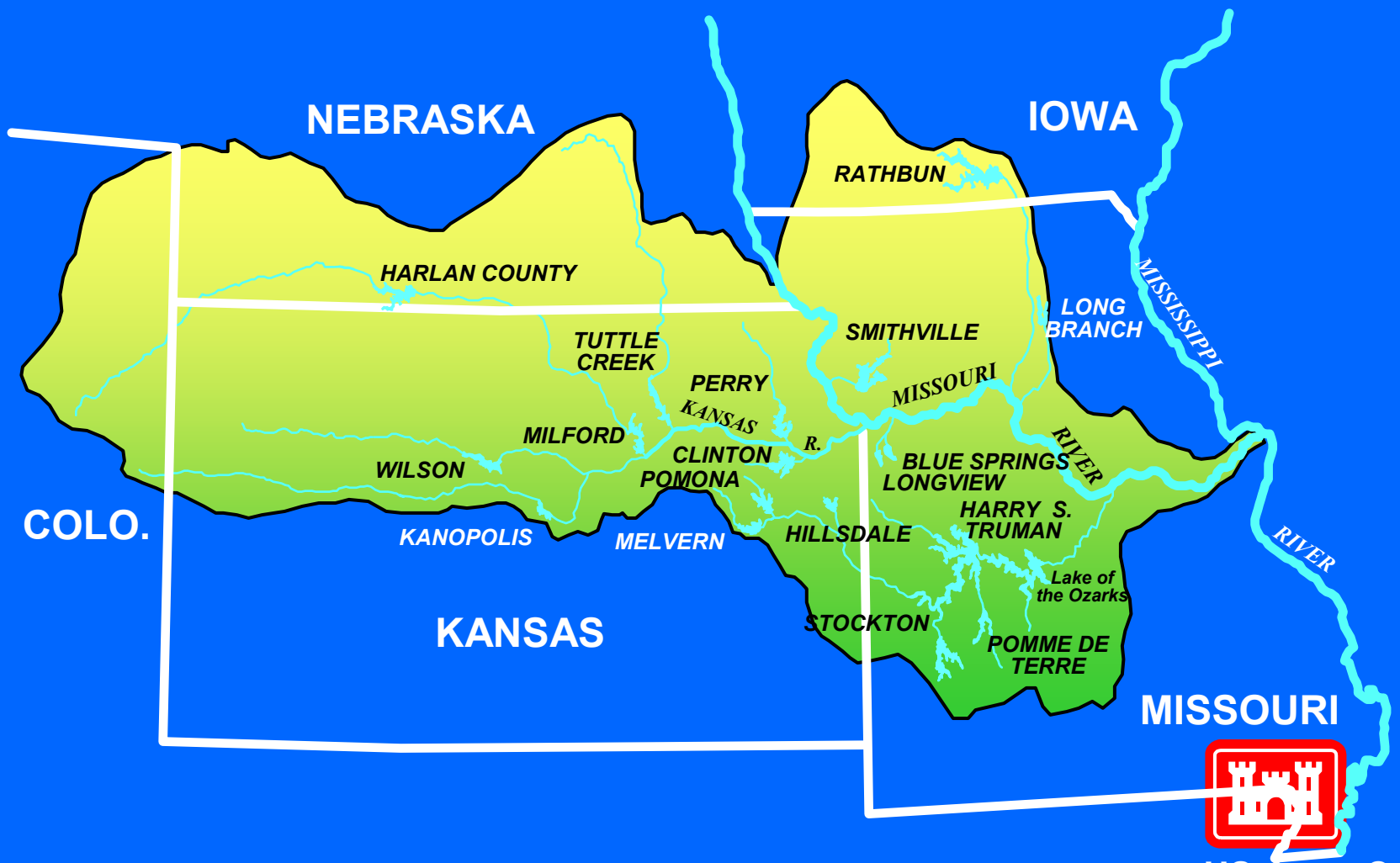
Kansas River Basin Model

Edward Parker, P.E.

US Army Corps
of Engineers
Kansas City District

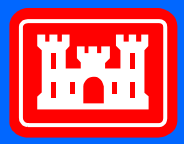
KANSAS CITY DISTRICT



US Army Corps of Engineers
Kansas City District

Kansas River Basin Operation Challenges

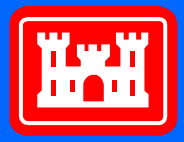
- Protect nesting Least Terns and Piping Plovers that have taken residence along the Kansas River.
- Supply navigation water support for the Missouri River.
- Reviewing requests from the State of Kansas and the USBR to alter the standard operation to improve support for recreation, irrigation, fish & wildlife.



US Army Corps of Engineers
Kansas City District

Model Requirements

- Model Period 1/1/1920 through 12/31/2000
- Six-Hour routing period
- Forecast local inflow using recession
- Use historic pan evaporation
  - Monthly vary pan coefficient
- Parallel and tandem operation
- Consider all authorized puposes
- Use current method of flood control



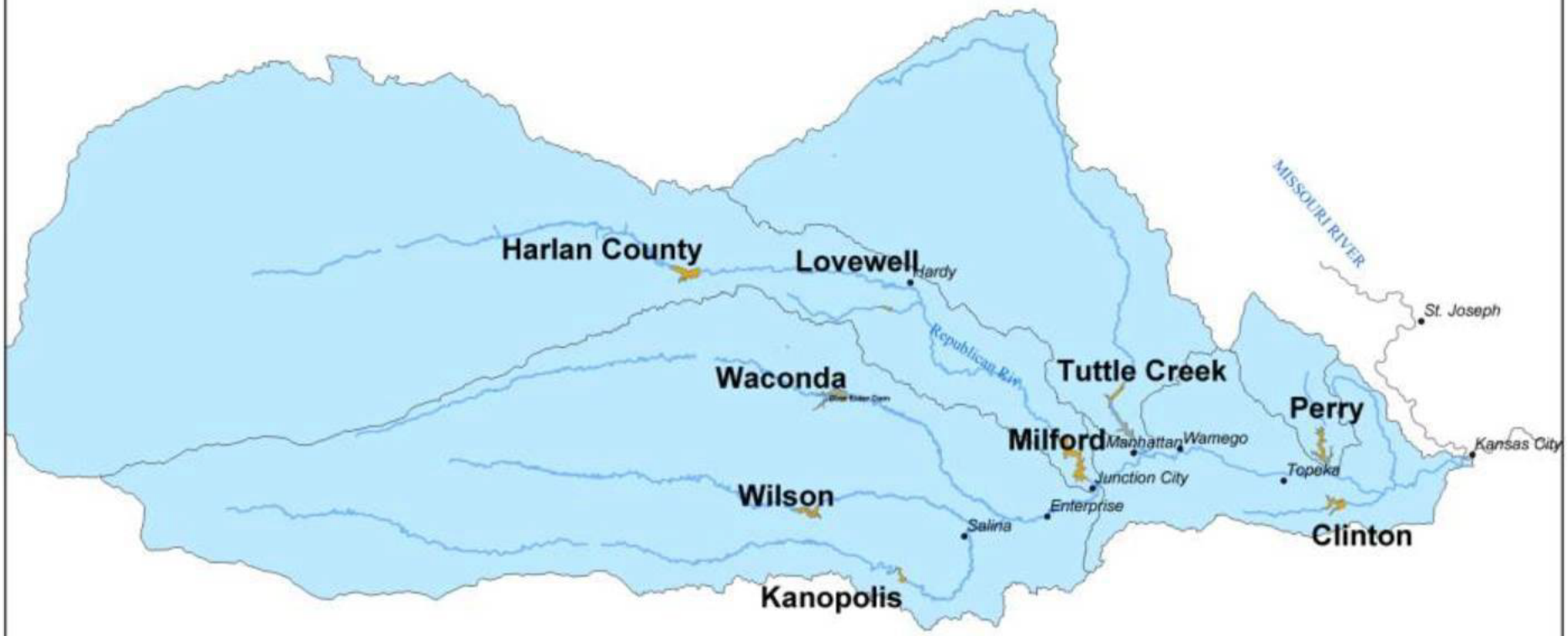
US Army Corps of Engineers
Kansas City District

Model PMP Revisions

- Model period from 1/1/1929 through 12/30/2001
- Mean daily flows for modeling rather than 6-hour data derived from mean daily flow values.
- Delete the requirement to forecast future hydrologic conditions.
- Average monthly lake evaporation rather than daily
- Utilize a standard pan evaporation coefficient of 0.7 rather than a monthly varying value.
- Separate the study basin between the Smoky River Basin and the Republican/Kansas River Basin.

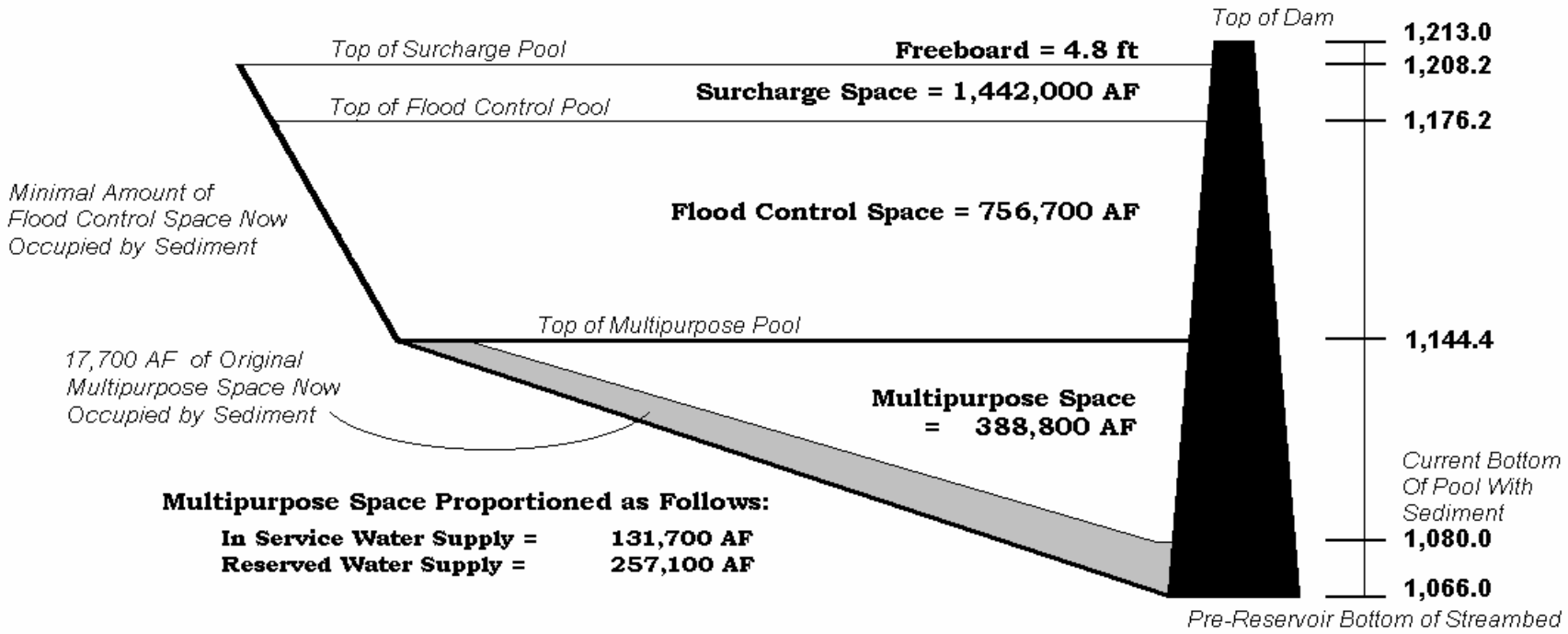
US Army Corps of Engineers
Kansas City District

Kansas River Basin



Milford Lake
Current Storage Allocations

As of Last Sediment Survey in 1980

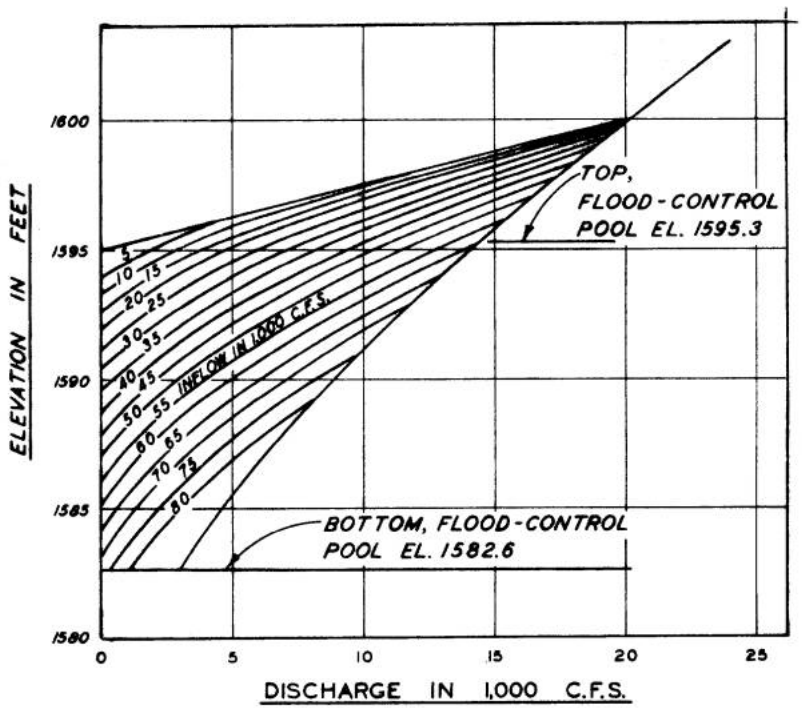


Multipurpose Space Proportioned as Follows:

In Service Water Supply =	**131,700 AF**
Reserved Water Supply =	**257,100 AF**

Storage Allocations	**At Closure (1964)**	**Current**	**At End of Design Life**
Flood Control	**754,800 AF**	**756,700 AF**	**700,000 AF**
Multipurpose	**406,500 AF**		
Water Supply			
In Service		**131,700 AF**	**101,650 AF**
Reserved		**257,100 AF**	**198,350 AF**

CORPS OF ENGINEERS U.S. ARMY



NOTE: THE DATA ON THIS CHART ARE FOR USE OF AUTHORIZED PERSONNEL OF THE WATER CONTROL SECTION OF THE KANSAS CITY DISTRICT. WHEN THE RESERVOIR IS ABOVE ELEVATION 1582.6, SPILLWAY GATES WILL BE OPENED UNIFORMLY, INSOFAR AS POSSIBLE, IN ACCORDANCE WITH THIS PLATE.

DURING RISING RESERVOIR STAGES, ADJUST THE OUTFLOW EACH HOUR AS INDICATED HEREON ON THE BASIS OF THE CURRENT RESERVOIR ELEVATION AND THE COMPUTED AVERAGE RATE OF INFLOW DURING THE PAST 3 HOURS OR THE PAST HOUR, WHICHEVER IS LESS. IN DETERMINING THE POOL ELEVATIONS, ADJUST FOR WIND EFFECT. SHOULD THE SCHEDULE INDICATE LESS OUTFLOW THAN IS CURRENTLY BEING RELEASED, MAINTAIN THE CURRENT RELEASE AND CONTINUE TO CHECK HOURLY.

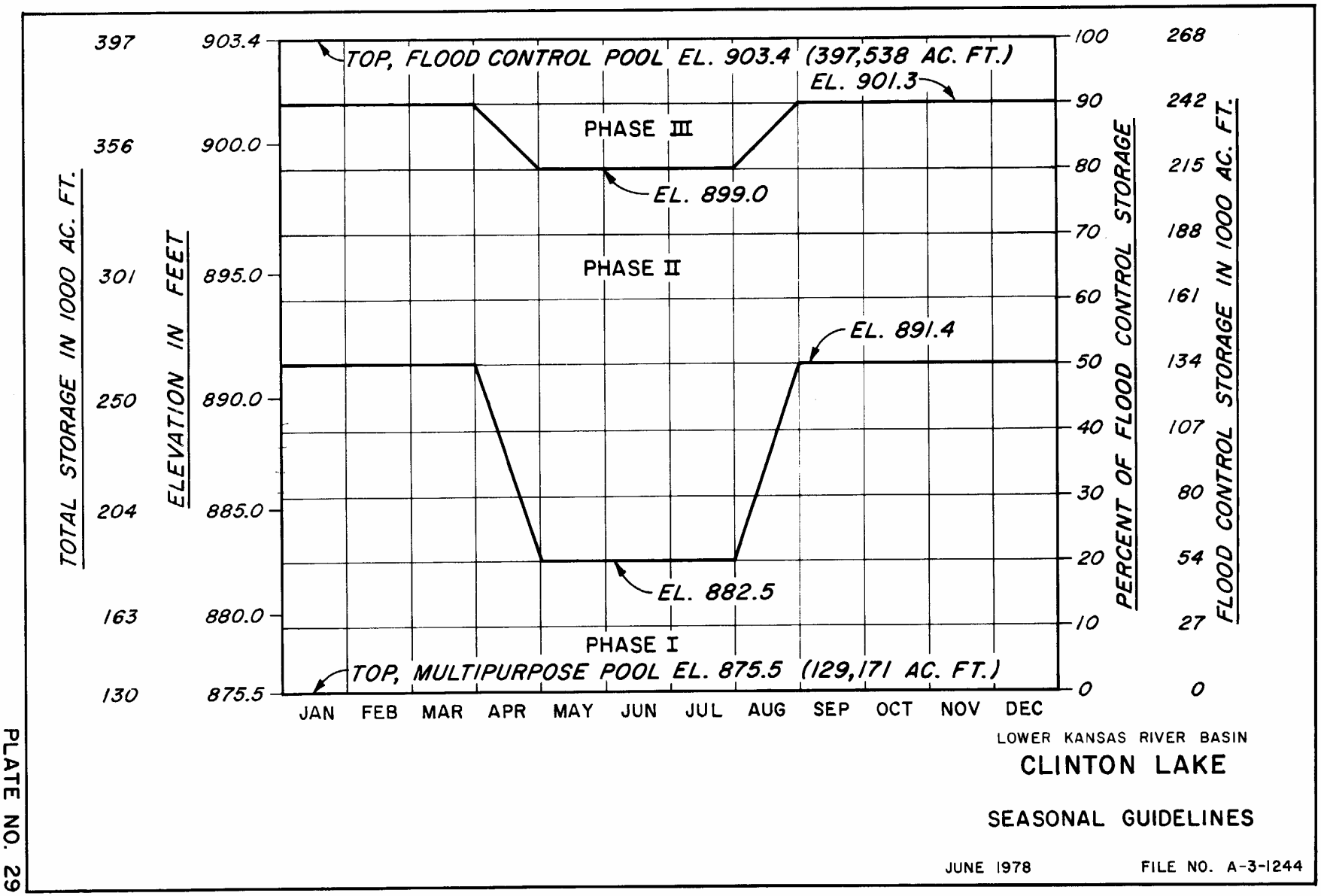
WHITE ROCK CREEK BASIN
LOVEWELL RESERVOIR
SPILLWAY
OPERATION CRITERIA

FILE NO. B-20-483 FEBRUARY 1967

PLATE NO. 26

DEC. 1968 PLATE NO. 26 OF LOVEWELL RESERVOIR MANUAL

US Army Corps of Engineers
Kansas City District



LOWER KANSAS RIVER BASIN

CLINTON LAKE

SEASONAL GUIDELINES

JUNE 1978 FILE NO. A-3-1244

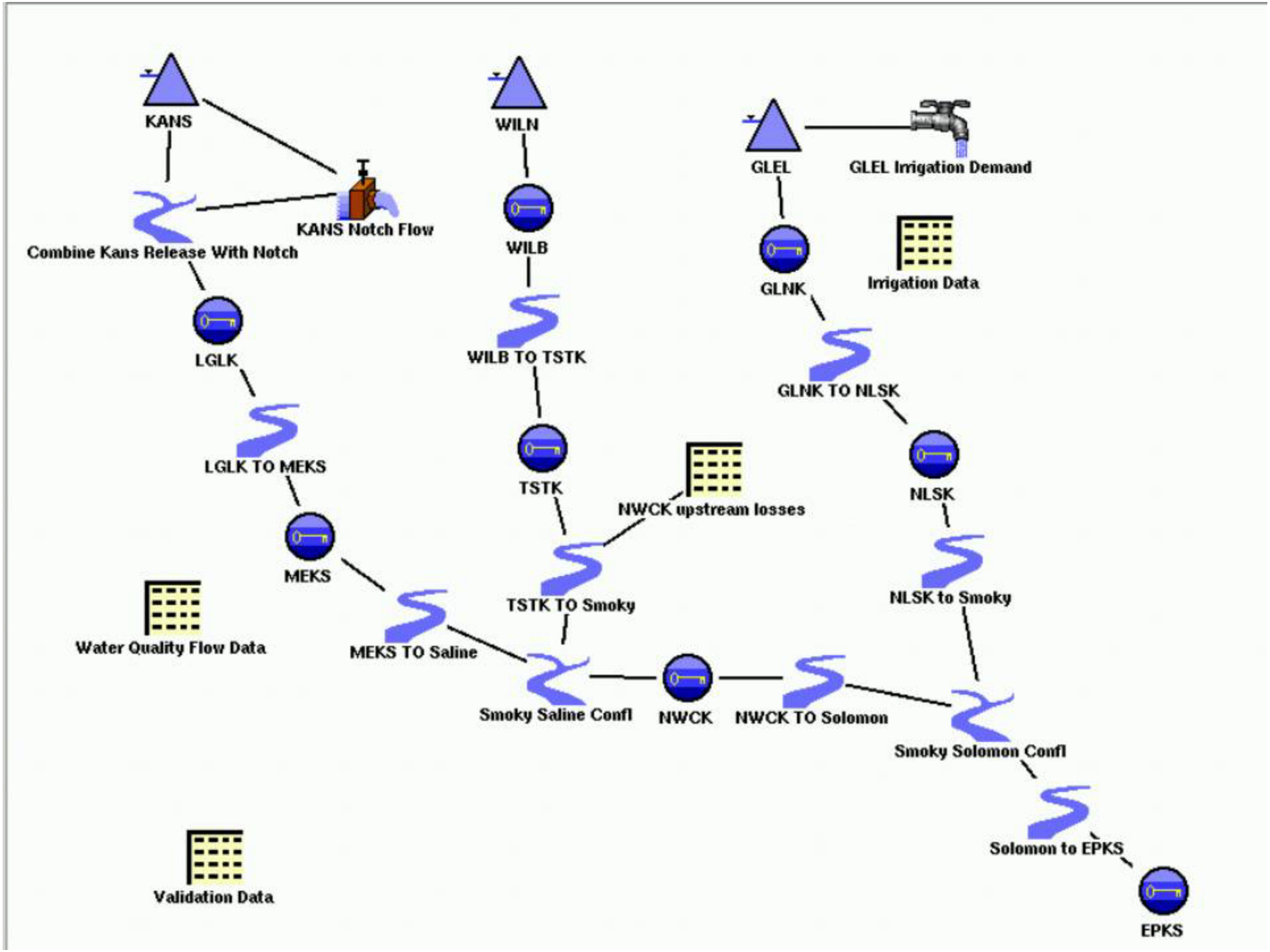
CORPS OF ENGINEERS U. S. ARMY

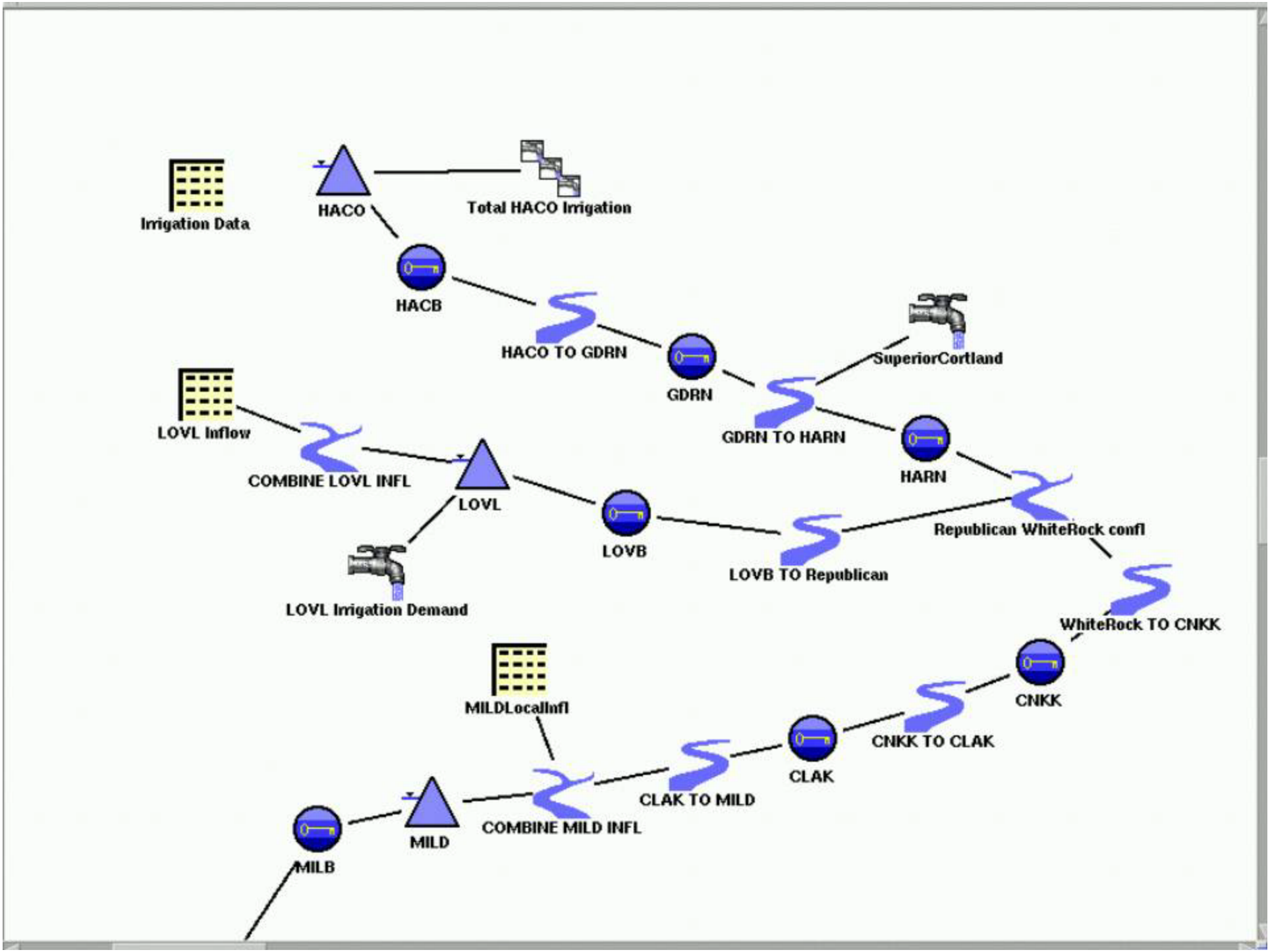
PLATE NO. 29

Milford Hydraulic and Regulating Data

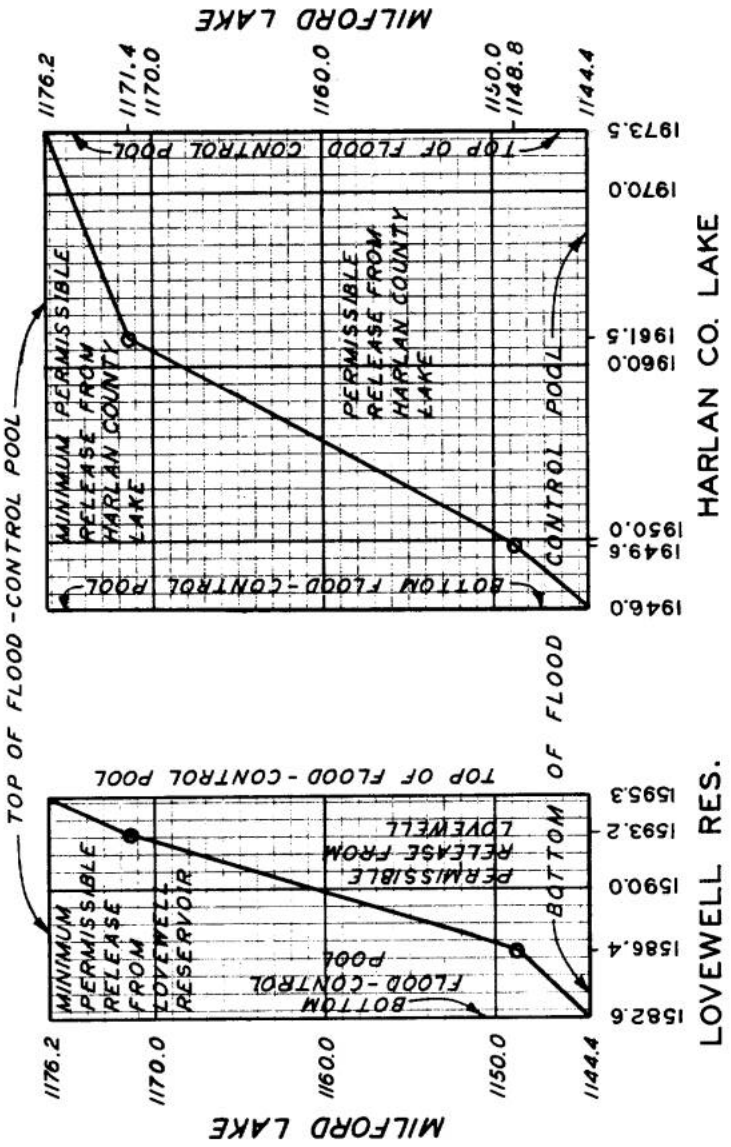
Station	River Mile Location	Datum Ft MSL	Gage Flood Stage (ft)	Flood Flow (cfs)	Travel Time (hrs)		Regulation Flows (cfs)			1993 Flood (cfs)	
					Average Flow	Dam Break	Phase I	Phase II	Phase III	Reg	Unreg
Junction City	(6)	1052.5	22	18,500	3	3	12,000	15,000	22,500	35,000	
Fort Riley	174	1034.7	21	41,000	5	4	27,000	45,000	65,000	87,600	200,000
Wamego	127	950.8	19	67,000	23	11	39,000	65,000	76,000	199,000	258,000
Topeka	83	846.7	26	74,000	41	21	48,000	80,000	90,000	170,000	260,000
Lecompton	64	821.8	17	72,000	49	29	61,000	102,000	120,000	190,000	282,000
Desoto	31	753.8	24	97,000	63	37	66,000	110,000	130,000	170,000	266,000
Kansas City	0 = 366	706.4	32	226,000	77	40	176,000	220,000	240,000	541,000	713,000
Waverly	293	645.5	20	123,000	95		90,000	130,000	180,000	633,000	700,000
Hermann	98	481.4	21	190,000	167		96,000	160,000	190,000	750,000	852,000

All values are preliminary and subject to revision. They were developed for this class and need further checking.


KANS
KANS Notch Flow
Combine Kans Release With Notch
LGLK
LGLK TO MEKS
MEKS
Water Quality Flow Data
MEKS TO Saline
WILN
WILB
WILB TO TSTK
TSTK
TSTK TO Smoky
NWCK upstream losses
Smoky Saline Confl
NWCK
NWCK TO Solomon
GLEL
GLEL Irrigation Demand
GLNK
Irrigation Data
GLNK TO NLSK
NLSK
NLSK to Smoky
Smoky Solomon Confl
Solomon to EPKS
EPKS
Validation Data


Irrigation Data
HACO
Total HACO Irrigation
HACB
HACO TO GDRN
GDRN
SuperiorCortland
GDRN TO HARN
HARN
LOVL Inflow
COMBINE LOVL INFL
LOVL
LOVB
LOVB TO Republican
Republican WhiteRock confl
LOVL Irrigation Demand
WhiteRock TO CNKK
CNKK
CNKK TO CLAK
CLAK
CLAK TO MILD
MILDLocalInfl
COMBINE MILD INFL
MILD
MILB

CORPS OF ENGINEERS U.S. ARMY



REPUBLICAN RIVER BASIN

MILFORD LAKE

TANDEM BALANCE

JULY 1971 FILE NO. B-I-1503

PLATE NO. 33

MARCH 1983 PLATE 33 OF MILFORD LAKE REG. MANUAL

Multipurpose Pool Operation

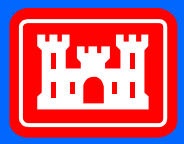
- Water Supply
  - Lake and River
- Water Quality
  - Mentor, Topeka, DeSoto
- Irrigation
  - Waconda, Harlan County, Lovewell
- Navigation Support
  - Milford, Tuttle Creek, Perry
- Endangered Species
  - Tuttle Creek, Milford
- Recreation & Fish/Wildlife

US Army Corps of Engineers
Kansas City District


RiverWare
C351-300-021198
Parker Dam

Data Development

- Study period WY 1929 through WY 2002
- Flow Data developed by Dr. Bob Barkau
  - Historic Lake Inflow data used when available
- Daily Actual Water Supply Demand
- Monthly Historic Data
  - Lake Pan Evaporation 1980 through 2002
    - 0.7 Pan Coefficient
  - USBR Irrigation Use
    - Converted to Daily Data
- Daily Rainfall from available gauges
  - Not applied to Historic Lake Inflow
- Reach Geometry from USGS measurements

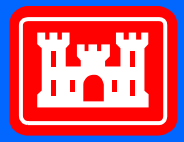


US Army Corps of Engineers
Kansas City District

Historic Lake Inflow

The inflow values from the database begins on the following dates for each lake:

KANS (Kanopolis Lake):	February 18, 1948
HACO (Harlan County Lake):	November 15, 1952
TUCR (Tuttle Creek Lake):	July 22, 1959
WILN (Wilson Lake):	September 4, 1963
PERY (Perry Lake):	August 1, 1966
GLEL (Waconda Lake):	October 18, 1967
CLIN (Clinton Lake):	December 1, 1977
LOVL (Lovewell Reservoir):	January 1, 1980
MILD (Milford Lake)	August 24, 1964



US Army Corps of Engineers
Kansas City District

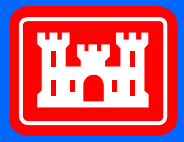
PRECIPATATION GAGES

HACO:	Phillipsburg 1928 - 1980
LOVL:	Burr Oak 1928 - 1954 Lovewell Dam 1955 - 1980
MILD:	Manhattan 1928 - 1938 Clay Center 1939 - 1947 Junction City 1948 - 1964 Milford Dam 1965 - 1980
TUCR:	Manhattan 1928 – 1980
PERY:	Horton 1928 - 1938 Lawrence 1939 - 1966 Perry Dam 1967 - 1980
CLIN:	Horton 1928 - 1938 Lawrence 1939 - 1976 Clinton Dam 1977 - 1980
KANS:	Ellsworth 1928 - 1947 Kanapolis Dam 1948 - 1980
WILN:	Ellsworth 1928 - 1938 Lincoln 1939 - 1963 Wilson Dam 1964 - 1980
GLEL:	Burr Oak 1928 - 1938 Lincoln 1939 - 1964 Waconda Lake 1964 - 1980

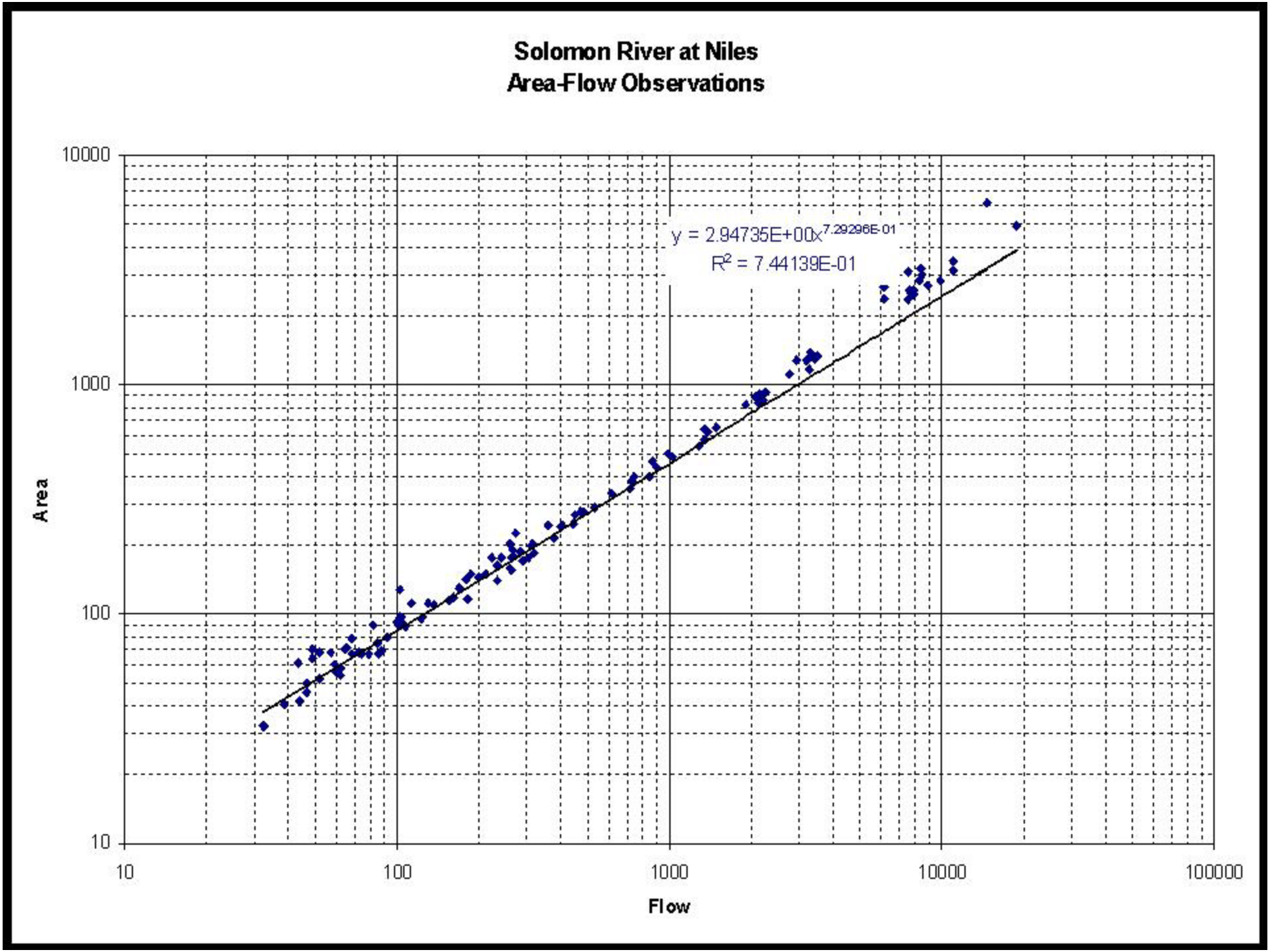
US Army Corps of Engineers
Kansas City District

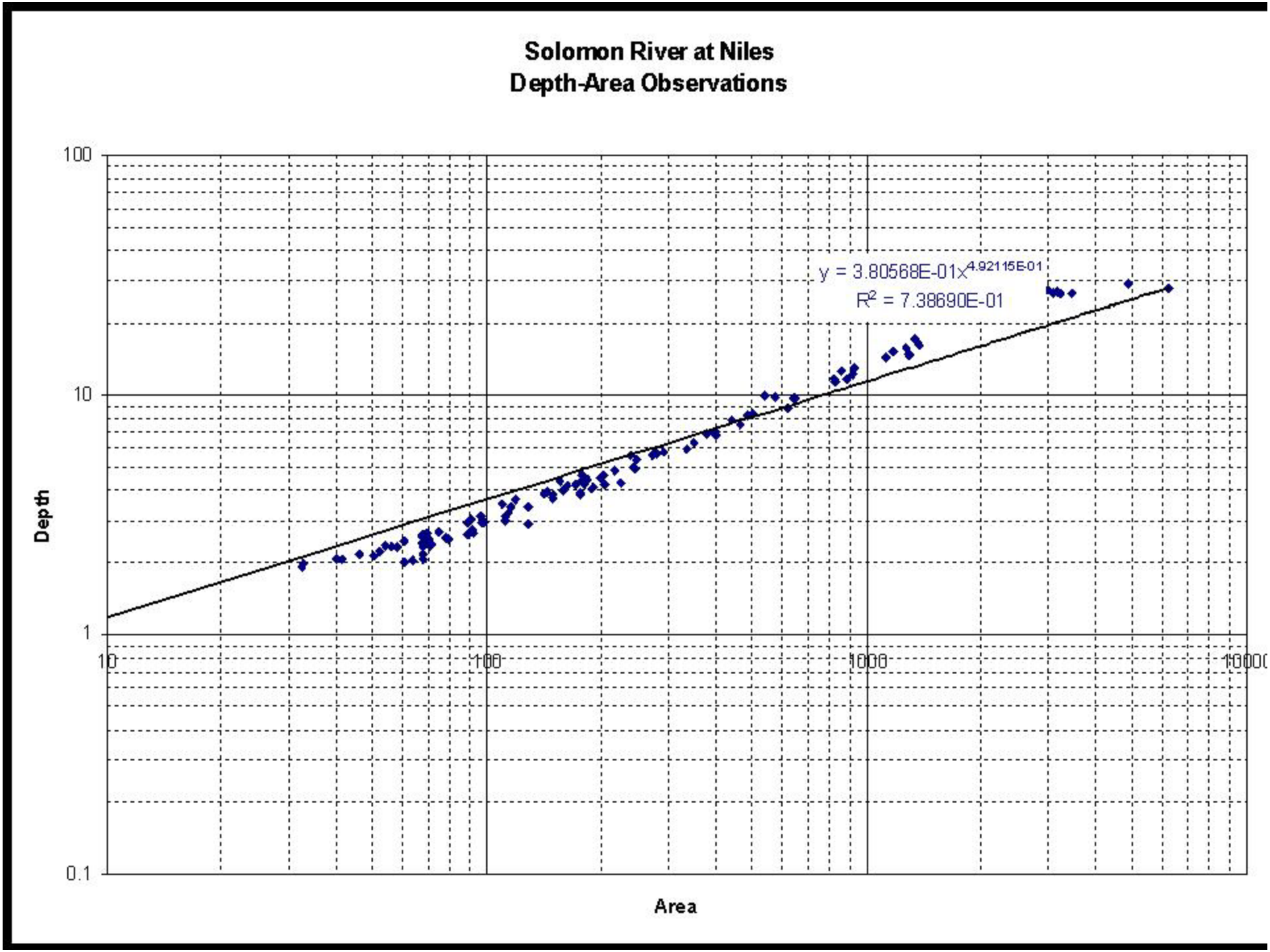
Routing Method

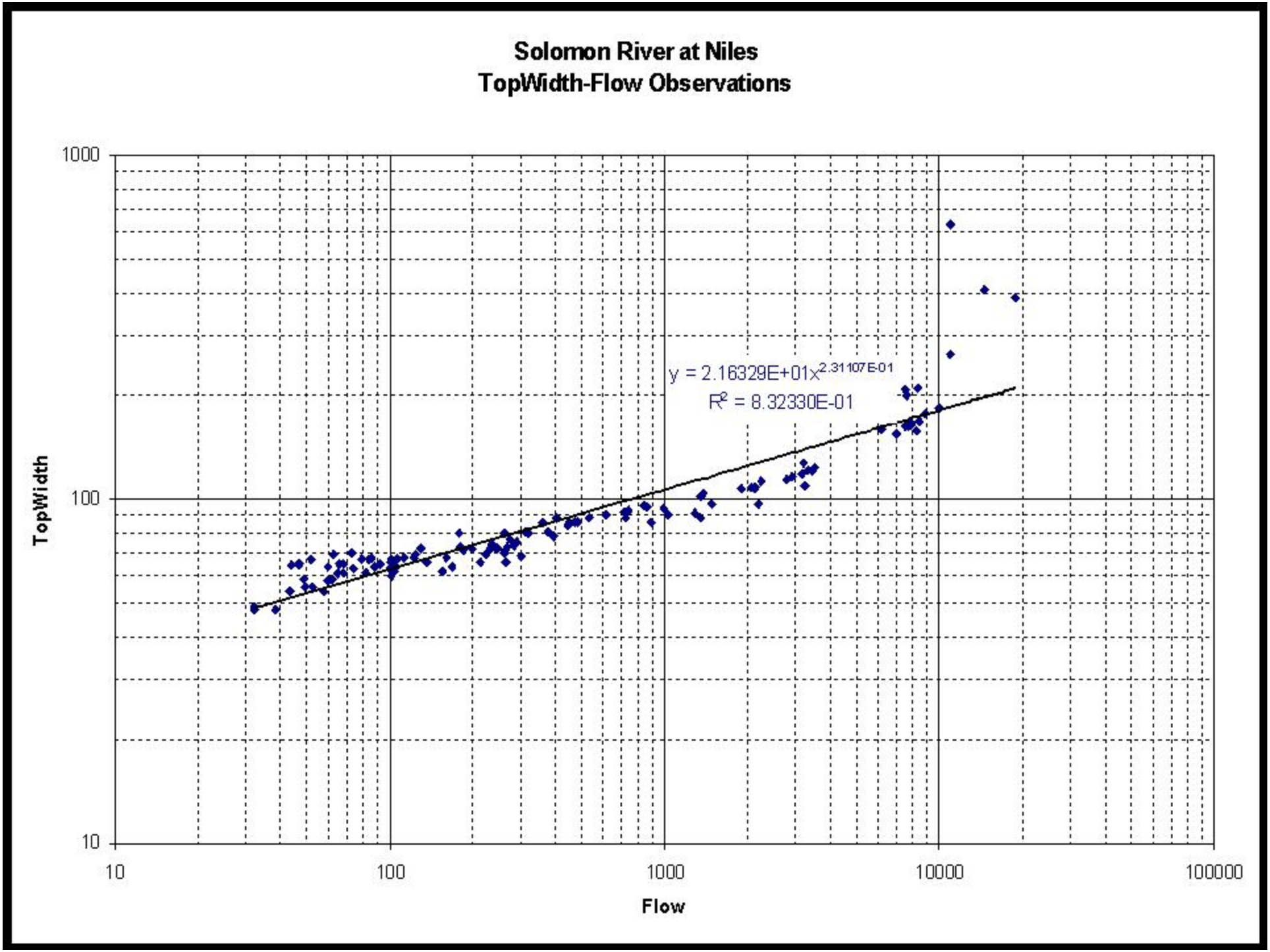
- Muskingum-Cunge
- River Geometry
  - Depth To Flow Power Function
    - Area-Flow
    - Depth-Area
    - TopWidth-Flow

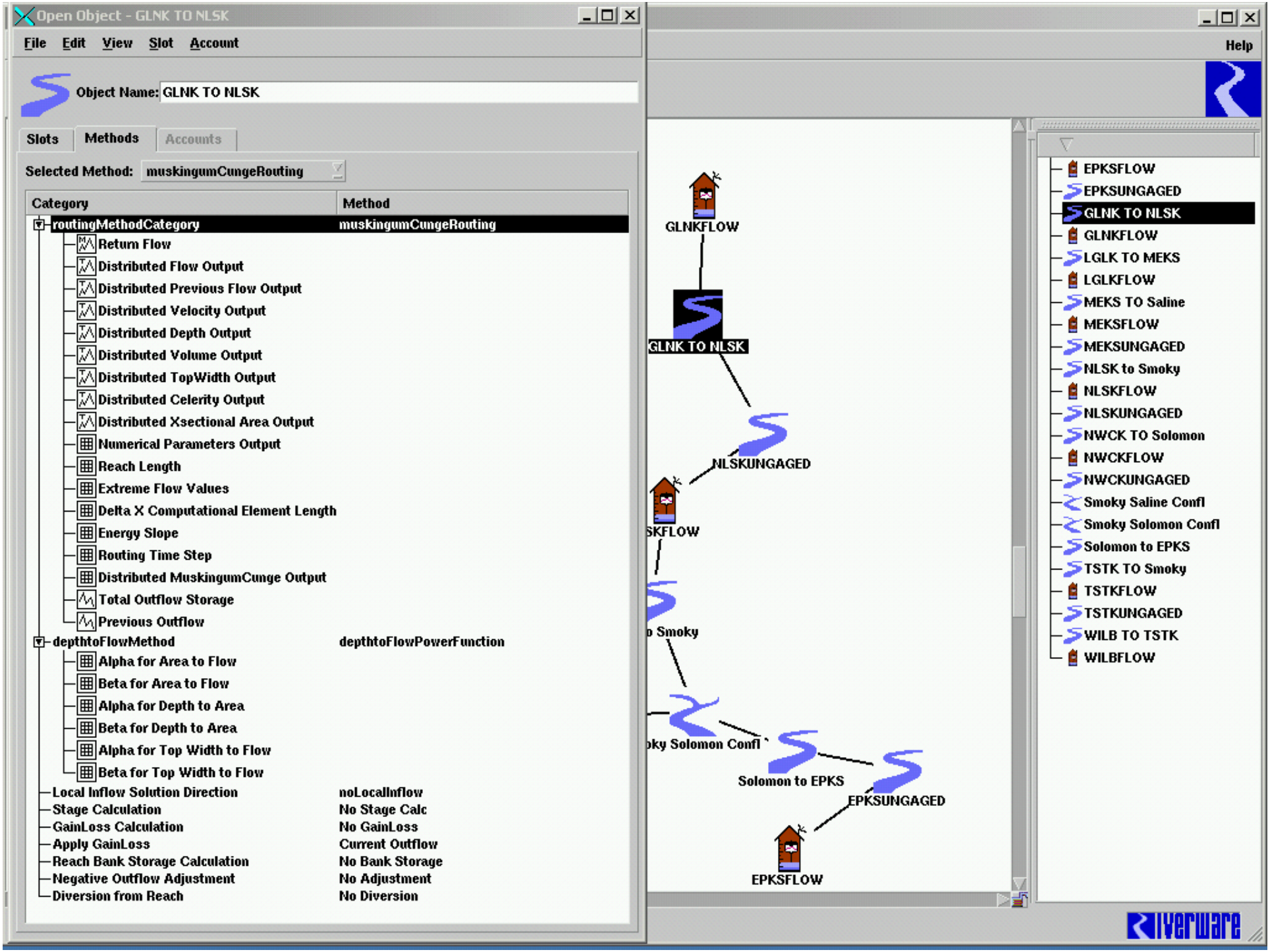


US Army Corps
of Engineers
Kansas City District


Solomon River at Niles
Area-Flow Observations
y = 2.94735E+00x^7.29296E-01
R² = 7.44139E-01
10000
1000
100
10
Area
10
100
1000
10000
100000
Flow

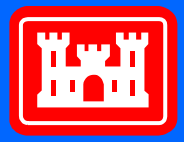

Solomon River at Niles
Depth-Area Observations
y = 3.80568E-01x^4.92115E-01
R² = 7.38690E-01
100
10
1
0.1
10
100
1000
10000
Depth
Area


Solomon River at Niles
TopWidth-Flow Observations
y = 2.16329E+01x^2.31107E-01
R² = 8.32330E-01
TopWidth
Flow
1000
100
10
10
100
1000
10000
100000

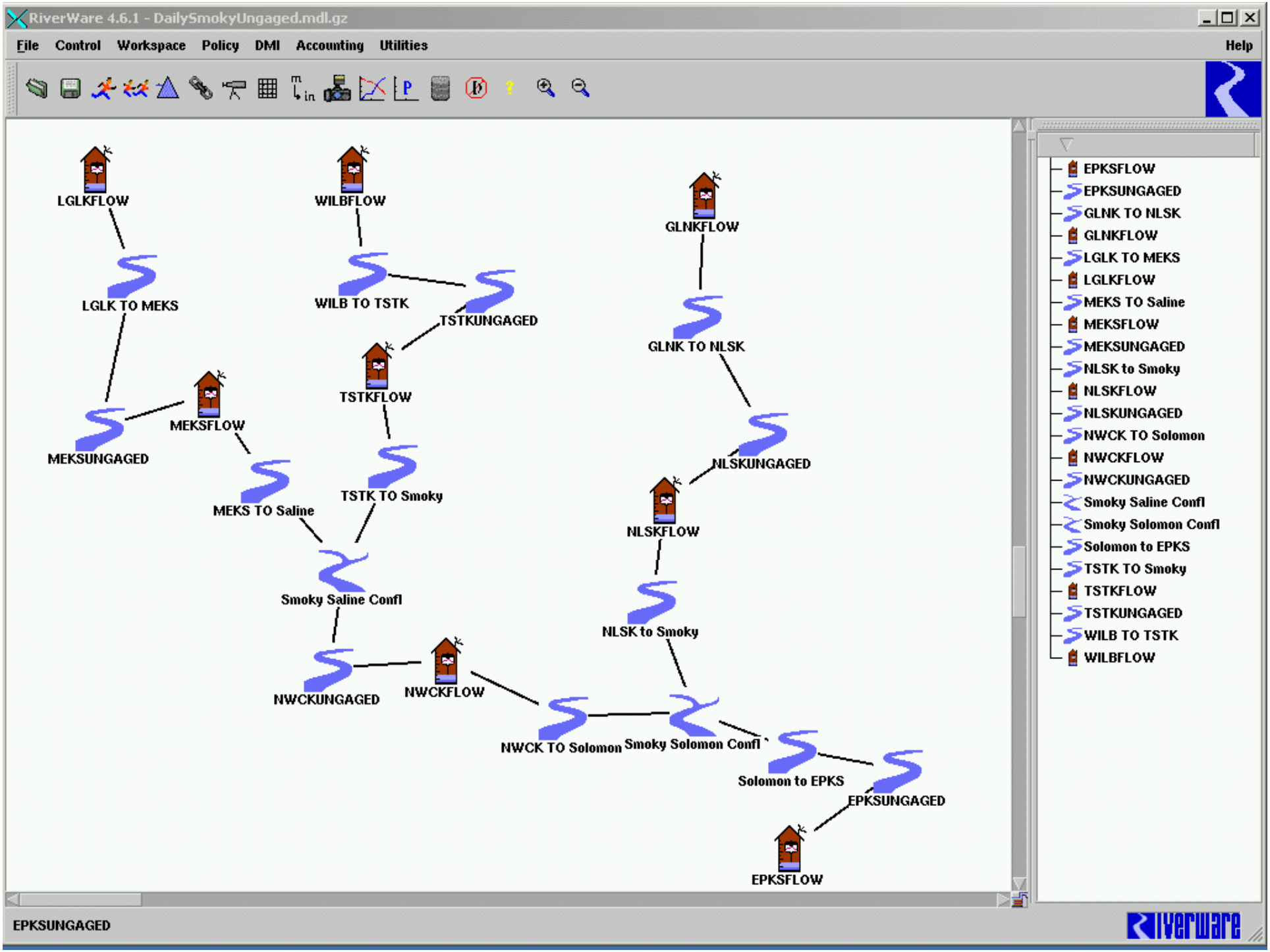

Open Object - GLNK TO NLSK
File Edit View Slot Account
Object Name: GLNK TO NLSK
Slots Methods Accounts
Selected Method: muskingumCungeRouting
Category Method
routingMethodCategory muskingumCungeRouting
Return Flow
Distributed Flow Output
Distributed Previous Flow Output
Distributed Velocity Output
Distributed Depth Output
Distributed Volume Output
Distributed TopWidth Output
Distributed Celerity Output
Distributed Xsectional Area Output
Numerical Parameters Output
Reach Length
Extreme Flow Values
Delta X Computational Element Length
Energy Slope
Routing Time Step
Distributed MuskingumCunge Output
Total Outflow Storage
Previous Outflow
depthtoFlowMethod depthtoFlowPowerFunction
Alpha for Area to Flow
Beta for Area to Flow
Alpha for Depth to Area
Beta for Depth to Area
Alpha for Top Width to Flow
Beta for Top Width to Flow
Local Inflow Solution Direction noLocalInflow
Stage Calculation No Stage Calc
GainLoss Calculation No GainLoss
Apply GainLoss Current Outflow
Reach Bank Storage Calculation No Bank Storage
Negative Outflow Adjustment No Adjustment
Diversion from Reach No Diversion
Help
GLNKFLOW
GLNK TO NLSK
NLSKUNGAGED
SKFLOW
o Smoky
oky Solomon Confl
Solomon to EPKS
EPKSUNGAGED
EPKSFLOW
EPKSFLOW
EPKSUNGAGED
GLNK TO NLSK
GLNKFLOW
LGLK TO MEKS
LGLKFLOW
MEKS TO Saline
MEKSFLOW
MEKSUNGAGED
NLSK to Smoky
NLSKFLOW
NLSKUNGAGED
NWCK TO Solomon
NWCKFLOW
NWCKUNGAGED
Smoky Saline Confl
Smoky Solomon Confl
Solomon to EPKS
TSTK TO Smoky
TSTKFLOW
TSTKUNGAGED
WILB TO TSTK
WILBFLOW
RiverWare

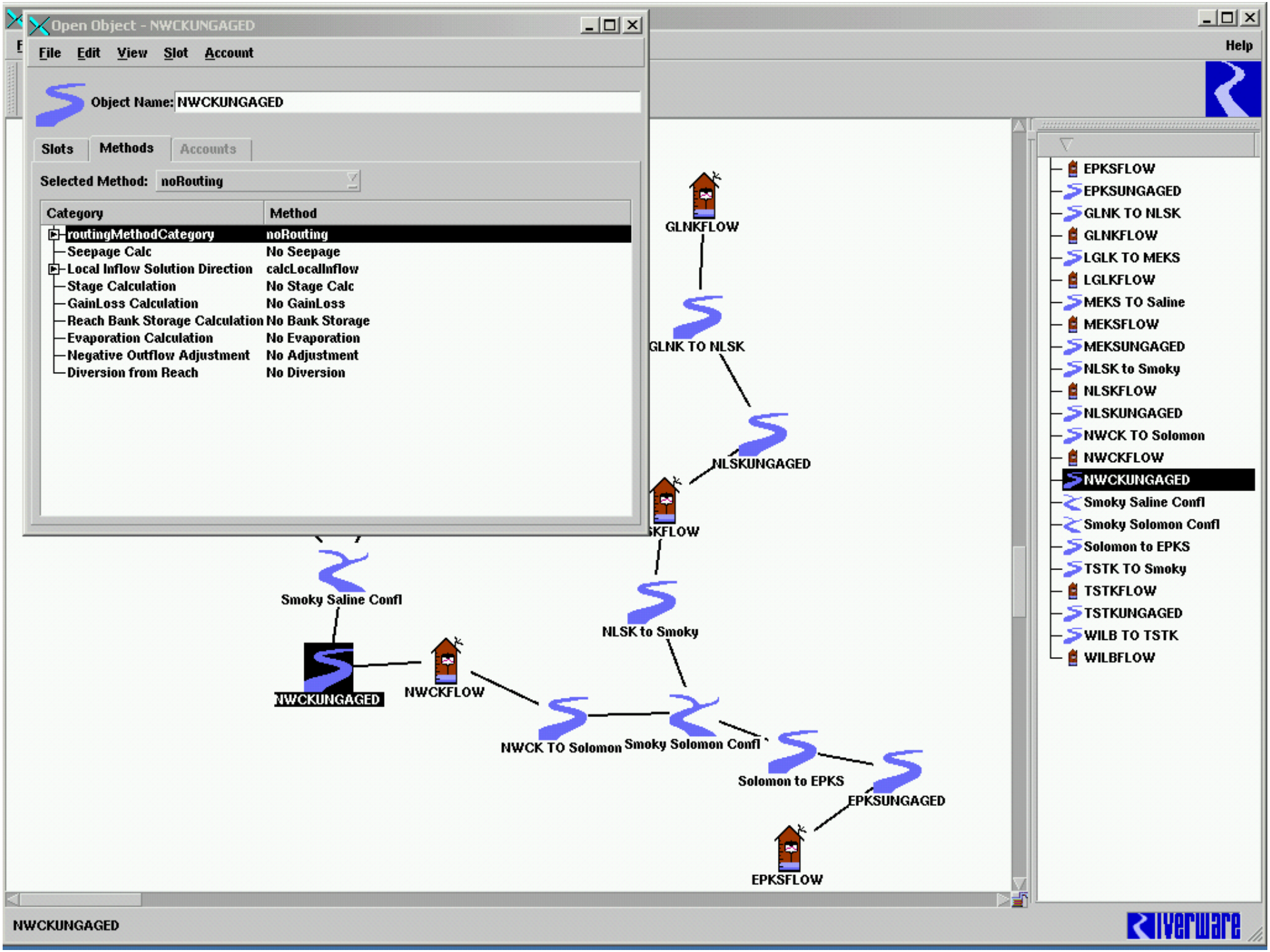
Modeling Process

- Create uncontrolled Model of historic flows
  - Historic flow at dam sites or lake releases
  - Historic river gage flow
  - Route flow to next downstream gage
  - Compare routed flow with the historic gage flow



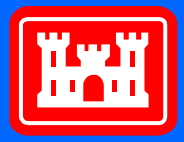
US Army Corps
of Engineers
Kansas City District


RiverWare 4.6.1 - DailySmokyUngaged.mdl.gz
File
Control
Workspace
Policy
DMI
Accounting
Utilities
Help
LGLKFLOW
WILBFLOW
GLNKFLOW
LGLK TO MEKS
WILB TO TSTK
TSTKUNGAGED
GLNK TO NLSK
TSTKFLOW
MEKSFLOW
MEKSUNGAGED
NLSKUNGAGED
MEKS TO Saline
TSTK TO Smoky
NLSKFLOW
Smoky Saline Confl
NLSK to Smoky
NWCKUNGAGED
NWCKFLOW
NWCK TO Solomon
Smoky Solomon Confl
Solomon to EPKS
EPKSUNGAGED
EPKSFLOW
EPKSFLOW
EPKSUNGAGED
GLNK TO NLSK
GLNKFLOW
LGLK TO MEKS
LGLKFLOW
MEKS TO Saline
MEKSFLOW
MEKSUNGAGED
NLSK to Smoky
NLSKFLOW
NLSKUNGAGED
NWCK TO Solomon
NWCKFLOW
NWCKUNGAGED
Smoky Saline Confl
Smoky Solomon Confl
Solomon to EPKS
TSTK TO Smoky
TSTKFLOW
TSTKUNGAGED
WILB TO TSTK
WILBFLOW
EPKSUNGAGED
RiverWare

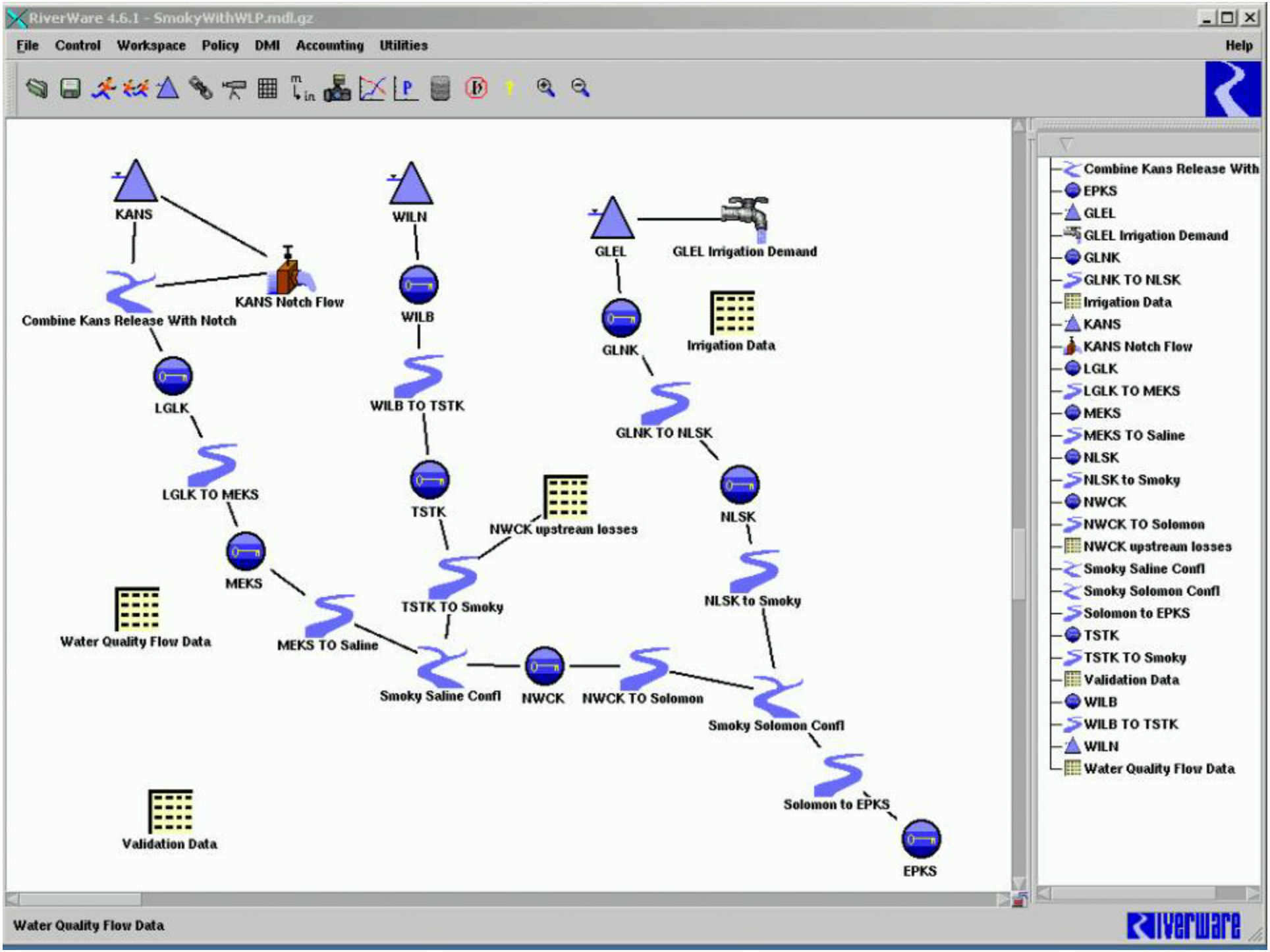

Open Object - NWCKUNGAGED
File Edit View Slot Account
Object Name: NWCKUNGAGED
Slots Methods Accounts
Selected Method: noRouting
Category Method
routingMethodCategory noRouting
Seepage Calc No Seepage
Local Inflow Solution Direction calcLocalInflow
Stage Calculation No Stage Calc
GainLoss Calculation No GainLoss
Reach Bank Storage Calculation No Bank Storage
Evaporation Calculation No Evaporation
Negative Outflow Adjustment No Adjustment
Diversion from Reach No Diversion
Help
EPKSFLOW
EPKSUNGAGED
GLNK TO NLSK
GLNKFLOW
LGLK TO MEKS
LGLKFLOW
MEKS TO Saline
MEKSFLOW
MEKSUNGAGED
NLSK to Smoky
NLSKFLOW
NLSKUNGAGED
NWCK TO Solomon
NWCKFLOW
NWCKUNGAGED
Smoky Saline Confl
Smoky Solomon Confl
Solomon to EPKS
TSTK TO Smoky
TSTKFLOW
TSTKUNGAGED
WILB TO TSTK
WILBFLOW
GLNKFLOW
GLNK TO NLSK
NLSKUNGAGED
Smoky Saline Confl
NLSK to Smoky
NWCKUNGAGED
NWCKFLOW
NWCK TO Solomon
Smoky Solomon Confl
Solomon to EPKS
EPKSUNGAGED
EPKSFLOW
NWCKUNGAGED
RiverWare

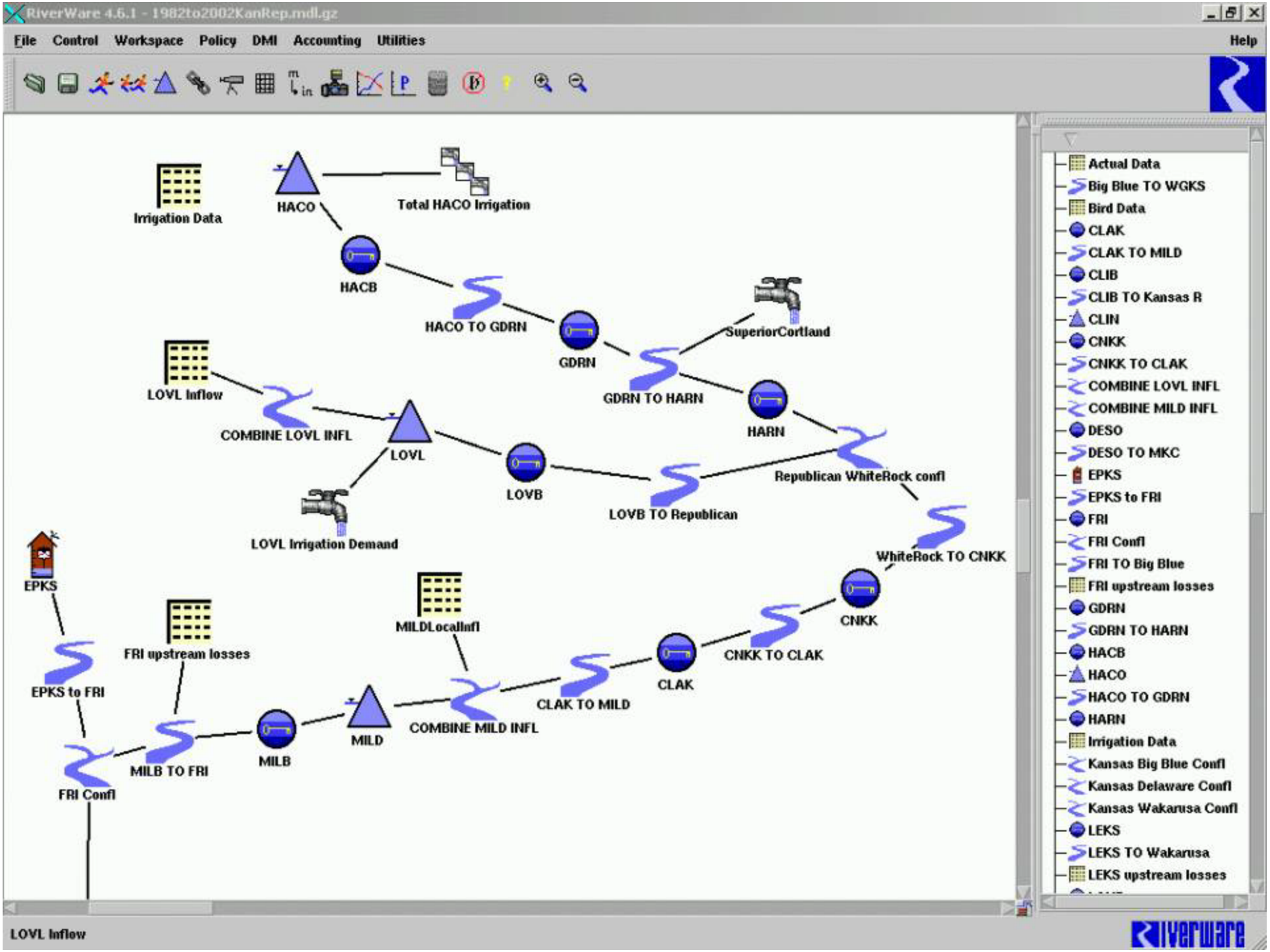
Negative Ungaged Flow

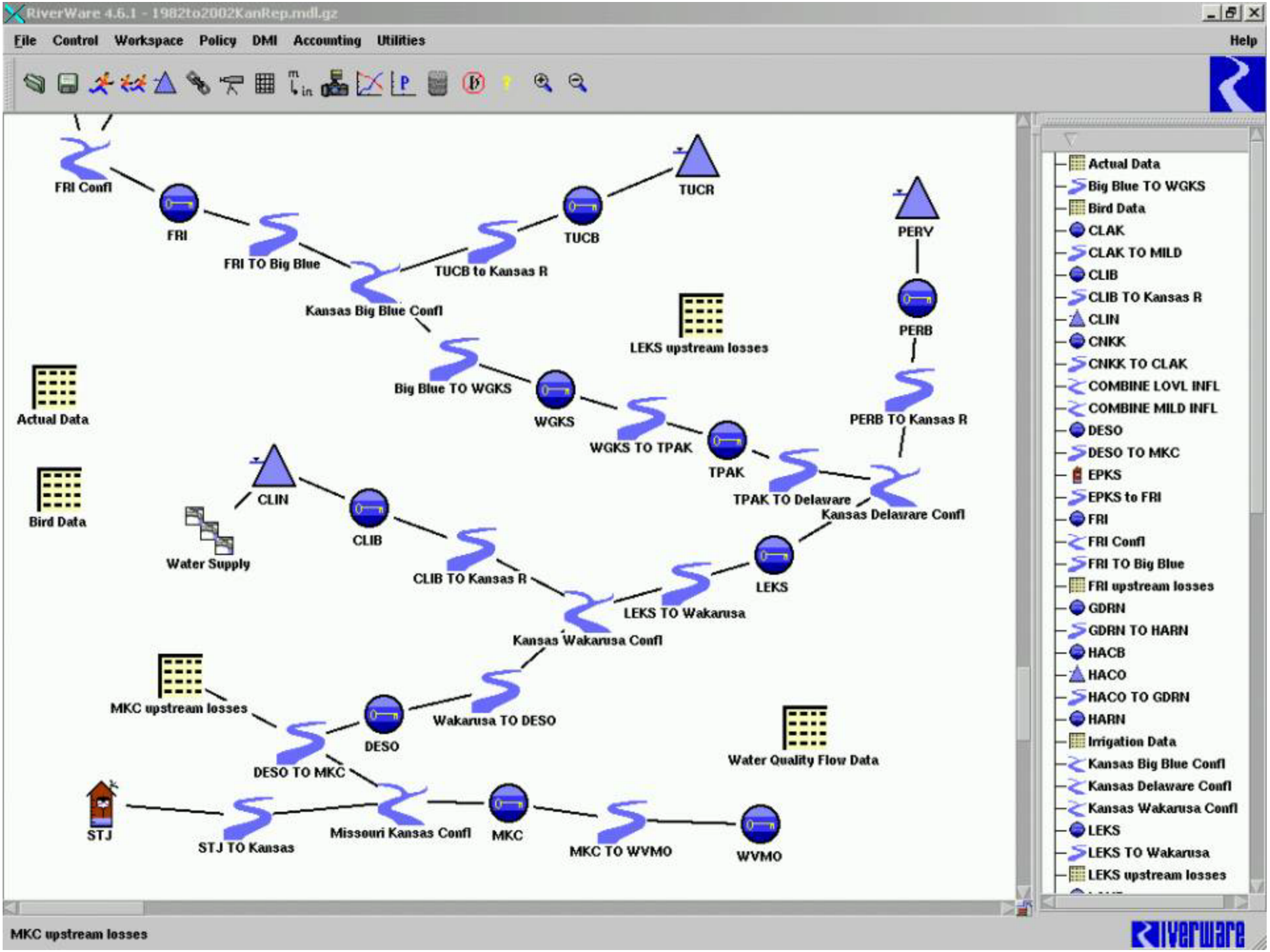
- Causes
  - Changed stream conditions affect routing
  - Input data challenges
  - Stream depletions
- Solution
  - Separate positive and negative values
  - Average negative values over 31 day period
  - Apply values over the period
  - Remaining negative values treated as losses



US Army Corps of Engineers
Kansas City District

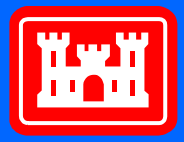

RiverWare 4.6.1 - SmokyWithWLP.mdl.gz
File Control Workspace Policy DMI Accounting Utilities Help
KANS
WILN
GLEL
GLEL Irrigation Demand
KANS Notch Flow
Combine Kans Release With Notch
WILB
GLNK
Irrigation Data
LGLK
WILB TO TSTK
GLNK TO NLSK
LGLK TO MEKS
TSTK
NWCK upstream losses
NLSK
MEKS
TSTK TO Smoky
NLSK to Smoky
Water Quality Flow Data
MEKS TO Saline
Smoky Saline Confl
NWCK
NWCK TO Solomon
Smoky Solomon Confl
Solomon to EPKS
Validation Data
EPKS
Combine Kans Release With
EPKS
GLEL
GLEL Irrigation Demand
GLNK
GLNK TO NLSK
Irrigation Data
KANS
KANS Notch Flow
LGLK
LGLK TO MEKS
MEKS
MEKS TO Saline
NLSK
NLSK to Smoky
NWCK
NWCK TO Solomon
NWCK upstream losses
Smoky Saline Confl
Smoky Solomon Confl
Solomon to EPKS
TSTK
TSTK TO Smoky
Validation Data
WILB
WILB TO TSTK
WILN
Water Quality Flow Data
Water Quality Flow Data
RiverWare


RiverWare 4.6.1 - 1982to2002KanRep.mdl.gz
File
Control
Workspace
Policy
DMI
Accounting
Utilities
Help
Irrigation Data
HACO
Total HACO Irrigation
HACB
HACO TO GDRN
GDRN
SuperiorCortland
GDRN TO HARN
HARN
LOVL Inflow
COMBINE LOVL INFL
LOVL
LOVB
LOVB TO Republican
Republican WhiteRock confl
LOVL Irrigation Demand
WhiteRock TO CNKK
CNKK
CNKK TO CLAK
CLAK
CLAK TO MILD
MILDLocalInfl
COMBINE MILD INFL
MILD
MILB
MILB TO FRI
FRI upstream losses
EPKS
EPKS to FRI
FRI Confl
Actual Data
Big Blue TO WGKS
Bird Data
CLAK
CLAK TO MILD
CLIB
CLIB TO Kansas R
CLIN
CNKK
CNKK TO CLAK
COMBINE LOVL INFL
COMBINE MILD INFL
DESO
DESO TO MKC
EPKS
EPKS to FRI
FRI
FRI Confl
FRI TO Big Blue
FRI upstream losses
GDRN
GDRN TO HARN
HACB
HACO
HACO TO GDRN
HARN
Irrigation Data
Kansas Big Blue Confl
Kansas Delaware Confl
Kansas Wakarusa Confl
LEKS
LEKS TO Wakarusa
LEKS upstream losses
LOVL Inflow
RiverWare


RiverWare 4.6.1 - 1982to2002KanRep.mdl.gz
File Control Workspace Policy DMI Accounting Utilities Help
FRI Confl
FRI
FRI TO Big Blue
TUCB to Kansas R
TUCB
TUCR
Kansas Big Blue Confl
LEKS upstream losses
PERV
PERB
Actual Data
Big Blue TO WGKS
WGKS
WGKS TO TPAK
TPAK
PERB TO Kansas R
TPAK TO Delaware
Kansas Delaware Confl
Bird Data
CLIN
CLIB
Water Supply
CLIB TO Kansas R
LEKS
LEKS TO Wakarusa
Kansas Wakarusa Confl
MKC upstream losses
Wakarusa TO DESO
DESO
DESO TO MKC
Water Quality Flow Data
STJ
STJ TO Kansas
Missouri Kansas Confl
MKC
MKC TO WVMO
WVMO
Actual Data
Big Blue TO WGKS
Bird Data
CLAK
CLAK TO MILD
CLIB
CLIB TO Kansas R
CLIN
CNKK
CNKK TO CLAK
COMBINE LOVL INFL
COMBINE MILD INFL
DESO
DESO TO MKC
EPKS
EPKS to FRI
FRI
FRI Confl
FRI TO Big Blue
FRI upstream losses
GDRN
GDRN TO HARN
HACB
HACO
HACO TO GDRN
HARN
Irrigation Data
Kansas Big Blue Confl
Kansas Delaware Confl
Kansas Wakarusa Confl
LEKS
LEKS TO Wakarusa
LEKS upstream losses
MKC upstream losses
riverware

Lake Objects

LAKE NAME	RIVER	OBJECT ID
Kanopolis Lake	Smoky Hill River	KANS
Wilson Lake	Saline River	WILN
Waconda Lake (Sec 7)	Solomon River	GLEL
Harlan County Lake	Republican River	HACO
Lovewell Reservoir (Sec 7)	White Rock Creek	LOVL
Milford Lake	Republican River	MILD
Tuttle Creek Lake	Big Blue River	TUCR
Perry Lake	Delaware River	PERY
Clinton Lake	Wakarusa River	CLIN



US Army Corps of Engineers
Kansas City District

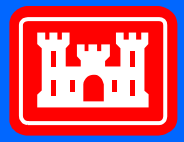
Control Points
Smoky Basin

GAGE NAME	USGS No.	OBJECT ID	LAKES REGULATED
Smoky Hill River:			
Near Langley (KS)	06865500	LNGK	KANS
Near Mentor (KS)	06866500	MEKS	KANS
New Cambria (KS)	06870200	NWCK	KANS, WILN
Enterprise (KS)	06877600	EPKS	KANS, WILN, GLEL
Saline River:			
At Wilson Dam (KS)	06868200	WILB	WILN
Tescott (KS)	06869500	TSTK	WILN
Solomon River:			
Near Glen Elder (KS)	06875900	WACB	GLEL
Niles (KS)	06876900	NLSK	GLEL

US Army Corps of Engineers
Kansas City District

Kansas/Republican Basin

GAGE NAME	USGS No.	OBJECT ID	LAKES REGULATED	
Republican River:				
Below Harlan County Dam (NE)		06849500	HACB	HACO
Guide Rock (NE)		06853020	GDRN	HACO
Hardy (NE)		06853500	HARN	HACO
Concordia (KS)		06856000	CNKK	HACO, LOVL
Clay Center (KS)		06856600	CLCK	HACO, LOVL
Below Milford Dam (KS)		06857100	MILB	MILD
White Rock Creek:				
At Lovewell (KS)		06854000	LOVB	LOVL
Kansas River:				
Fort Riley (KS)		06879100	FRI	MILD
Wamego (KS)		06887500	WGKS	MILD, TUCR
Topeka (KS)		06889000	TPAK	MILD, TUCR
LeCompton (KS)		06891000	LCKS	MILD, TUCR, PERY
DeSoto		06892350	DESO	MILD, TUCR, PERY, CLIN
Big Blue River:				
Manhattan (KS)		06887000	MHKS	TUCR
Delaware River:				
Below Perry Dam (KS)		06890900	PERB	PERY
Wakarusa River:				
Lawrence (KS)		06891500	LWKS	CLIN
Missouri River:				
St. Joseph (MO)		06818000	STJ	<NONE>
Kansas City (MO)		06893000	MKC	MILD, TUCR, PERY, CLIN
Waverly (MO)		06895500	WVMO	MILD, TUCR, PERY, CLIN



US Army Corps of Engineers
Kansas City District

Reaches

Reach objects: The river length between each adjacent control point, or the river length between a control point and a major confluence.

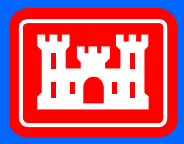
Major Confluences:

- Smoky-Saline
- Smoky-Solomon
- Republican-White Rock
- Smoky-Republican
- Kansas-Big Blue
- Kansas-Delaware
- Kansas-Wakarusa
- Kansas-Missouri

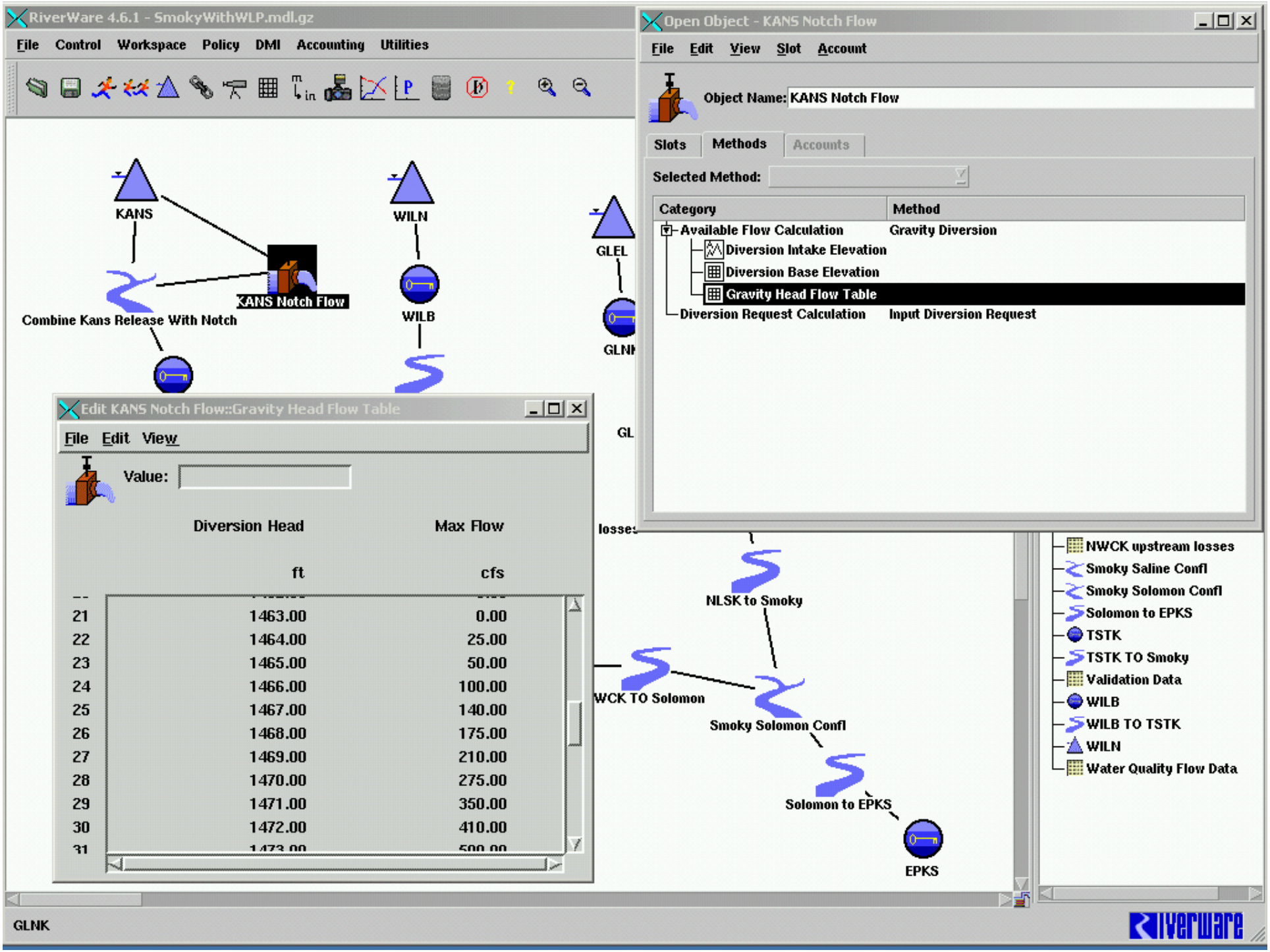
US Army Corps of Engineers
Kansas City District

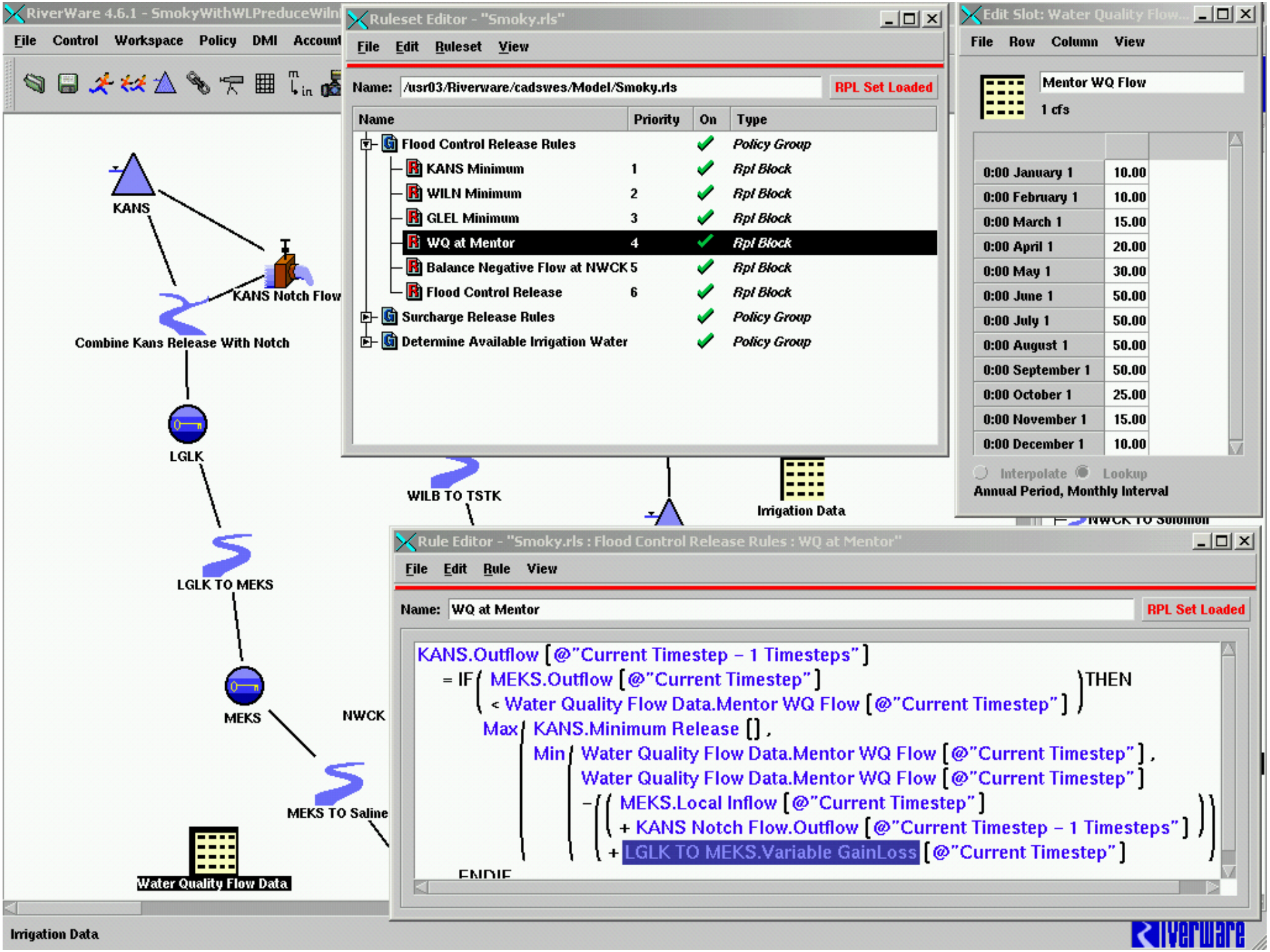
Model Data Inputs

- Lake Physical Characteristics
  - Area-Capacity, Surcharge Curves, Outlet Capacity
- Lake Operation Criteria
  - Surcharge, Phase Levels and Flows, Tandem Balance
- Daily Lake Inflow
- Lake Evaporation, Precipitation
- Lake Demands
  - Water Supply/Quality, Irrigation, Navigation
- Reach Loss
- Control Point Ungaged Local Inflow
- Reach Geometry
  - Taken from USGS measurements



US Army Corps of Engineers
Kansas City District


RiverWare 4.6.1 - SmokyWithWLP.mdl.gz
File Control Workspace Policy DMI Accounting Utilities
KANS
WILN
GLEL
KANS Notch Flow
Combine Kans Release With Notch
WILB
GLNK
Open Object - KANS Notch Flow
File Edit View Slot Account
Object Name: KANS Notch Flow
Slots Methods Accounts
Selected Method:
Category
Method
Available Flow Calculation
Gravity Diversion
Diversion Intake Elevation
Diversion Base Elevation
Gravity Head Flow Table
Diversion Request Calculation
Input Diversion Request
Edit KANS Notch Flow::Gravity Head Flow Table
File Edit View
Value:
Diversion Head
Max Flow
ft
cfs
21 1463.00 0.00
22 1464.00 25.00
23 1465.00 50.00
24 1466.00 100.00
25 1467.00 140.00
26 1468.00 175.00
27 1469.00 210.00
28 1470.00 275.00
29 1471.00 350.00
30 1472.00 410.00
NLSK to Smoky
WCK TO Solomon
Smoky Solomon Confl
Solomon to EPKS
EPKS
NWCK upstream losses
Smoky Saline Confl
Smoky Solomon Confl
Solomon to EPKS
TSTK
TSTK TO Smoky
Validation Data
WILB
WILB TO TSTK
WILN
Water Quality Flow Data
GLNK
RiverWare


RiverWare 4.6.1 - SmokyWithWLPreduceWiln
File Control Workspace Policy DMI Account
KANS
KANS Notch Flow
Combine Kans Release With Notch
LGLK
LGLK TO MEKS
MEKS
NWCK
MEKS TO Saline
Water Quality Flow Data
WILB TO TSTK
Irrigation Data
Irrigation Data
Ruleset Editor - "Smoky.rls"
File Edit Ruleset View
Name: /usr03/Riverware/cadswes/Model/Smoky.rls
RPL Set Loaded
Name
Priority
On
Type
Flood Control Release Rules
Policy Group
KANS Minimum 1 Rpl Block
WILN Minimum 2 Rpl Block
GLEL Minimum 3 Rpl Block
WQ at Mentor 4 Rpl Block
Balance Negative Flow at NWCK 5 Rpl Block
Flood Control Release 6 Rpl Block
Surcharge Release Rules
Policy Group
Determine Available Irrigation Water
Policy Group
Edit Slot: Water Quality Flow...
File Row Column View
Mentor WQ Flow
1 cfs
0:00 January 1 10.00
0:00 February 1 10.00
0:00 March 1 15.00
0:00 April 1 20.00
0:00 May 1 30.00
0:00 June 1 50.00
0:00 July 1 50.00
0:00 August 1 50.00
0:00 September 1 50.00
0:00 October 1 25.00
0:00 November 1 15.00
0:00 December 1 10.00
Interpolate Lookup
Annual Period, Monthly Interval
Rule Editor - "Smoky.rls : Flood Control Release Rules : WQ at Mentor"
File Edit Rule View
Name: WQ at Mentor
RPL Set Loaded
KANS.Outflow [@"Current Timestep - 1 Timesteps"]
= IF(MEKS.Outflow [@"Current Timestep"]
< Water Quality Flow Data.Mentor WQ Flow [@"Current Timestep"])THEN
Max(KANS.Minimum Release [] ,
Min(Water Quality Flow Data.Mentor WQ Flow [@"Current Timestep"] ,
Water Quality Flow Data.Mentor WQ Flow [@"Current Timestep"]
-((MEKS.Local Inflow [@"Current Timestep"]
+ KANS Notch Flow.Outflow [@"Current Timestep - 1 Timesteps"])
+ LGLK TO MEKS.Variable GainLoss [@"Current Timestep"]
ENDIF

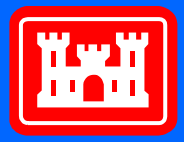
RiverWare Calibration Slots

Lake Objects

- Objective Release Pattern
- Objective Release Pattern Threshold
- Phase Tolerance
- Permissible Outflow Increase Constraints
- Permissible Outflow Decrease Constraints

Control Points

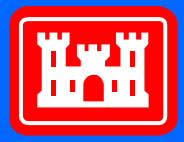
- Phase Space Tolerance



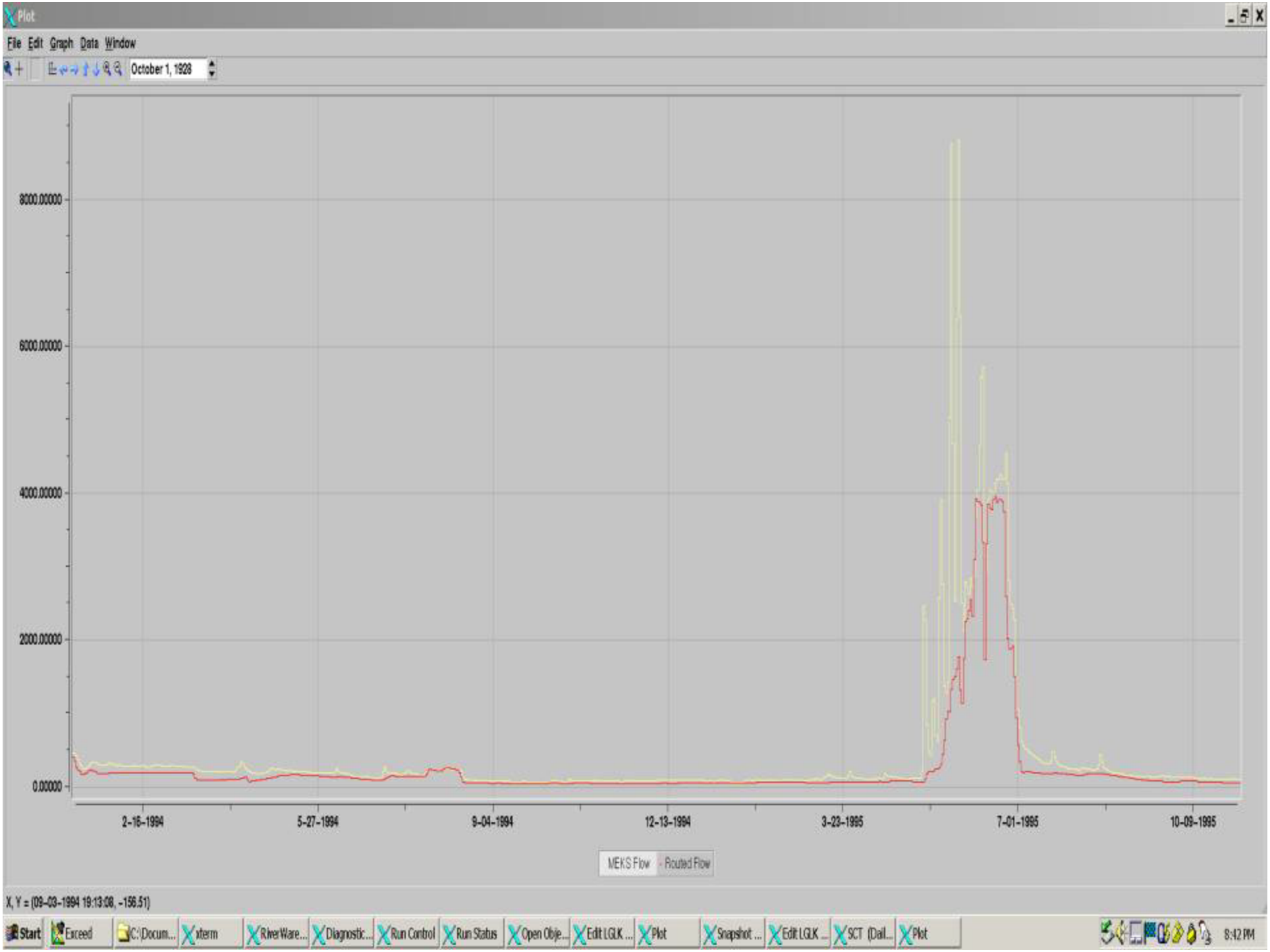
US Army Corps of Engineers
Kansas City District

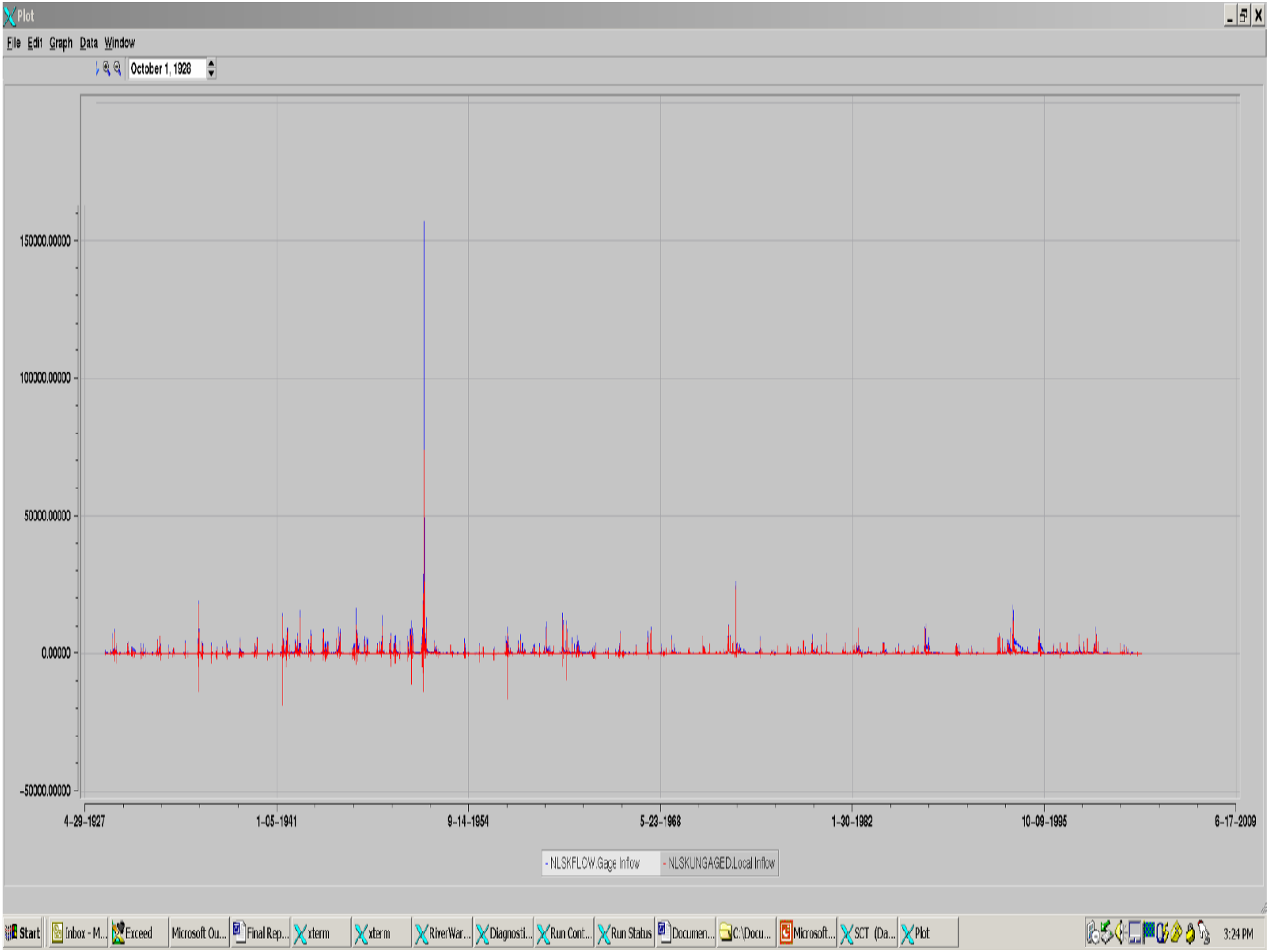
Reach Calibration

- Review ungaged calculation
- Extreme values may indicate poor routing
- Negative values at edges of hydrograph
  - Incorrect travel time
  - Insufficient attenuation
  - Positive values may be local inflow



US Army Corps of Engineers
Kansas City District


Plot
File Edit Graph Data Window
October 1, 1928
8000.00000
6000.00000
4000.00000
2000.00000
0.00000
2-16-1994
5-27-1994
9-04-1994
12-13-1994
3-23-1995
7-01-1995
10-09-1995
MEKS Flow
Routed Flow
X, Y = (09-03-1994 19:13:08, -156.51)
Start
Exceed
C:\Docum...
xterm
RiverWare...
Diagnostic...
Run Control
Run Status
Open Obje...
Edit LGLK ...
Plot
Snapshot ...
Edit LGLK ...
SCT (Dail...
Plot
8:42 PM

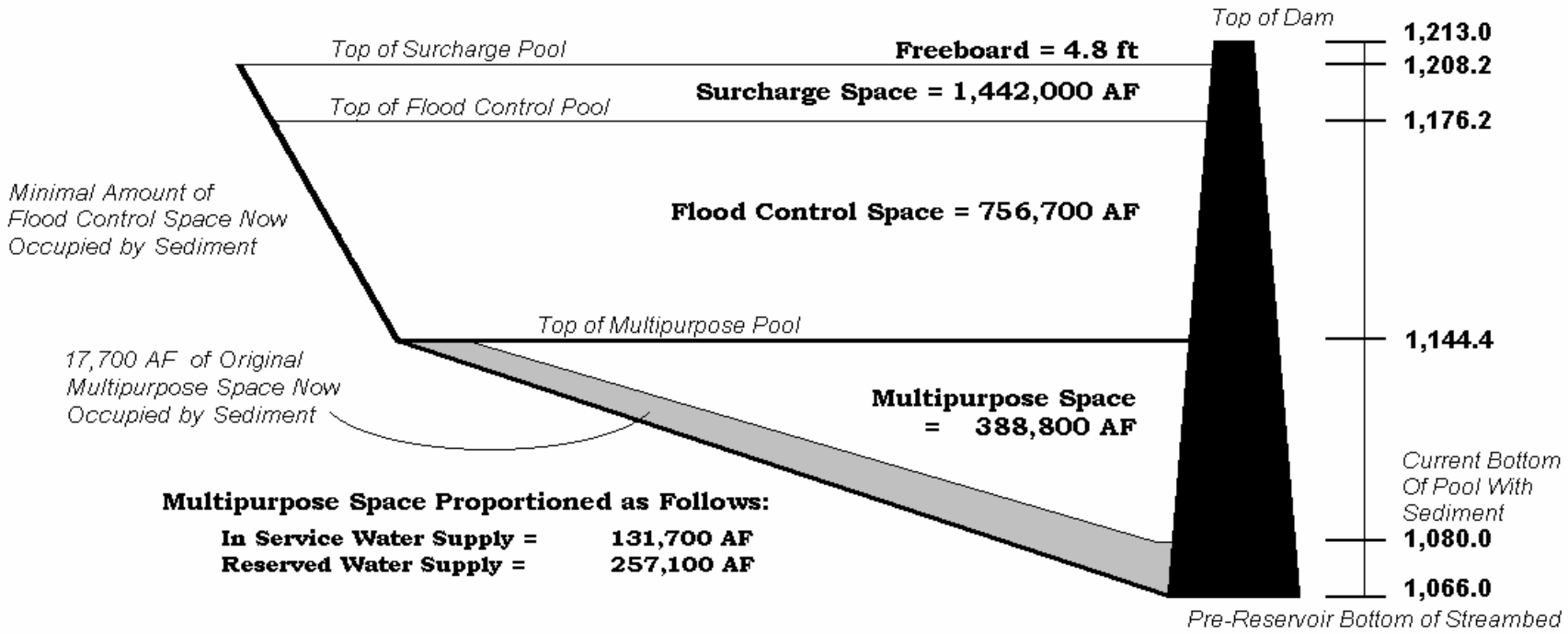

Plot
File Edit Graph Data Window
October 1, 1928
150000.00000
100000.00000
50000.00000
0.00000
-50000.00000
4-29-1927
1-05-1941
9-14-1954
5-23-1968
1-30-1982
10-09-1995
6-17-2009
NLSKFLOW.Gage Inflow
NLSKUNGAGED.Local Inflow
Start
Inbox - M...
Exceed
Microsoft Ou...
Final Rep...
xterm
xterm
RiverWar...
Diagnosti...
Run Cont...
Run Status
Documen...
C:\Docu...
Microsoft...
SCT (Da...
Plot
3:24 PM

RiverWare Enhancements

- Phase Balance Flood Control
- Surcharge Operation
  - Pass Inflows
  - Induced Surcharge Curve
  - Specified Surcharge

Milford Lake
Current Storage Allocations

As of Last Sediment Survey in 1980



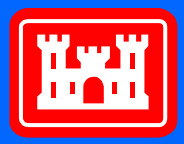
Multipurpose Space Proportioned as Follows:

In Service Water Supply =	**131,700 AF**
Reserved Water Supply =	**257,100 AF**

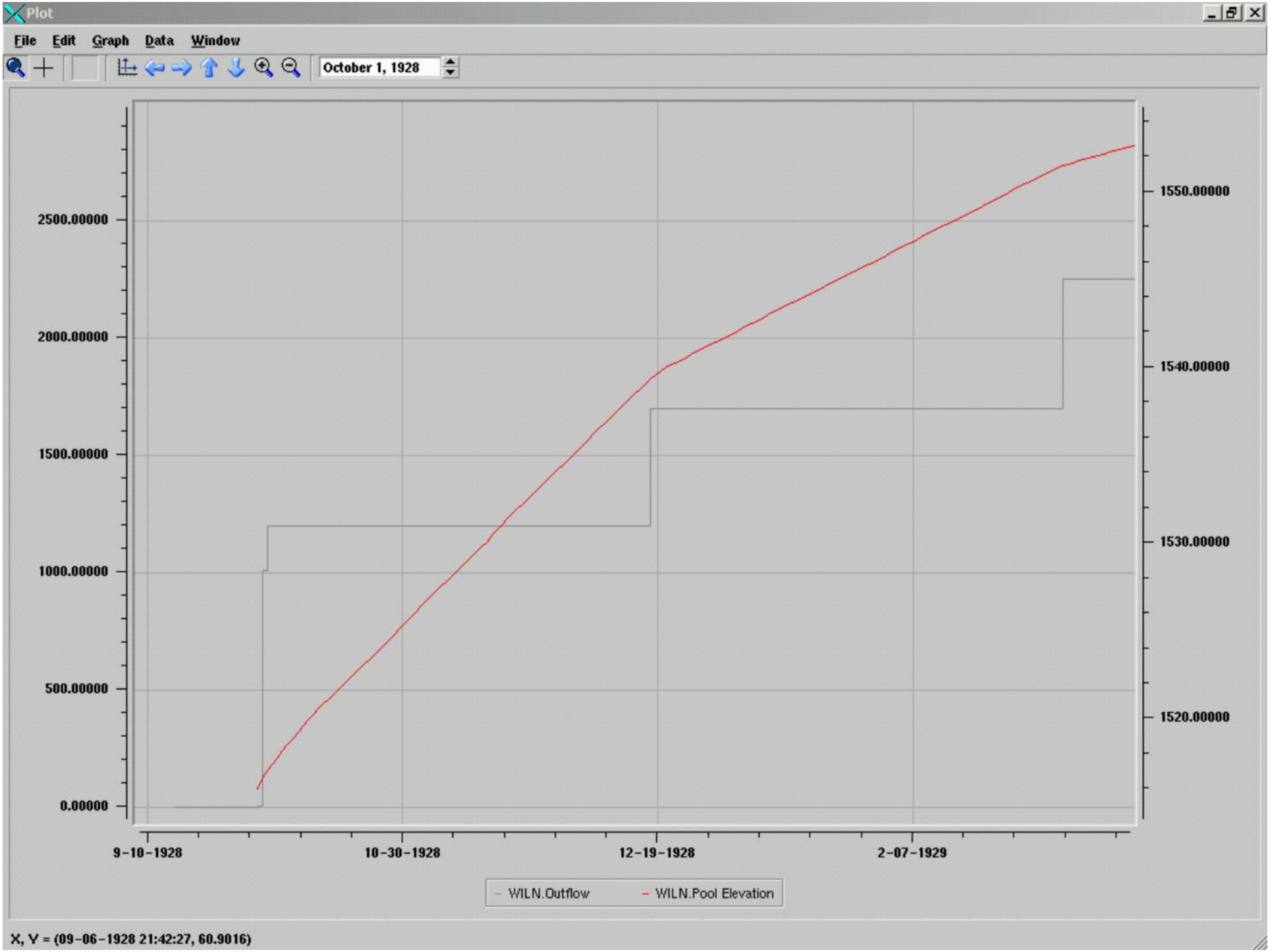
Storage Allocations	**At Closure (1964)**	**Current**	**At End of Design Life**
Flood Control	**754,800 AF**	**756,700 AF**	**700,000 AF**
Multipurpose	**406,500 AF**		
Water Supply			
In Service		**131,700 AF**	**101,650 AF**
Reserved		**257,100 AF**	**198,350 AF**

Phase Balance / Surcharge Validation

- Hypothetical Flow Events
  - Input high steady inflow to Lakes
  - Check flow at downstream Control Points
  - Insure that lake operation appropriate
  - Check tandem operation of HACO & LOVL
- Six hour model of each surcharge method
  - Rout spillway design flood
  - Insure appropriate lake elevation/release

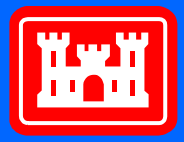


US Army Corps of Engineers
Kansas City District


Plot
File Edit Graph Data Window
October 1, 1928
2500.00000
2000.00000
1500.00000
1000.00000
500.00000
0.00000
1550.00000
1540.00000
1530.00000
1520.00000
9-10-1928
10-30-1928
12-19-1928
2-07-1929
WILN.Outflow
WILN.Pool Elevation
X, Y = (09-06-1928 21:42:27, 60.9016)

Surcharge Validation

	Manual Study (2 hour data)		RiverWare (6 hour data)	
	Peak Elev	Max Release	Peak Elev	Max Release
Clinton	921.7	54,500 cfs	921.39	55,040 cfs
Tuttle	1151.4	579,000 cfs	1151.79	587,360 cfs
Milford	1207.13	549,000 cfs	1207.4	551,000 cfs

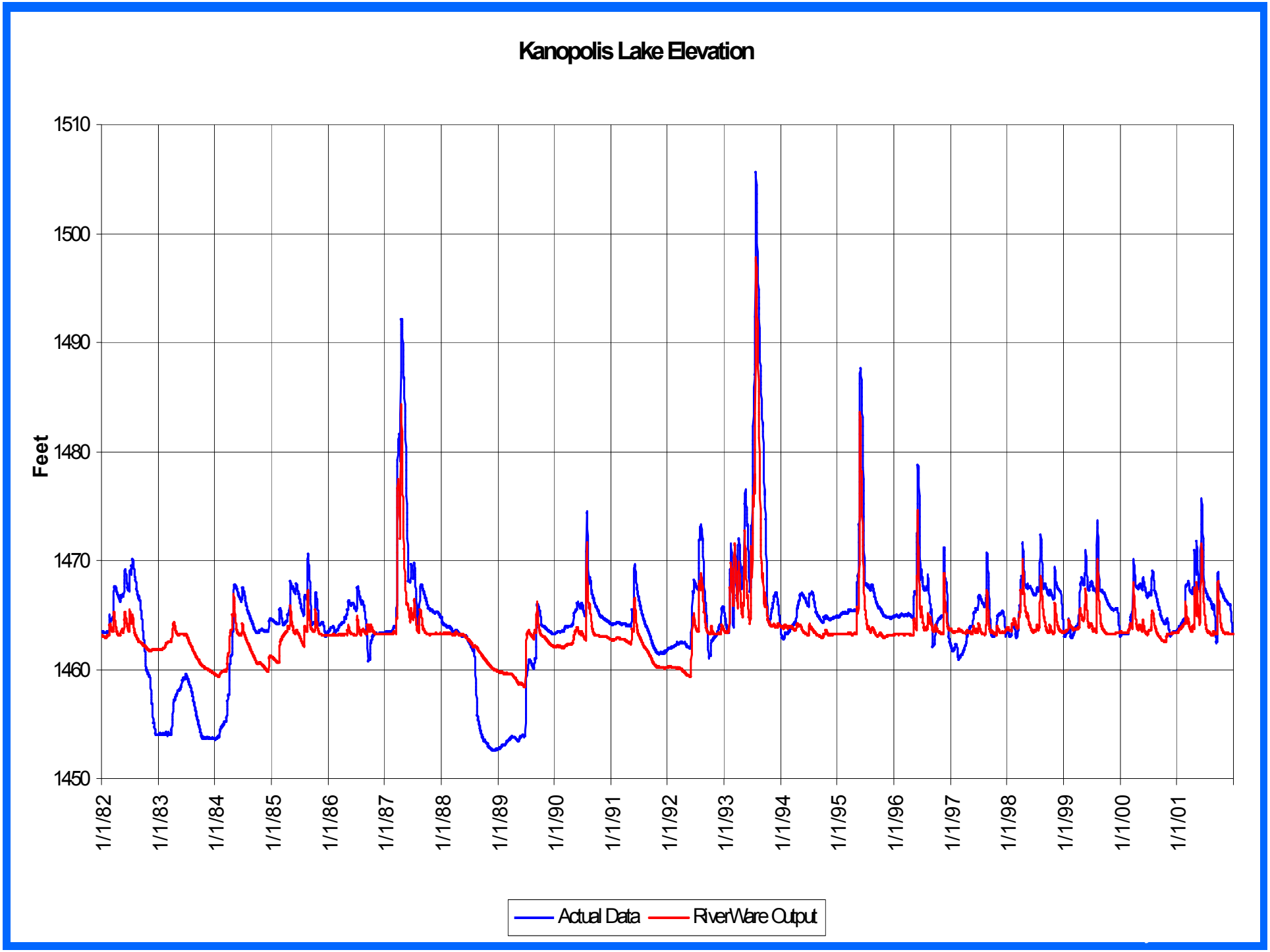


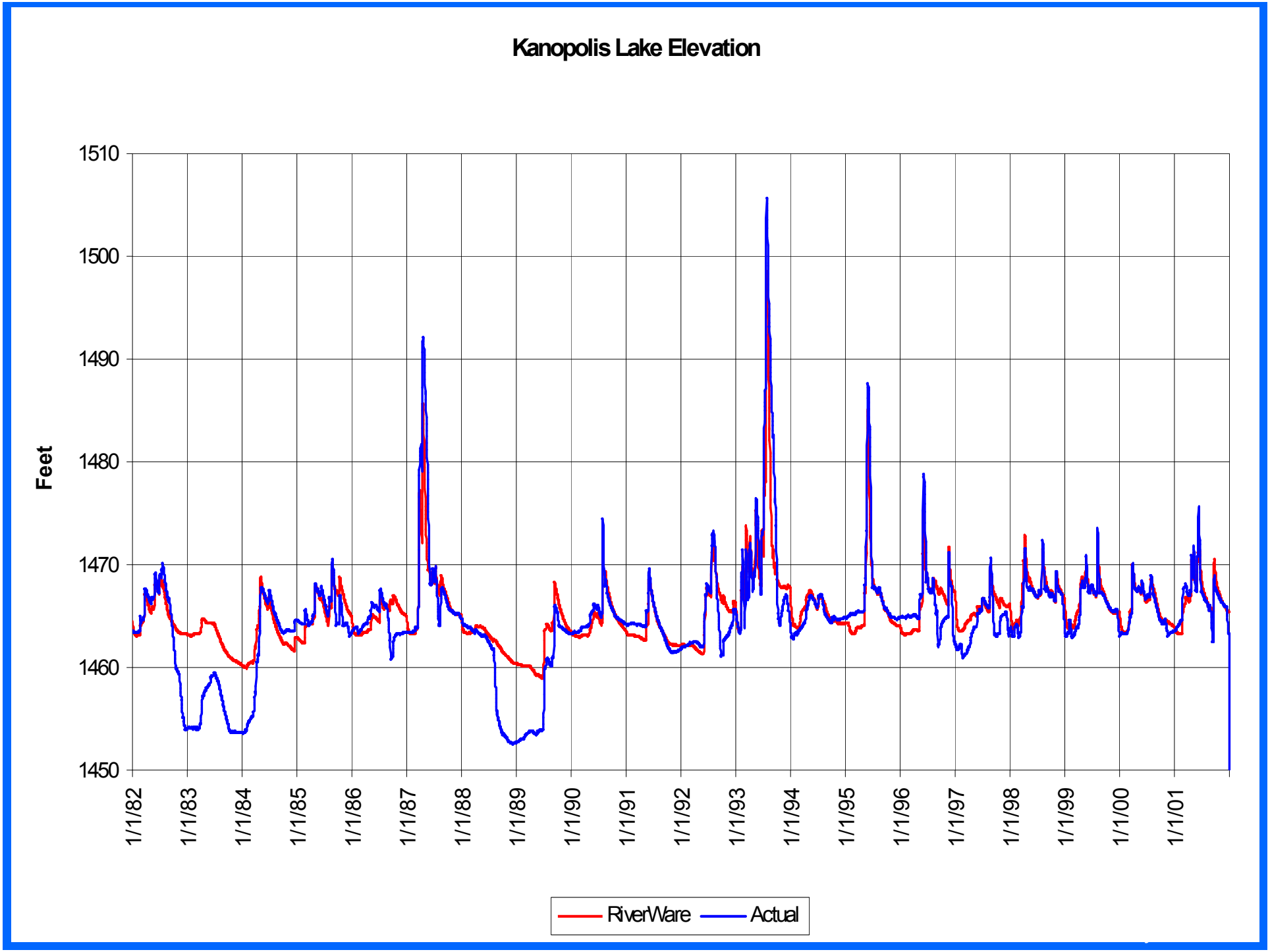
US Army Corps of Engineers
Kansas City District

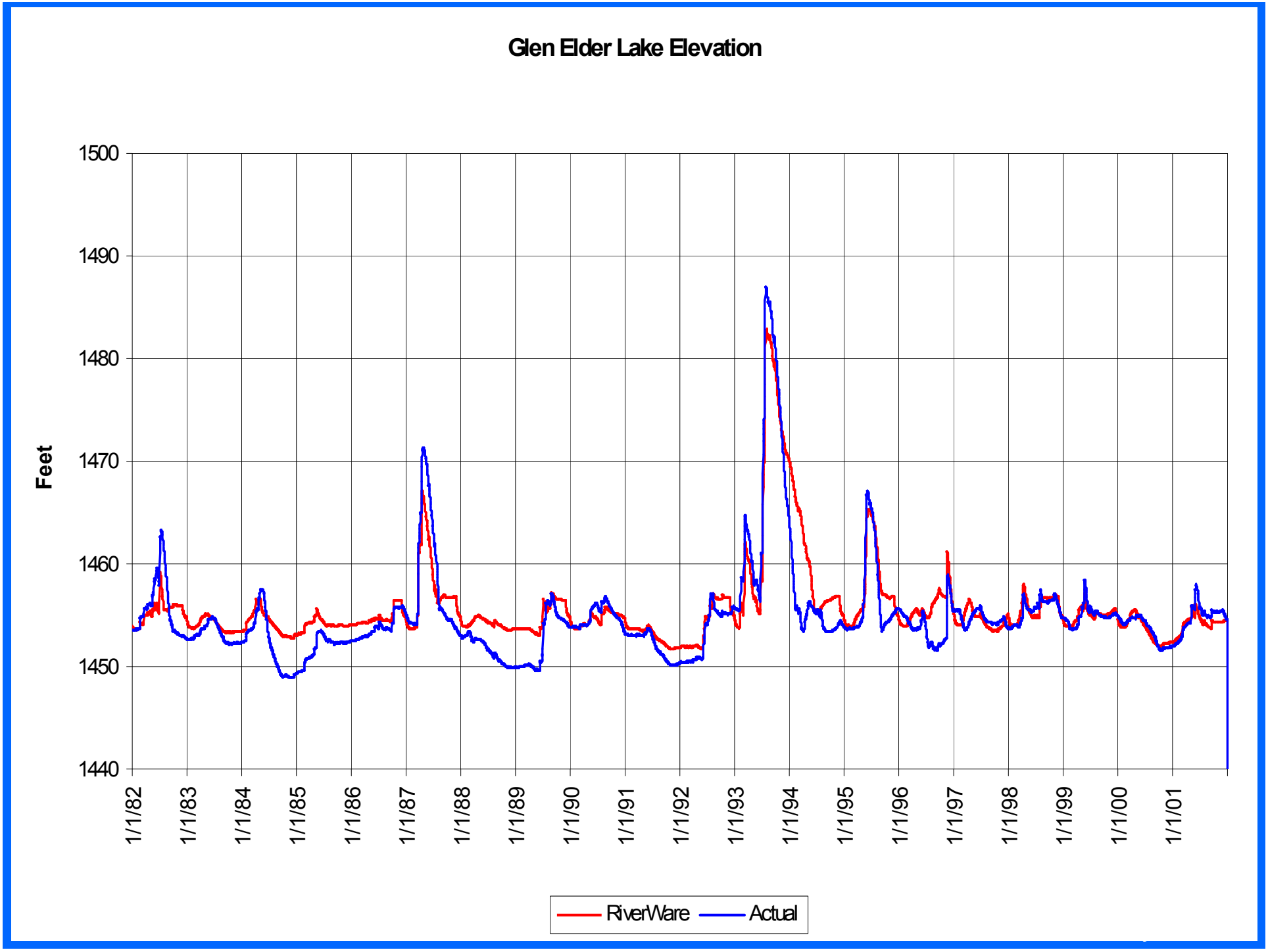
Model Validation

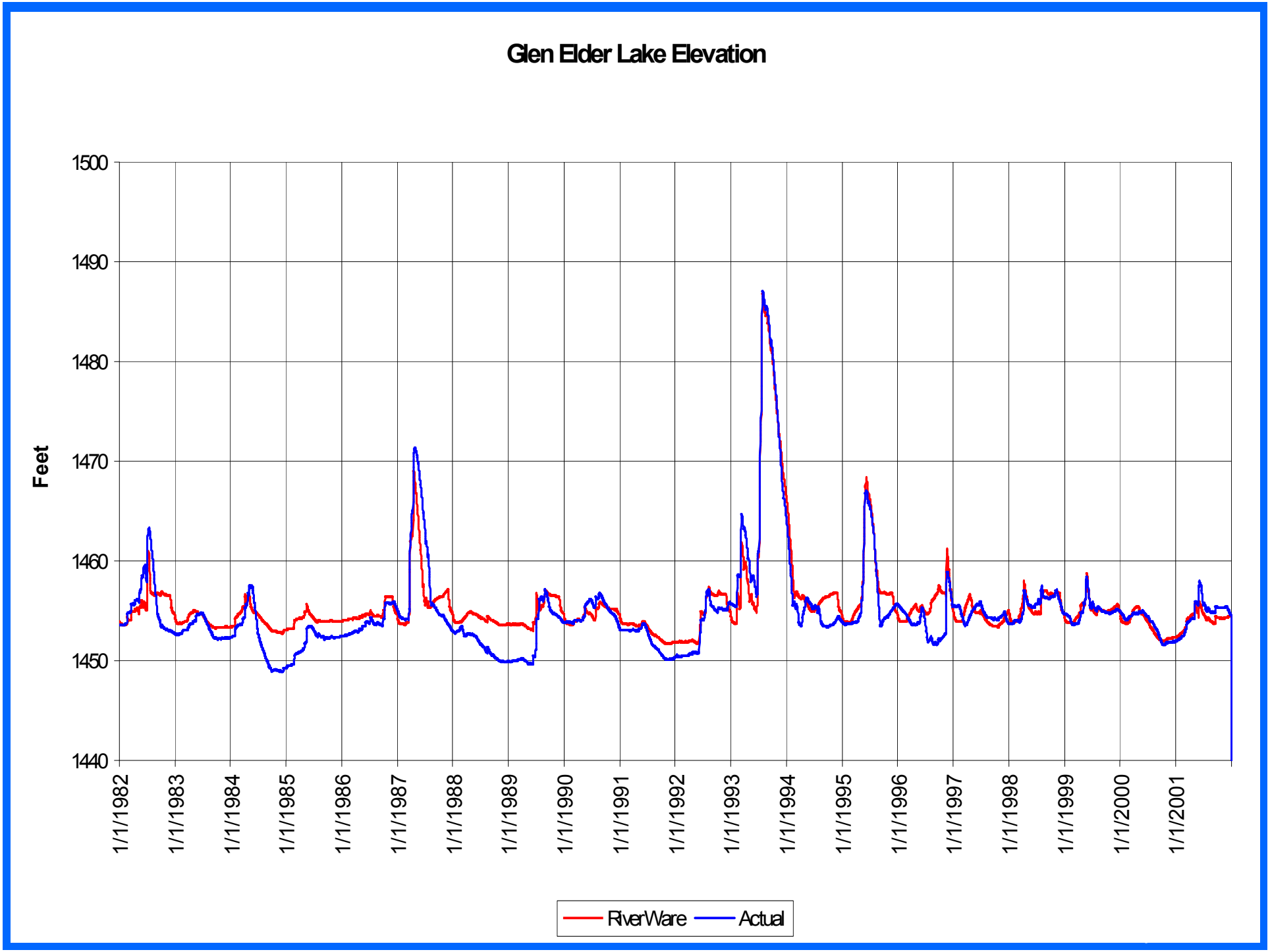
- Validation Period: 1982 through 2001
- Lakes Constructed Prior to 1982
- Input Data Higher Quality
- Very Dry Period
  - 1988 through 1992
- Very Wet Period
  - 1993
- Ongoing Process

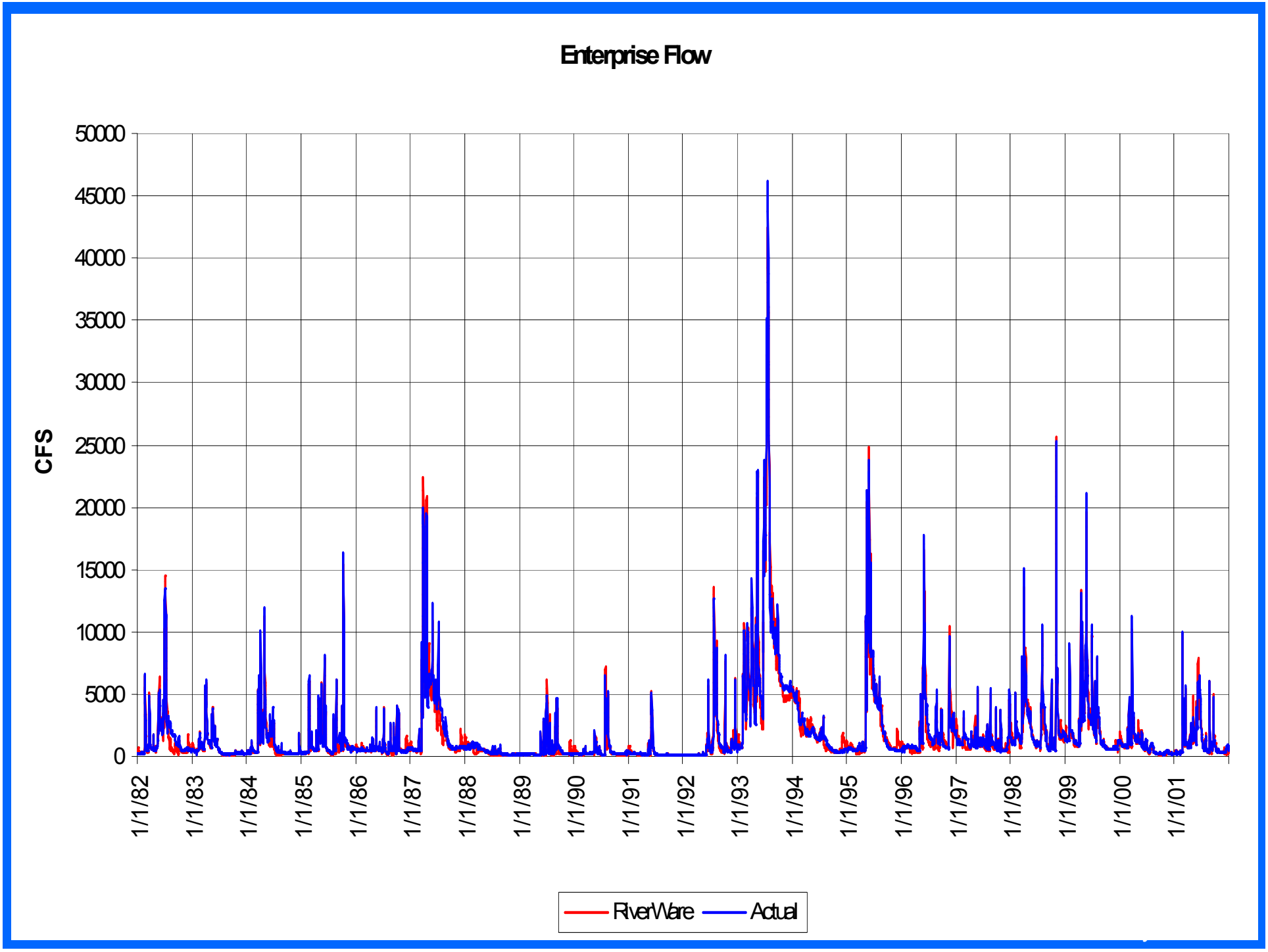
US Army Corps of Engineers
Kansas City District


Kanopolis Lake Elevation
Feet
1510
1500
1490
1480
1470
1460
1450
1/1/82
1/1/83
1/1/84
1/1/85
1/1/86
1/1/87
1/1/88
1/1/89
1/1/90
1/1/91
1/1/92
1/1/93
1/1/94
1/1/95
1/1/96
1/1/97
1/1/98
1/1/99
1/1/00
1/1/01
Actual Data
RiverWare Output


Kanopolis Lake Elevation
Feet
1510
1500
1490
1480
1470
1460
1450
1/1/82
1/1/83
1/1/84
1/1/85
1/1/86
1/1/87
1/1/88
1/1/89
1/1/90
1/1/91
1/1/92
1/1/93
1/1/94
1/1/95
1/1/96
1/1/97
1/1/98
1/1/99
1/1/00
1/1/01
RiverWare
Actual


Glen Elder Lake Elevation
Feet
1500
1490
1480
1470
1460
1450
1440
1/1/82
1/1/83
1/1/84
1/1/85
1/1/86
1/1/87
1/1/88
1/1/89
1/1/90
1/1/91
1/1/92
1/1/93
1/1/94
1/1/95
1/1/96
1/1/97
1/1/98
1/1/99
1/1/00
1/1/01
RiverWare
Actual


Glen Elder Lake Elevation
Feet
1500
1490
1480
1470
1460
1450
1440
1/1/1982
1/1/1983
1/1/1984
1/1/1985
1/1/1986
1/1/1987
1/1/1988
1/1/1989
1/1/1990
1/1/1991
1/1/1992
1/1/1993
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001
RiverWare
Actual


Enterprise Flow
CFS
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1/1/82
1/1/83
1/1/84
1/1/85
1/1/86
1/1/87
1/1/88
1/1/89
1/1/90
1/1/91
1/1/92
1/1/93
1/1/94
1/1/95
1/1/96
1/1/97
1/1/98
1/1/99
1/1/00
1/1/01
RiverWare
Actual

Model Limitations

- Time for execution
  - Smoky Basin – 20 Minutes
  - Kansas/Republican Basin – 2 Hours
- Depletion of flows
  - Farming practices
  - Groundwater development
- Does not incorporate upstream reservoirs
- Difficult to simulate older data

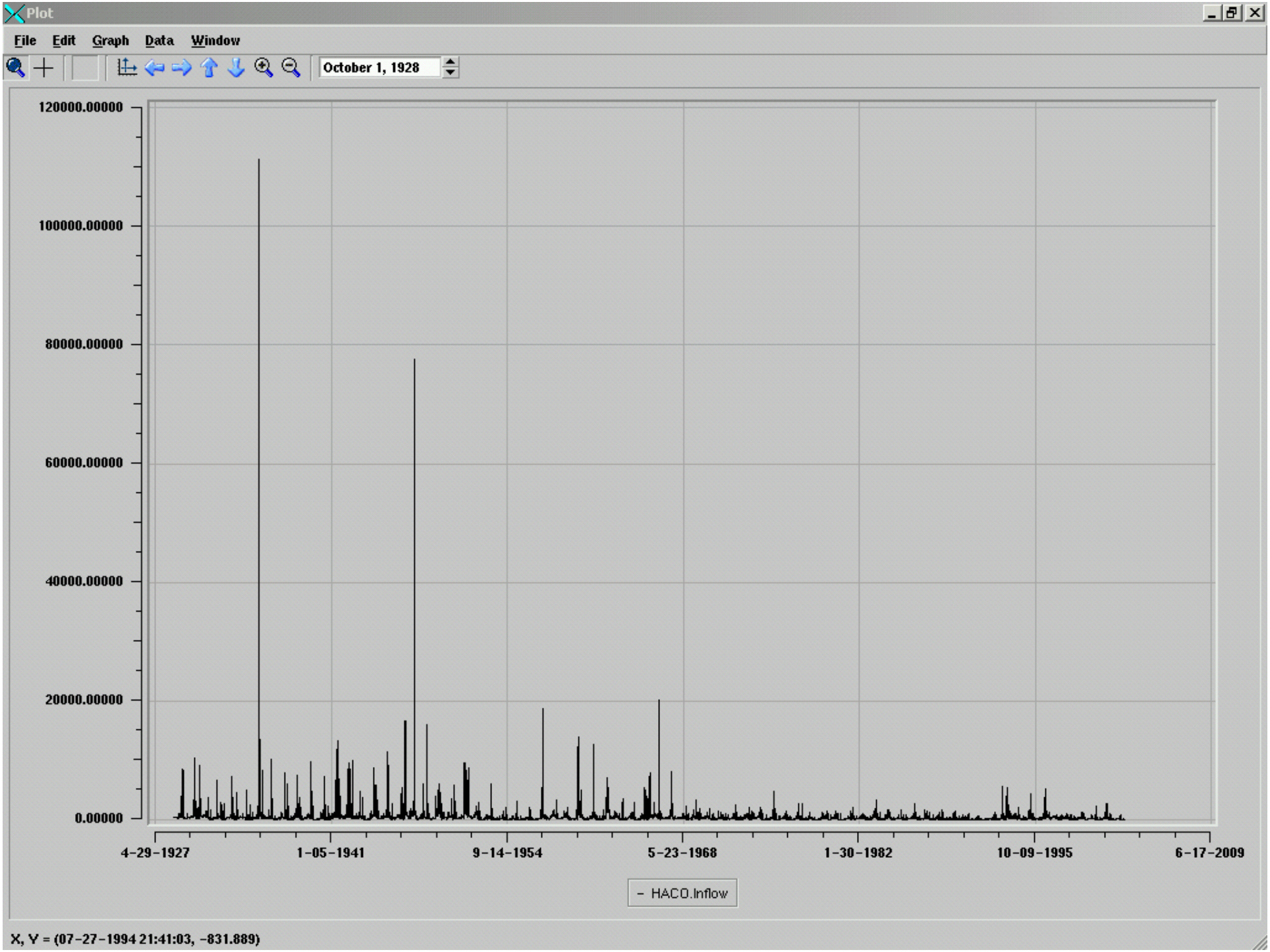
US Army Corps of Engineers
Kansas City District

Basin Lakes Not Modeled

In accordance with the PMP, many upstream lakes have not been included in the Model. Model lakes that have upstream flood control structures are:

Model Lake	Upstream Lake
KANS	Cedar Bluff
GLEL	Kirwin, Webster
HACO	Norton, Bonny, Swanson, Hugh Butler, Harry Strunk, and Enders

US Army Corps of Engineers
Kansas City District


Plot
File
Edit
Graph
Data
Window
October 1, 1928
120000.00000
100000.00000
80000.00000
60000.00000
40000.00000
20000.00000
0.00000
4-29-1927
1-05-1941
9-14-1954
5-23-1968
1-30-1982
10-09-1995
6-17-2009
- HACO.Inflow
X, Y = (07-27-1994 21:41:03, -831.889)


RiverWare
C351-300-021198
Parker Dam

Edward Parker
816 983-3145
Kansas City District
U.S. Army Corps of Engineers
Edward.e.parker@usace.army.mil

US Army Corps of Engineers
Kansas City District