Challenges in Calibrating a Large Watershed Model with Varying Hydrogeologic Conditions

Presented by
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In cooperation with the Lower Colorado River Authority

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Outline

• LCRA CREMs
• Study Area
  - Colorado River
  - Highland Lakes
  - Lake LBJ Watershed
• Sub-basin Delineation
• Hydrology Calibration
• Conclusions

Source: sailingtexas.com
LCRA

- Lower Colorado River Authority (LCRA)
  - Texas conservation and reclamation district
  - Delivers electricity and manages the water supply and environment of the lower Colorado River basin, including the Highland Lakes
CREMs

- Colorado River Environmental Models (CREMs) Project
  - Integrated toolkit of watershed and water quality models
  - Diagnose existing water quality problems
  - Discern water quality trends
  - Predict the consequences of various management decisions and associated actions
Highland Lakes

- Run-of-river reservoirs
- LCRA Managed: Buchanan, Inks, Marble Falls, Travis, and Austin
- Habitat
- Hydroelectric power
- Recreation
- Municipal water supply
Lake LBJ Watershed

- Lake LBJ
  - Volume when full: ~134,000 acre-feet (0.17 km³)
  - Surface area when full: ~160 acres (0.7 km²)
- ~3 million acre (~12,000 km²) watershed spanning the Texas Hill Country, including the Llano Uplift, into West Texas
- Primarily rangeland brush and grasses
- Development occurring near and around the lake
Lake LBJ Sub-watersheds

- Total Area: ~3 Million Acres (~12,000 km²)
  - Llano River: 90%
  - Sandy Creek: 7%
  - Direct Drainage: 2%
Geology

- Cretaceous limestone karst
- Llano Uplift: Precambrian and Paleozoic igneous and metamorphic (crystalline) rocks

TWDB, 2006
Precipitation Contours

- West to east: From 22 to 32 inches per year (56-81 cm)
Soils

- STATSGO
- Parent rock → Soil type
- Calibration parameters varied by soil type

NRCS, 2006
Land Cover

- 71% Brush
- 13% Evergreen
- 9% Grasses
- 5.5% Deciduous
Sub-basin Delineation

- Watershed Ordinance
  - Stormwater runoff
  - Erosion controls
- Lake Segmentation
Primary Calibration Stations

- Llano at Junction: Limestone soils
- Sandy Creek: Crystalline
- Llano at Llano: Both
- Llano at Mason: Validation

Primary Calibration Stations

- 17 USGS and LCRA flow gages
- 4 Primary (3 Llano, 1 Sandy Creek)
Base Case Plots

Llano River near Junction (Reach 69)
- $R^2 = 0.89$
- $NS = 0.21$
- % Diff = 230.55
- POR = 1984 to 2008

Llano River near Mason (Reach 32)
- $R^2 = 0.75$
- $NS = 0.05$
- % Diff = 350.97
- POR = 1984 to 2008

Llano River at Llano (Reach 13)
- $R^2 = 0.76$
- $NS = 0.03$
- % Diff = 366.04
- POR = 1984 to 2008

Sandy Creek near Kingsland (Reach 63)
- $R^2 = 0.76$
- $NS = 0.21$
- % Diff = 242.73
- POR = 1984 to 2008
## Calibration Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Description</th>
<th>Subbasins</th>
<th>Orig. Value</th>
<th>Final Value</th>
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<tbody>
<tr>
<td>CN</td>
<td>--</td>
<td>SCS Curve Number</td>
<td>Llano at Junction, Llano at Llano, Sandy Creek</td>
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<td></td>
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<td></td>
<td>RNGB<em>75%, Rest</em>85% FRSE<em>78% for FRSE (except TX151 no change), RNGB</em>70%, Rest*72%</td>
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<tr>
<td>GW_DELAY</td>
<td>Day</td>
<td>Recharge to Discharge Delay</td>
<td>Llano at Junction, Llano at Llano, Sandy Creek</td>
<td>31</td>
<td>365</td>
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<td></td>
<td>31</td>
<td>0</td>
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<tr>
<td>RCH_DP</td>
<td>--</td>
<td>Recharge % to Deep Aquifer</td>
<td>Llano at Junction, Llano at Llano, Sandy Creek</td>
<td>5</td>
<td>55%</td>
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<td></td>
<td></td>
<td>5</td>
<td>80%</td>
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<tr>
<td>SOL_AWC</td>
<td>--</td>
<td>mmH20/mmSoil</td>
<td>All</td>
<td>--</td>
<td>+0.04</td>
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<td>ESCO</td>
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<td>Evap Coefficient</td>
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<tr>
<td>EPCO</td>
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<td>Uptake Coefficient</td>
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<tr>
<td>ALPHA_BF</td>
<td>Day</td>
<td>Baseflow recession constant</td>
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<tr>
<td>SOL_K</td>
<td>mm/hr</td>
<td>Soil Ksat</td>
<td>All</td>
<td>--</td>
<td>SOL_K*25%</td>
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<tr>
<td>CH_K2</td>
<td>mm/hr</td>
<td>Channel Keff</td>
<td>Llano at Junction, Llano at Llano, Sandy Creek</td>
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<td>1.5</td>
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<td>0.2</td>
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</table>
Groundwater Parameters

- **CH_K2**: Channel hydraulic conductivity
  - Increased value, combined with delay, in karst areas simulated spring flow (1.5 mm/hr)
  - Bank storage then discharge to reach

- **GW_DELAY**: Groundwater discharge delay
  - 365 days in Karst areas
  - 0 days in Crystalline rock areas simulated groundwater transport and discharge isolated to shallow soils

- **RCH_DP**: Recharge to the deep aquifer
  - 80% in crystalline rock areas simulates losses to regional, fractured rock aquifer
Calibration Plots

- Llano River near Junction (Reach 69)
  - $R^2 = 0.88$
  - $NS = 0.91$
  - % Diff = 3.96
  - POR = 1984 to 2008

- Llano River near Mason (Reach 32)
  - $R^2 = 0.84$
  - $NS = 0.93$
  - % Diff = 15.02
  - POR = 1984 to 2008

- Llano River at Llano (Reach 13)
  - $R^2 = 0.82$
  - $NS = 0.91$
  - % Diff = 18.7
  - POR = 1984 to 2008

- Sandy Creek near Kingsland (Reach 63)
  - $R^2 = 0.89$
  - $NS = 0.91$
  - % Diff = 16.68
  - POR = 1984 to 2008
Calibration Metrics

- Good fit of model to data for Llano River (90% of total watershed)
- Satisfactory fit for Sandy Creek (7% of total watershed)

<table>
<thead>
<tr>
<th>Reach Name</th>
<th>% Watershed Area</th>
<th>$R^2$</th>
<th>Nash-Sutcliffe Coefficient</th>
<th>Volume % Difference</th>
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</thead>
<tbody>
<tr>
<td>Llano at Junction</td>
<td>37</td>
<td>0.83</td>
<td>0.81</td>
<td>-3.96</td>
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<tr>
<td>Llano at Mason</td>
<td>70</td>
<td>0.84</td>
<td>0.83</td>
<td>15.02</td>
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<tr>
<td>Llano at Llano</td>
<td>84</td>
<td>0.82</td>
<td>0.81</td>
<td>1.87</td>
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<td>Sandy Creek near Kingsland</td>
<td>7</td>
<td>0.69</td>
<td>0.61</td>
<td>-16.68</td>
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</tbody>
</table>
Conclusions

• Successful calibration of Lake LBJ watershed hydrology required:
  - Attention to hydrogeologic conditions
  - Spring discharge
  - Regional aquifer flows out of the watershed.

• Providing large sinks for rainfall into the basins
Next Steps

- Calibrated watershed model hydrologic output will be used for lake model water balance.
- Calibrated hydrology is the first step in sediment and nutrient (P and N species) calibrations.
- Calibration parameters will be extrapolated to Inks Lake and Lake Marble Falls watersheds.
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• TAMU
  - Raghavan ‘Srini’ Srinivasan, PhD

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Questions?