QUANTITATIVE TECHNIQUES FOR MEANDER MIGRATION

LESSON 16
LEARNING OUTCOMES

• Describe quantitative techniques to assess and predict meander migration
FLOW PATTERNS THROUGH MEANDER BENDS

• Superelevation of the water surface
• Secondary circulation produced by transverse currents
• Shifting of the maximum-velocity current
MEANDER GEOMETRY

- Defined by shape, bend radius, and wavelength
- Empirical relationships exist between these parameters and channel width
- Based on idealized meander
GENERAL RELATIONSHIPS

- Pools are located in bends, riffles are located near crossings
- Riffle spacing $\approx 5$ to $7W$ or $\approx \frac{1}{2} \lambda$
- $\lambda \approx 10$ to $14W$
- $R_c \approx 2$ to $3W$
Channel migration is defined as the *lateral shift* (perpendicular to the channel centerline) and *downvalley migration* of an alluvial river.
MODES OF MEANDER LOOP DEVELOPMENT

- Extension
- Translation
- Rotation
- Conversion to a compound loop
- Neck cutoff by closure
- Diagonal cutoff by chute
- Neck cutoff by chute
CHANNEL MIGRATION HAS A DIRECT IMPACT ON:

- Urban Development
- Transportation Infrastructure
- Flood Control Facilities
- Existing Riparian Habitat & River Restoration Works

- Levee
- Agriculture
OBJECTIVE

Develop a practical methodology to predict the rate and extent of stream channel migration.
HIGHWAY APPLICATIONS

- Consider channel migration in the location and design of infrastructure
- Evaluate the risk to existing infrastructure
- Determine the need for and design of countermeasures
- Determine the potential impacts on channel restoration and rehabilitation works
PROCEDURE

- Assemble comprehensive data set
- Screen and classify river and meander types
- Measure meander morphology
- Collect data on controlling variables
- Develop the methodology
DATA SETS

- 141 meander sites containing 1503 bends
- 89 rivers in the U.S.
- Covering 1930’s/1940’s, 1960’s/1970’s, and 1990’s (25 to 30 year intervals)
SCREENING AND CLASSIFICATION

• Initial screening based on channel planform:
  - straight, meandering, braided, or anabranched

• Secondary screening using Modified Brice Classification
SCREENING AND CLASSIFICATION

Classification:
- Based on a modified classification scheme of channel pattern originally developed by Brice (1975)
- Used to classify meandering river types and screen out very stable or extremely unstable meandering channels
**Modified Meander Pattern Classification Scheme**

(☐ = Screened out)

<table>
<thead>
<tr>
<th>MODIFIED BRICE CLASSIFICATION</th>
<th>SCREEN</th>
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<tbody>
<tr>
<td>A SINGLE PHASE, EQUIWIDTH CHANNEL INCISED OR DEEP</td>
<td>☐</td>
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<tr>
<td>B₁ SINGLE PHASE, EQUIWIDTH CHANNEL</td>
<td>☐</td>
</tr>
<tr>
<td>B₂ SINGLE PHASE, WIDER AT BENDS, NO BARS</td>
<td>☐</td>
</tr>
<tr>
<td>C SINGLE PHASE, WIDER AT BENDS WITH POINT BARS</td>
<td>☐</td>
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<tr>
<td>D SINGLE PHASE, WIDER AT BENDS WITH POINT BARS, CHUTES COMMON</td>
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</tr>
<tr>
<td>E SINGLE PHASE, IRREGULAR WIDTH VARIATION</td>
<td>☐</td>
</tr>
<tr>
<td>F TWO PHASE UNDERFIT, LOW-WATER SINUOSITY (WANDERING)</td>
<td>☐</td>
</tr>
<tr>
<td>G₁ TWO PHASE, BIMODAL BANKFULL SINUOSITY, EQUIWIDTH</td>
<td>☐</td>
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<tr>
<td>G₂ TWO PHASE, BIMODAL BANKFULL SINUOSITY, WIDER AT BENDS WITH POINT BARS</td>
<td>☐</td>
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</tbody>
</table>
Example of Meander Pattern Classification
CONTROLLING VARIABLES

- Channel and valley slope
- Alluvial valley floor variability
- Bedrock and man-made controls
- Hydrologic data
- Bed and bank sediment data
- Channel dimensions
DATA LOGGER

- Measure meander planform variables
- Provide a database of measured variables for future use
**DATA BASE FOR EACH SITE**

**Workbooks for Each River Site**

**Spreadsheets for Individual Bends**

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### Brazos River

**BEND #5**

- **Location:** at Thompsons, TX
- **USGS 7.5' Quad Name:** at Richmond, TX, 08114000

#### SITE CLASSIFICATION

| Flow Habit: | PERENNIAL |
| River Classification: | C |

| Sediment Load Type: | Simple Symmetrical |

#### Group | Variable | English Value | Units | Metric Value | Units |
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<tbody>
<tr>
<td>Outside Bank Avg. Radius of Curvature</td>
<td>1083</td>
<td>1192</td>
<td>1237</td>
<td>feet</td>
<td>332.4</td>
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<tr>
<td>Right or Left Hand Bend</td>
<td>L</td>
<td>L</td>
<td>L</td>
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<tr>
<td>Center Point of Bend - Rotating</td>
<td>10723</td>
<td>10720090</td>
<td>1072200</td>
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<td>Center Point of Bend -Easting</td>
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<td>819089</td>
<td>81973</td>
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<td>Valley Orientation</td>
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<td>Bend Chirality</td>
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<td>Center Stream Velocity</td>
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<td>ft/sec</td>
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<td>Meander Wavelength</td>
<td>5176</td>
<td>5491</td>
<td>5475</td>
<td>feet</td>
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<td>Meander Amplitude</td>
<td>1240</td>
<td>1507</td>
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<td>Channel Width at Crossing</td>
<td>452</td>
<td>446</td>
<td>417</td>
<td>feet</td>
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<td>Channel Width at Bank Apex</td>
<td>512</td>
<td>571</td>
<td>430</td>
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<td>Channel Hydraulic Depth at Crossing</td>
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<td>0.27</td>
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<td>Maximum Channel Depth at Bank Apex</td>
<td>NM</td>
<td>NM</td>
<td>NM</td>
<td>feet</td>
<td>NM</td>
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<td>Cross Section Width in Bend</td>
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<td>107.3</td>
<td>feet</td>
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<td>Average Floodplain Width</td>
<td>1967</td>
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<td>Depth Slope</td>
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<td>m/m</td>
<td>0.00049</td>
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#### Reach List

- **Vegetation Types:**
  - Dense trees, swamps, and farming
  - Activity indicators: Old oxbows in floodplain, farming to edge of channel, vertical erosion banks along most of rightbank
  - Upstream Controls:
    - Flows regulated since 1941 by upstream reservoirs, floodwater retaining structures, and irrigation diversions
  - Downstream Controls:
    - 0

**Activity Indicators:**
- Bluffs, old oxbows, vertical erosion banks, farming to edge of channel (vertical erosion banks along most of rightbank)
- NM = Not Measured or No Data
METHODOLOGIES

- Guidelines on simple comparison techniques using historic maps and aerial photos
- Development of the ArcView-based Channel Migration Predictor extension that uses the Data Logger database and historic bankline positions to predict channel migration
CHANNEL MIGRATION PREDICTOR

Predicted
PREDICTION TECHNIQUES

1. Image showing a map with the year 1937 marked.

2. Image showing a map with the year 1966 marked.

3. Diagram showing a flow direction with the year 1937 marked.


5. Image showing 1966 photo and marked areas A and B.

6. Image showing 1995 photo and marked areas A and B.

Predicted 1995 bankline.
PREDICTION RESULTS

1995 Photo

Predicted 1995 Bankline
NCHRP 24-16

• A stand-alone Handbook with guidelines on the use of map and aerial photo comparison techniques

• ArcView-based *Data Logger* and *Meander Migration Predictor* extensions included with Handbook to assist in measuring and predicting channel migration

• NCHRP Report No. 533
LEARNING OUTCOMES

• Describe quantitative techniques to assess and predict meander migration