume per unit time (e.g., m³/hour)
    • Mass per unit time (e.g., Mg/year)

• **Yield:** Amount exported from a defined area (i.e., watershed), over a given time
  – Expressed as:
    • Volume per unit area per unit time (e.g., m³/Ha/Hour)
    • Mass per unit area (e.g., kg/Ha/Year)

• **Rating Curve:** relationship between measured variables (e.g., suspended sediment concentration or load vs. stream discharge)
  – Used to estimate loads, or concentration, during unmeasured periods
Subtask 1.2: Calculate Loading Curves

Determining constituent loads
(i.e., sediment, nutrients, etc.)

• **Empirical methods**
  – Applied when data is plentiful
  – Direct calculation
  – Sum of measured concentrations * measured discharges per time interval

• **Estimation methods**
  – Applied when data is sparse
  – Averaging
  – Ratios
  – Regression
    » USGS Load Estimator tool (LOADEST)
      – Inputs: streamflow, constituent concentrations
      – Outputs: constituent loads and/or constituent concentrations by period of interest (day, month, season, year, etc.), and regression statistics
      – Constituent concentration may not be a simple function of discharge
      – May NOT be applicable to small watershed such as SESSOM CREEK
Subtask 1.2: Calculate Loading Curves

Sessom Creek Sediment Rating Curve
(Storm Runoff, 9 storms, 2010-2011)

\[ y = 14.95x^{1.54} \]
\[ R^2 = 0.71 \]
Subtask 1.2: Calculate Loading Curves

Sessom Creek Flow Duration Curve
(Single Event - 24 Dec 2010 storm runoff)
Subtask 1.2: Calculate Loading Curves

1) Compile summary statistics
2) Generate sediment loading curves

References:
Subtask 1.3: Examine Factors Influencing Exports

Constituent hysteresis (e.g., concentration lag with respect to flow)

- 5 major types
- Each infers constituent delivery process information
- Often normalized and/or indexed for comparison
Subtask 1.3: Examine Factors Influencing Export
Subtask 1.3: Examine Factors Influencing Exports

Multivariate analysis

- **Response variables**
  - Constituent concentration
  - Constituent load or yield

- **Explanatory variables (15+)**
  - Hydrological variability
    - Runoff amount, intensity, timing
  - Meteorological variability
    - Rainfall amount, intensity, timing

- **Principal Components Analysis (PCA)**
  - Reduces large correlated observed variable set to smaller uncorrelated set
  - Retains as much of the original variance as possible
  - Results may provide standalone insight (i.e., no hypothesis testing)
  - Reduced variable set may be further analyzed
    - ANOVA
    - Regression
### Subtask 1.3: Examine Factors Influencing Exports

#### Data Formatting:
- Spreadsheet i.e., MS Excel

#### Storm variables Influencing sediment yield

#### Example output

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>STORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEPENDENT</td>
<td></td>
</tr>
<tr>
<td>Sediment Yield (Mg)</td>
<td>0.483 0.057 0.070 0.472 2.878 0.187 0.189</td>
</tr>
<tr>
<td>INDEPENDENT</td>
<td></td>
</tr>
<tr>
<td>Base Flow (m3/s)</td>
<td>0.076 0.074 0.025 0.032 0.007 0.025 0.017</td>
</tr>
<tr>
<td>Peak Flow (m3/s)</td>
<td>0.897 0.289 0.456 0.390 2.379 1.860 0.315</td>
</tr>
<tr>
<td>Total Runoff (m3)</td>
<td>3998 4751 1779 4974 5413 6233 1596</td>
</tr>
<tr>
<td>Runoff to Peak (m3)</td>
<td>584 956 394 425 1229 2374 154</td>
</tr>
<tr>
<td>Runoff after Peak (m3)</td>
<td>3415 3794 1385 4549 4184 3859 1441</td>
</tr>
<tr>
<td>Cumulative Rainfall (mm)</td>
<td>17.8 34.3 24.6 48.5 36.6 53.3 6.1</td>
</tr>
<tr>
<td>Time Since Last Rain (days)</td>
<td>13 11 7 21 36 30 93</td>
</tr>
</tbody>
</table>

#### Importance of components:
- Comp.1  Comp.2  Comp.3  Comp.4  Comp.5  Comp.6  Comp.7
  - Standard deviation: 1.8893097 1.2485131 1.0619803 0.7601806 0.36980759 0.171142122 3.789257e-04
  - Proportion of Variance: 0.5099273 0.2226836 0.1611146 0.0825535 0.01953681 0.004184232 2.051209e-08
  - Cumulative Proportion: 0.5099273 0.7326109 0.8937254 0.9762789 0.99581575 0.999999979 1.000000e+00

#### Component loadings:
- BASE     -0.2497092 -0.4294113  0.6406415  0.1215628 -0.28894511  0.4945318 -0.0010636785
- PEAK     -0.4017292  0.4130104  0.1421025 -0.4484266  0.23583639  0.6254093 -0.0009776497
- RAIN_L   -0.4702800  0.2556434 -0.0171319  0.1579548 -0.82857297 -0.0413102 -0.0004796515
- RAIN_T   -0.3175766 -0.3442319 -0.4933004  0.5437363  0.16480674  0.4631343 -0.0007070331
- RUNOFF   -0.4435929 -0.3937709  0.1717418 -0.1839033  0.10385909 -0.2360734 -0.7199560942
- RUNOFF_A -0.3973502 -0.4857038  0.0514226 -0.3342755  0.02008384 -0.1923689  0.6741002364
- RUNOFF_P -0.3155613  0.2649822  0.5418552  0.5638941  0.36879185 -0.2352980  0.1650735492

#### Component Scores:
- PC1       PC2 PC3 PC4 PC5 PC6 PC7
  - Storm1   1.01580770 -0.2168961  1.18571394
  - Storm2   0.01686496 -1.3626810  0.89244237
  - Storm3   2.59551551  1.3570337 -1.41807076
  - Storm4   -1.28022244 -1.7752810 -2.01890968
  - Storm5   -4.08997092 -0.3937709  0.1717418 -0.1839033
  - Storm6   -0.47028000  0.2556434 -0.0171319  0.1579548 -0.82857297 -0.0413102 -0.0004796515
  - Storm7   -0.3175766 -0.3442319 -0.4933004  0.5437363  0.16480674  0.4631343 -0.0007070331
  - Storm8   -0.4435929 -0.3937709  0.1717418 -0.1839033  0.10385909 -0.2360734 -0.7199560942

#### Data Analysis:
- Statistical software i.e., R
  - Principle Components Analysis (PCA)
  - Example output
Subtask 1.3: Examine Factors Influencing Exports

> Stepwise regression (LinearModel.1, direction='forward/backward', criterion='BIC')

Start: AIC=-0.22  
SED_YLD ~ 1

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum of Sq</th>
<th>RSS</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ PC1</td>
<td>4.4479</td>
<td>1.5517  -8.9618</td>
</tr>
<tr>
<td>&lt;none&gt;</td>
<td></td>
<td>5.9996</td>
<td>-0.2226</td>
</tr>
<tr>
<td>+ PC2</td>
<td>1</td>
<td>0.8847</td>
<td>5.1149  0.5806</td>
</tr>
<tr>
<td>+ PC3</td>
<td>1</td>
<td>0.0349</td>
<td>5.9646  1.8101</td>
</tr>
</tbody>
</table>

Step: AIC=-8.96  
SED_YLD ~ PC1

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum of Sq</th>
<th>RSS</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ PC2</td>
<td>1</td>
<td>0.8847</td>
<td>0.6670  -13.6366</td>
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<tr>
<td>&lt;none&gt;</td>
<td></td>
<td>1.5517</td>
<td>-8.9618</td>
</tr>
<tr>
<td>+ PC3</td>
<td>1</td>
<td>0.0349</td>
<td>1.5168  -7.0644</td>
</tr>
<tr>
<td>- PC1</td>
<td>1</td>
<td>4.4479</td>
<td>5.9996  -0.2226</td>
</tr>
</tbody>
</table>

Step: AIC=-13.64  
SED_YLD ~ PC1 + PC2

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum of Sq</th>
<th>RSS</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;none&gt;</td>
<td></td>
<td>0.6670</td>
<td>-13.6366</td>
</tr>
<tr>
<td>+ PC3</td>
<td>1</td>
<td>0.0349</td>
<td>0.6321  -11.9872</td>
</tr>
<tr>
<td>- PC2</td>
<td>1</td>
<td>0.8847</td>
<td>1.5517  -8.9618</td>
</tr>
<tr>
<td>- PC1</td>
<td>1</td>
<td>4.4479</td>
<td>5.1149  0.5806</td>
</tr>
</tbody>
</table>

Call:  
`lm(formula = SED_YLD ~ PC1 + PC2, data = SessomComp)`

Coefficients:  
(Intercept) PC1 PC2  
0.6686 -0.3947 0.2663

Residual standard error: 0.3652 on 5 degrees of freedom  
Multiple R-squared: 0.8888, Adj R-squared: 0.8443
F-statistic: 19.99 on 2 and 5 DF, p-value: 0.004122

INTREPRETATION

1) Both PC1 and PC2 significant at $p \leq 0.05$
2) ~47% of variability in PC1 due to Days Since Last Rain
3) ~49% of variability in PC2 due to Runoff After Peak
4) PC1 and PC2 explain ~84% of observed variability
5) The variables “Days Since Last Rainfall” and “Runoff After Peak” are significant in explaining Sediment Yield
6) Include in future monitoring efforts
7) Consider when developing process-based model
Subtask 1.3: Examine Factors Influencing Exports

1) Constituent hysteresis analysis
2) Multi-criteria analysis

References:


Watershed Assessment

Sessom Creek Watershed

Outlet
- <all other values>

Type
- Linking stream added Outlet
- Manually added Outlet

Reach

Watershed
Basin

Elevation
(ft)
- High: 811.98
- Low: 565.72
SWAT Simulation Strategies

- SWAT subdaily simulation module
- Urban BMPs & Green Infrastructure

Proposed Tasks

1. Build a SWAT model
2. Calibrate flow/sediment
3. Identify critical sources
   - Soil types/Land uses
   - Locations
4. Relate to monitoring data statistics
Questions/Discussion

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