Modeling the Lower Colorado River Authority System

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WAVE Engineering, Inc.

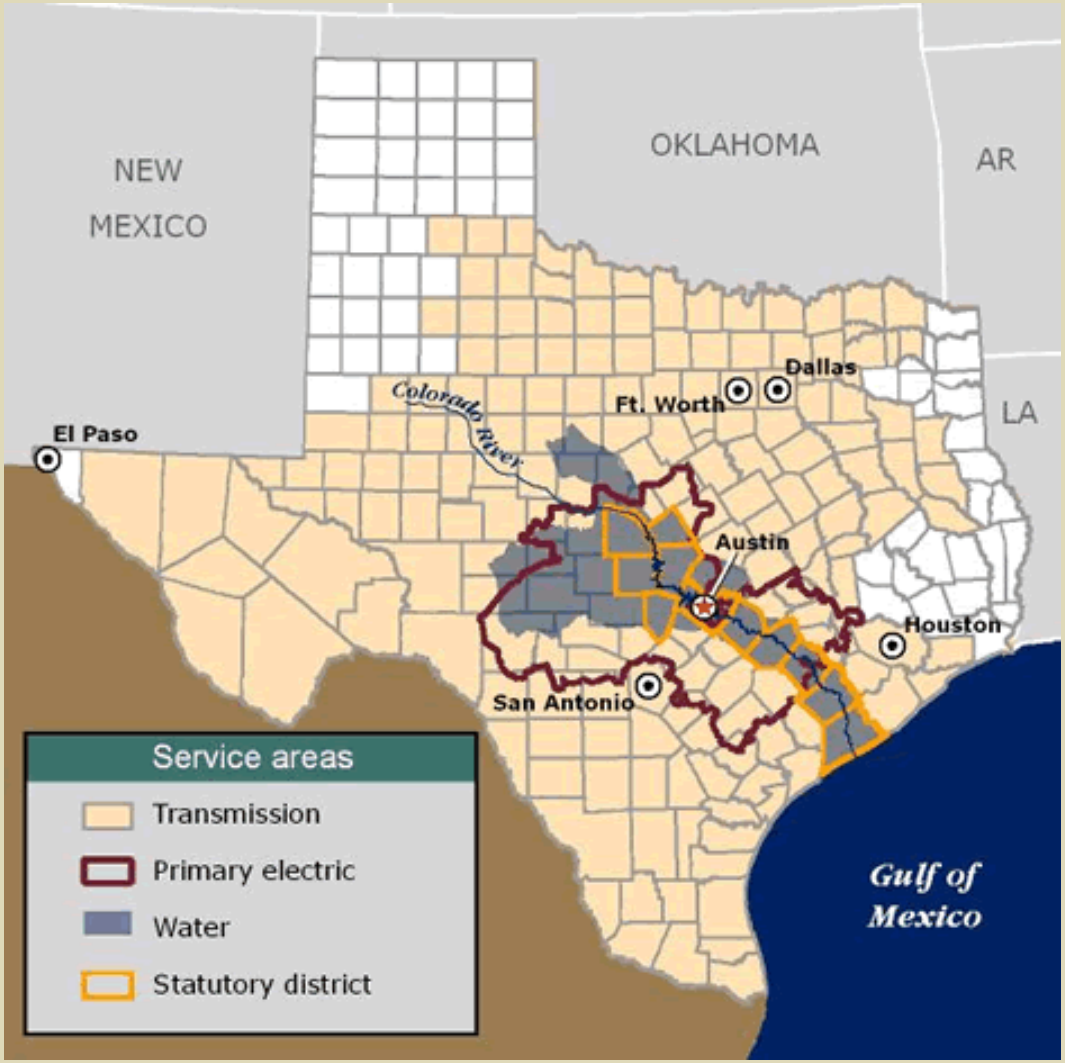
RiverWare
LCRA ENERGY • WATER • COMMUNITY SERVICES
Water Supply Model Development Project

HYDROSPHERE
Resource Consultants

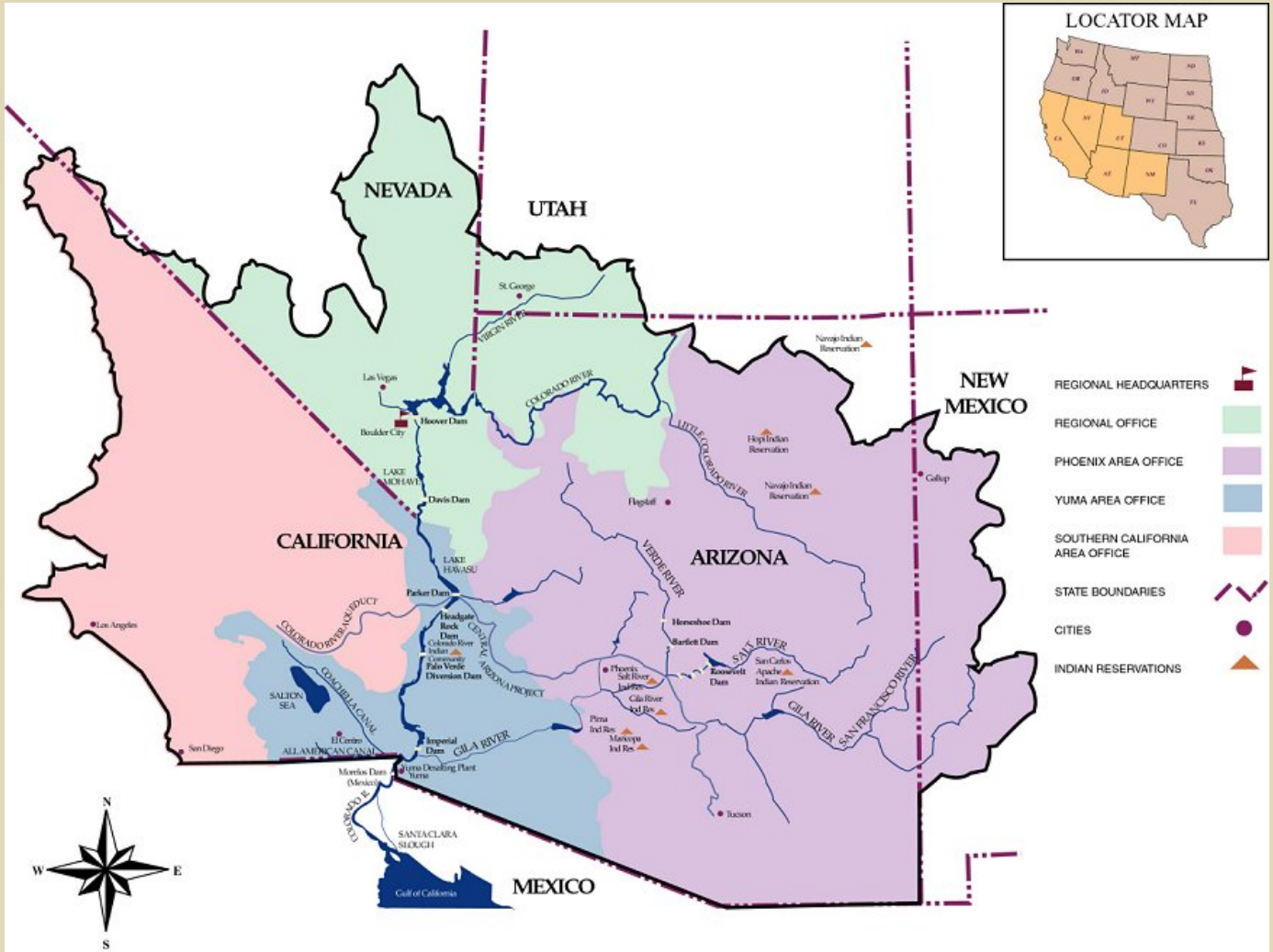
Outline

- Background
- Motivation and Objectives
- RiverWare Model Development
- Water Rights Accounting and Administration
- Conclusions
- Current Status / Future Work

Geography 101: THIS Colorado River...

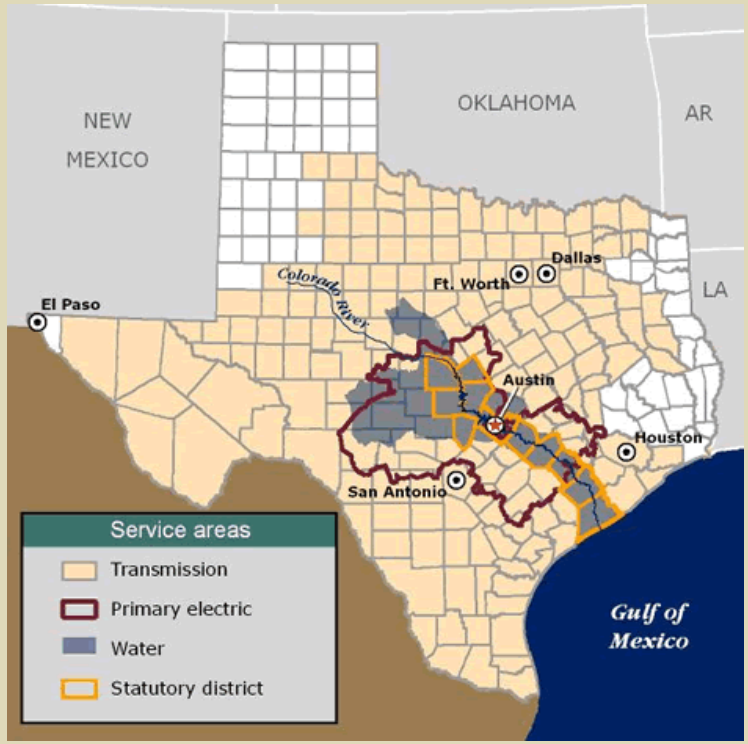


NOT this one...


LOCATOR MAP
NEVADA
UTAH
NEW MEXICO
CALIFORNIA
ARIZONA
MEXICO
St. George
Las Vegas
Boulder City
Hoover Dam
Davis Dam
Parker Dam
Flagstaff
Gallup
Navajo Indian Reservation
Hopi Indian Reservation
Los Angeles
San Diego
Phoenix
Tucson
Roosevelt Dam
Horseshoe Dam
Barfett Dam
Imperial Dam
Morelos Dam (Mexico)
Gulf of California
VIRGIN RIVER
COLORADO RIVER
LITTLE COLORADO RIVER
VERDE RIVER
SALT RIVER
GILA RIVER
SAN FRANCISCO RIVER
LAKE MOHAVE
LAKE HAVASU
SALTON SEA
SANTA CLARA SLOUGH
COLORADO RIVER AQUEDUCT
CENTRAL ARIZONA PROJECT
ALL AMERICAN CANAL
COACHELLA CANAL
REGIONAL HEADQUARTERS
REGIONAL OFFICE
PHOENIX AREA OFFICE
YUMA AREA OFFICE
SOUTHERN CALIFORNIA AREA OFFICE
STATE BOUNDARIES
CITIES
INDIAN RESERVATIONS
N
W
E
S

Background

- LCRA provider of water and power in central Texas
- Approximately 2 Maf of conservation storage in Highland Lakes reservoirs
- Water demands: irrigation, municipal, industrial, thermal cooling, hydro-electric, environmental
- Water rights and contracts: bypass water to Senior diverters, storage and deliveries under firm and interruptible contracts



Modeling objectives

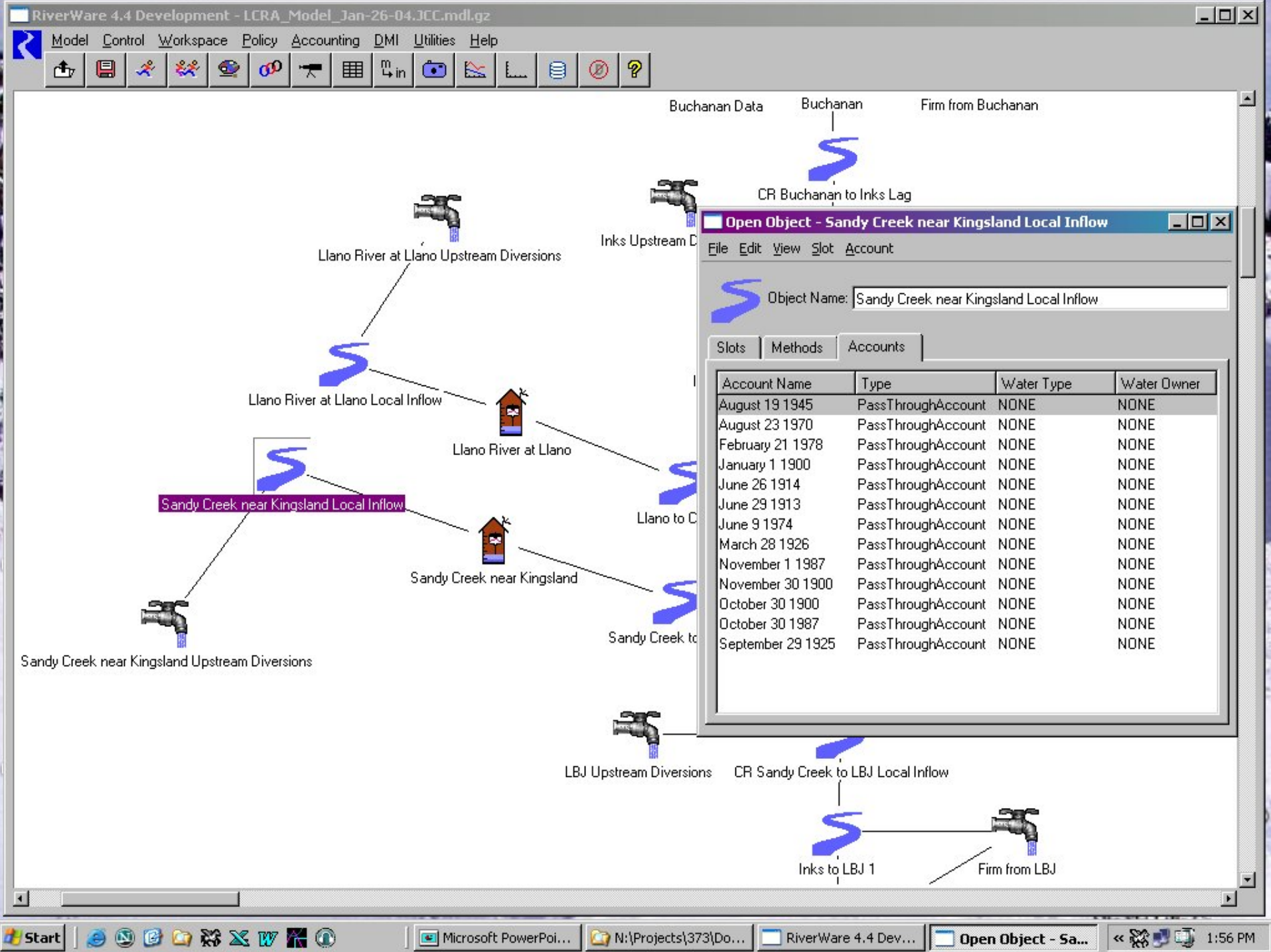
- **Need a river basin model to:**
  - Evaluate long-term management options
  - Allocate native water based on priority administration
  - Deliver contract water based on “firm”, “interruptible” priority and unmet demands
  - Account for water rights administration and contractual water deliveries
  - Operate Highland Lakes system for multiple objectives (flood control, maximization of yield, recreation, etc.)
- **Other requirements:**
  - Transparent / Easy to modify
  - User friendly (e.g., GUI)
  - Daily timestep

Existing Models

- **WAM / WRAP:**
  - TCEQ uses this model to evaluate water rights permit applications
  - Iterative approach to priority administration of water rights
  - Connection to LCRA RiverWare Project:
    - Data source for tributary inflows
    - Evaluates water availability based on administrative date
    - Multiple tributary inflow sets for RiverWare based on priority date of water users
- **Response:**
  - LCRA planning model since 1970s
  - Valid for existing conditions, but difficult to modify to evaluate new options
  - Validation basis for new RiverWare model

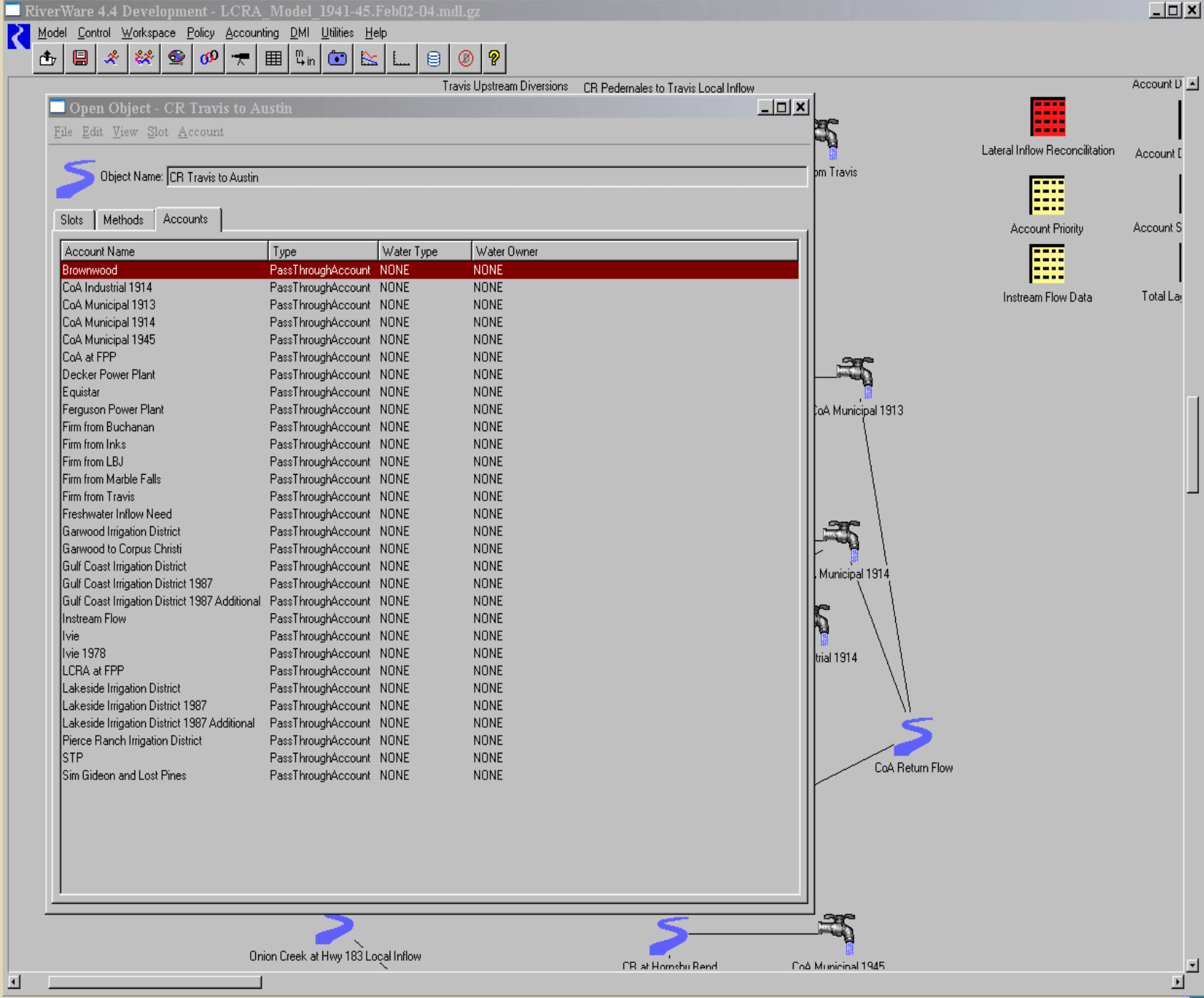
RiverWare Implementation: Water Rights Administration

- **Natural flows distributed via accounts to ~ two dozen water rights (both direct flow and storage rights)**
- **Tributary inflows based on "multiple administrative realizations of hydrology" (...say what?)**
  - How to represent rights not explicitly modeled?
  - Needed to decrement inflows available to each succeeding junior right
  - Alternate between modeled rights and "all others"
  - Based on WAM estimates of diversions by tributary rights


RiverWare 4.4 Development - LCRA_Model_Jan-26-04.JCC.mdl.gz
Model Control Workspace Policy Accounting DMI Utilities Help
Buchanan Data
Buchanan
Firm from Buchanan
CR Buchanan to Inks Lag
Inks Upstream D
Llano River at Llano Upstream Diversions
Llano River at Llano Local Inflow
Llano River at Llano
Llano to C
Sandy Creek near Kingsland Local Inflow
Sandy Creek near Kingsland
Sandy Creek to
Sandy Creek near Kingsland Upstream Diversions
LBJ Upstream Diversions
CR Sandy Creek to LBJ Local Inflow
Inks to LBJ 1
Firm from LBJ
Open Object - Sandy Creek near Kingsland Local Inflow
File Edit View Slot Account
Object Name: Sandy Creek near Kingsland Local Inflow
Slots Methods Accounts
Account Name | Type | Water Type | Water Owner
August 19 1945 | PassThroughAccount | NONE | NONE
August 23 1970 | PassThroughAccount | NONE | NONE
February 21 1978 | PassThroughAccount | NONE | NONE
January 1 1900 | PassThroughAccount | NONE | NONE
June 26 1914 | PassThroughAccount | NONE | NONE
June 29 1913 | PassThroughAccount | NONE | NONE
June 9 1974 | PassThroughAccount | NONE | NONE
March 28 1926 | PassThroughAccount | NONE | NONE
November 1 1987 | PassThroughAccount | NONE | NONE
November 30 1900 | PassThroughAccount | NONE | NONE
October 30 1900 | PassThroughAccount | NONE | NONE
October 30 1987 | PassThroughAccount | NONE | NONE
September 29 1925 | PassThroughAccount | NONE | NONE
Start
Microsoft PowerPoi...
N:\Projects\373\Do...
RiverWare 4.4 Dev...
Open Object - Sa...
1:56 PM

Two accounting systems

- **Above Travis water right dates**
  - Propagates various priority date hydrology to Travis
- **Below Travis delivery accounts**
  - Tracks delivery of water to various diversion site
- **There is no connection between these two accounting systems**
  - The only connection is via rules


RiverWare 4.4 Development - LCRA_Model_1941-45.Feb02-04.mdl.gz
Model Control Workspace Policy Accounting DMI Utilities Help
Travis Upstream Diversions
CR Pedernales to Travis Local Inflow
Open Object - CR Travis to Austin
File Edit View Slot Account
Object Name: CR Travis to Austin
Slots Methods Accounts
Account Name Type Water Type Water Owner
Brownwood PassThroughAccount NONE NONE
CoA Industrial 1914 PassThroughAccount NONE NONE
CoA Municipal 1913 PassThroughAccount NONE NONE
CoA Municipal 1914 PassThroughAccount NONE NONE
CoA Municipal 1945 PassThroughAccount NONE NONE
CoA at FPP PassThroughAccount NONE NONE
Decker Power Plant PassThroughAccount NONE NONE
Equistar PassThroughAccount NONE NONE
Ferguson Power Plant PassThroughAccount NONE NONE
Firm from Buchanan PassThroughAccount NONE NONE
Firm from Inks PassThroughAccount NONE NONE
Firm from LBJ PassThroughAccount NONE NONE
Firm from Marble Falls PassThroughAccount NONE NONE
Firm from Travis PassThroughAccount NONE NONE
Freshwater Inflow Need PassThroughAccount NONE NONE
Garwood Irrigation District PassThroughAccount NONE NONE
Garwood to Corpus Christi PassThroughAccount NONE NONE
Gulf Coast Irrigation District PassThroughAccount NONE NONE
Gulf Coast Irrigation District 1987 PassThroughAccount NONE NONE
Gulf Coast Irrigation District 1987 Additional PassThroughAccount NONE NONE
Instream Flow PassThroughAccount NONE NONE
Ivie PassThroughAccount NONE NONE
Ivie 1978 PassThroughAccount NONE NONE
LCRA at FPP PassThroughAccount NONE NONE
Lakeside Irrigation District PassThroughAccount NONE NONE
Lakeside Irrigation District 1987 PassThroughAccount NONE NONE
Lakeside Irrigation District 1987 Additional PassThroughAccount NONE NONE
Pierce Ranch Irrigation District PassThroughAccount NONE NONE
STP PassThroughAccount NONE NONE
Sim Gideon and Lost Pines PassThroughAccount NONE NONE
Lateral Inflow Reconcilitation
Account Priority
Instream Flow Data
CoA Municipal 1913
Municipal 1914
CoA Return Flow
Onion Creek at Hwy 183 Local Inflow
CoA Municipal 1945

Water Rights Accounting

- **Approximately 30 individual water rights**
- **Multiple sources for each right:**
  - Native (direct) flow
  - Firm contract (storage)
  - Interruptible contract (storage)
  - Flood (storage in flood pool)
- **Demands satisfied by sources in order:**
  - Natural inflows above and below Highland Lakes
  - Flood
  - Interruptible from storage
  - Firm from storage


Supplies Manager
File Supply Object System Sort Column1 Column2
Show Supplies to:
Storage Accounts
PassThrough Accounts
Diversion Accounts
Supplies to/from Object:
CR Travis to Austin
inflows
internal flows
outflows
NONE
Set Release Type
NONE
Set Destination
Supply
Release Type
Destination
Equistar Firm Firm Equistar
Equistar Flood Flood Equistar
Ferguson Power Plant Firm Firm Ferguson Power Plant
Ferguson Power Plant Flood Flood Ferguson Power Plant
Ferguson Power Plant PassThru PassThru Ferguson Power Plant
Firm from Buchanan Firm Firm Firm from Buchanan
Firm from Buchanan Flood Flood Firm from Buchanan
Firm from Inks Firm Firm Firm from Inks
Firm from Inks Flood Flood Firm from Inks
Firm from LBJ Firm Firm Firm from LBJ
Firm from LBJ Flood Flood Firm from LBJ
Firm from Marble Falls Firm Firm Firm from Marble Falls
Firm from Marble Falls Flood Flood Firm from Marble Falls
Firm from Travis Firm Firm Firm from Travis
Firm from Travis Flood Flood Firm from Travis
Freshwater Inflow Need Level 1 Firm Firm Freshwater Inflow Need
Freshwater Inflow Need Level 1 Flood Flood Freshwater Inflow Need
Freshwater Inflow Need Level 1 Interruptible Interruptible Freshwater Inflow Need
Garwood Irrigation District Flood Flood Garwood Irrigation District
Garwood Irrigation District Interruptible Interruptible Garwood Irrigation District
Garwood Irrigation District PassThru PassThru Garwood Irrigation District
Garwood to Corpus Christi Flood Flood Garwood to Corpus Christi
Garwood to Corpus Christi Interruptible Interruptible Garwood to Corpus Christi
Garwood to Corpus Christi PassThru PassThru Garwood to Corpus Christi
Gulf Coast Irrigation District 1987 Additional Flood Flood Gulf Coast Irrigation District 1987 Additional
Gulf Coast Irrigation District 1987 Additional Interru Interruptible Gulf Coast Irrigation District 1987 Additional
Gulf Coast Irrigation District 1987 Additional PassTI PassThru Gulf Coast Irrigation District 1987 Additional
Gulf Coast Irrigation District Flood Flood Gulf Coast Irrigation District
Gulf Coast Irrigation District Interruptible Interruptible Gulf Coast Irrigation District
Gulf Coast Irrigation District PassThru PassThru Gulf Coast Irrigation District
Instream Flow Level 1 Firm Firm Instream Flow
Instream Flow Level 1 Flood Flood Instream Flow
Instream Flow Level 1 Interruptible Interruptible Instream Flow
Instream Flow Level 2 Firm Firm Instream Flow
Instream Flow Level 2 Flood Flood Instream Flow
Instream Flow Level 2 Interruptible Interruptible Instream Flow
Instream Flow Level 3 Firm Firm Instream Flow
Instream Flow Level 3 Flood Flood Instream Flow
Instream Flow Level 3 Interruptible Interruptible Instream Flow
Configure Destination ...
Configure Source ...
Edit Destination ...
Edit Source ...
Close

Current Status

- **Model in “debug” mode:**
  - Confirmation of mass balance between physical and accounting systems
  - Water allocation behavior
  - Comparison to existing planning model results (e.g., firm yield)

Conclusions

- **Prior Appropriations Water Rights modeling Riverware**
  - Setting up accounting in RiverWare is still a very very painful time consuming process.
  - Need to be able to tie dates to accounts
  - Need easier way to stringify dates
  - Addition of several new pre-defined functions will help to speed up required rules
  - With some of these improvements the accounting system could be used more effectively for water rights modeling
- **RiverWare needs to improve data handling**
  - Long time horizons in larger accounting models are not currently possible due to hardware memory constraints
  - Only work around at this time is to set up consecutive runs

Future Additions: FY '05 – FY '06

- Extension of model:
  - New reservoirs (esp. thermal cooling)
  - New water delivery options (basin import/export)
  - Additional tributary water rights
  - Hydropower planning and optimization
  - Conjunctive use operations
- Run-time optimizations and model streamlining
- File management and organization
- Integration with Arc Hydro and RM^2 (DST)