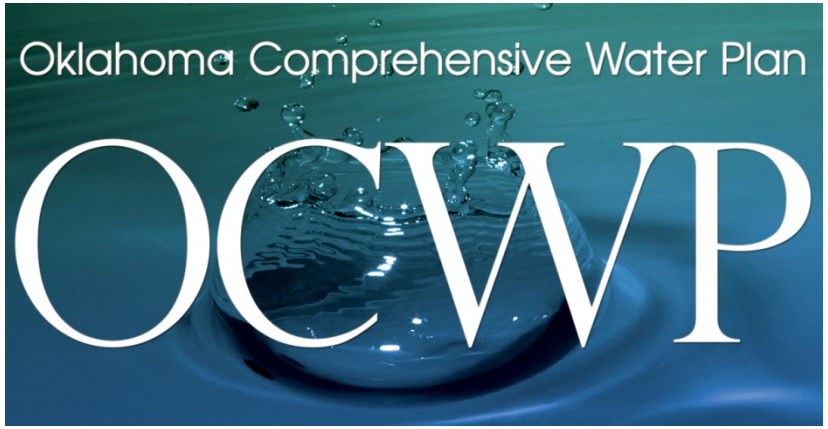
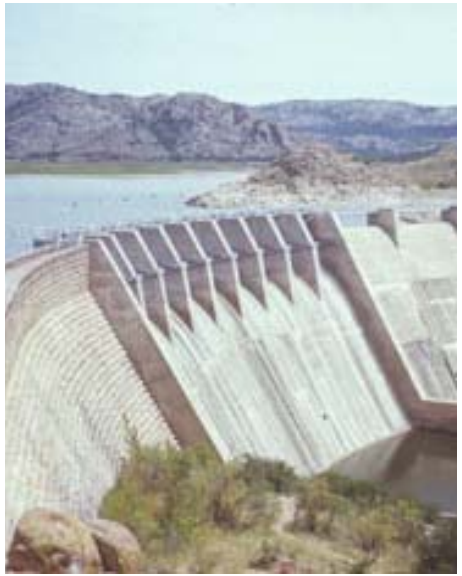
State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency



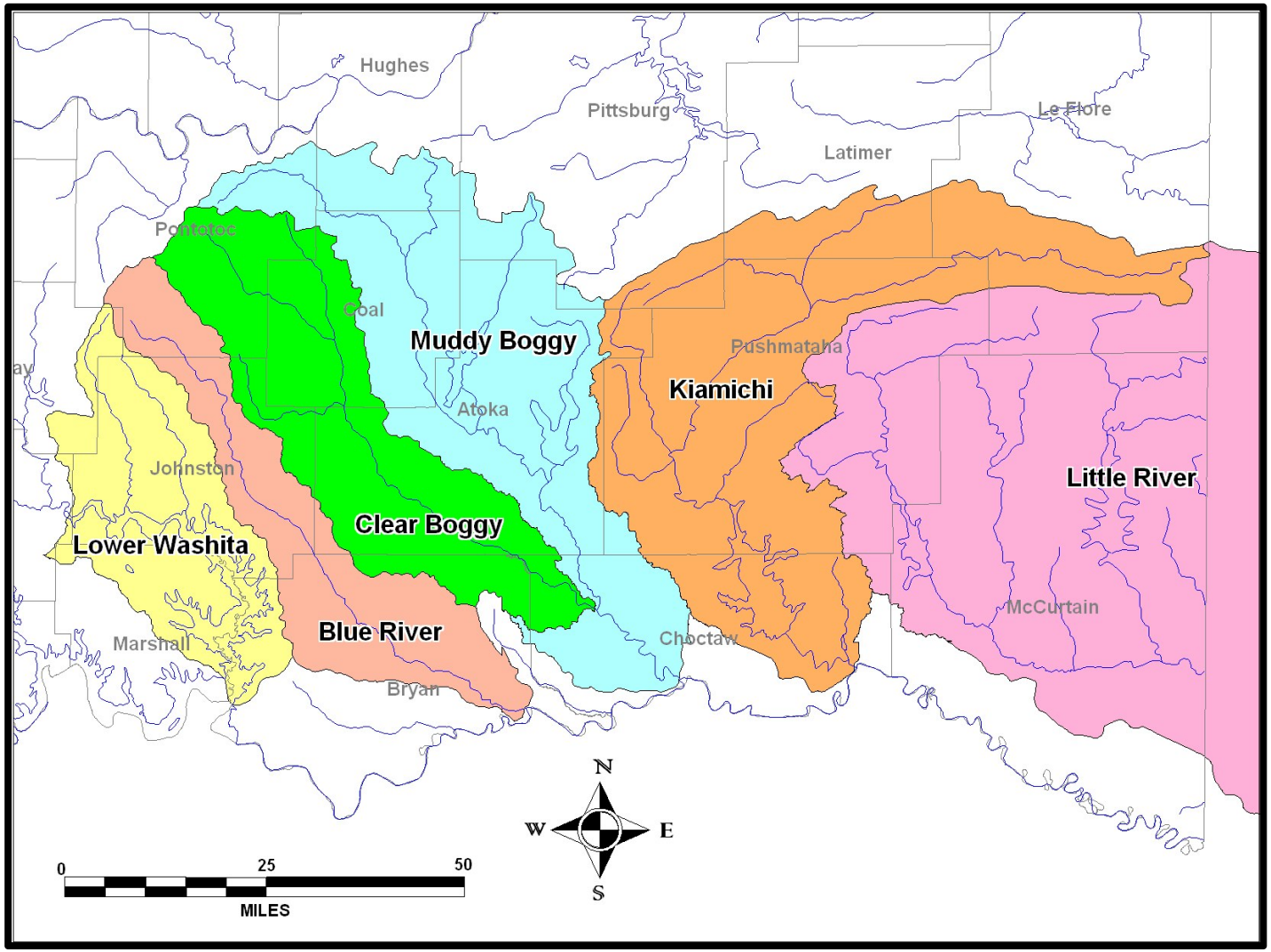
amec

Enhanced Management Through Technology

Water Allocation Modeling



Water Allocation Modeling in Oklahoma



Water Allocation Modeling: What is it?

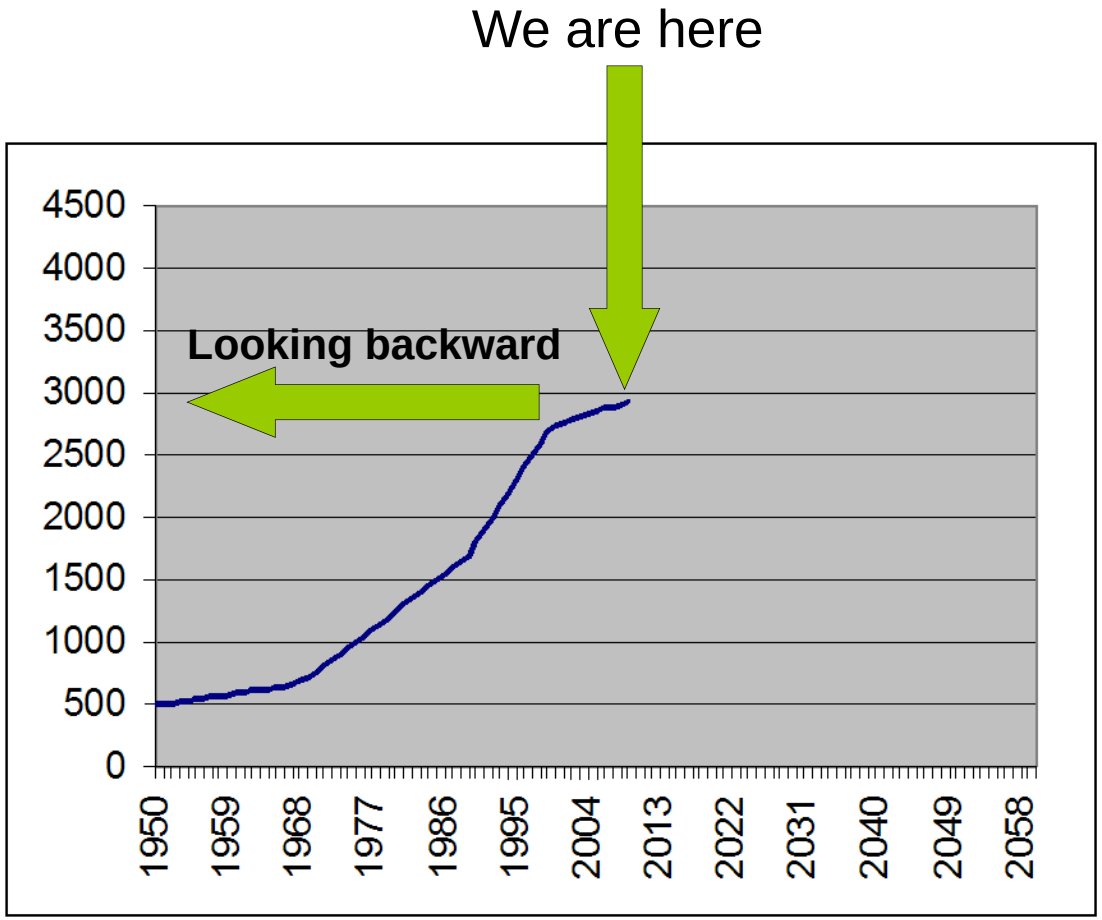
- **Balancing the River's Checkbook**
  - Add in inflows (deposits)
  - Subtract outflows (expenditures)
- **Objective: Avoid bouncing any checks**
- **A River System is a Complex Bookkeeping Problem**
  - Inflows vary rapidly
  - Uses need water at specific times
  - Inflows and uses are in specific places
  - Using averages (in space or time) can conceal shortfalls
- **Water Allocation Model**
  - Balances the checkbook for each day or each month
  - Delivers water to users according to their priority
    - "First in time, first in line"

Water Allocation Modeling: What Can We do with it?

- **Simulate historical conditions**

Historical Water Use

- Model validation
- Performance of project or water rights

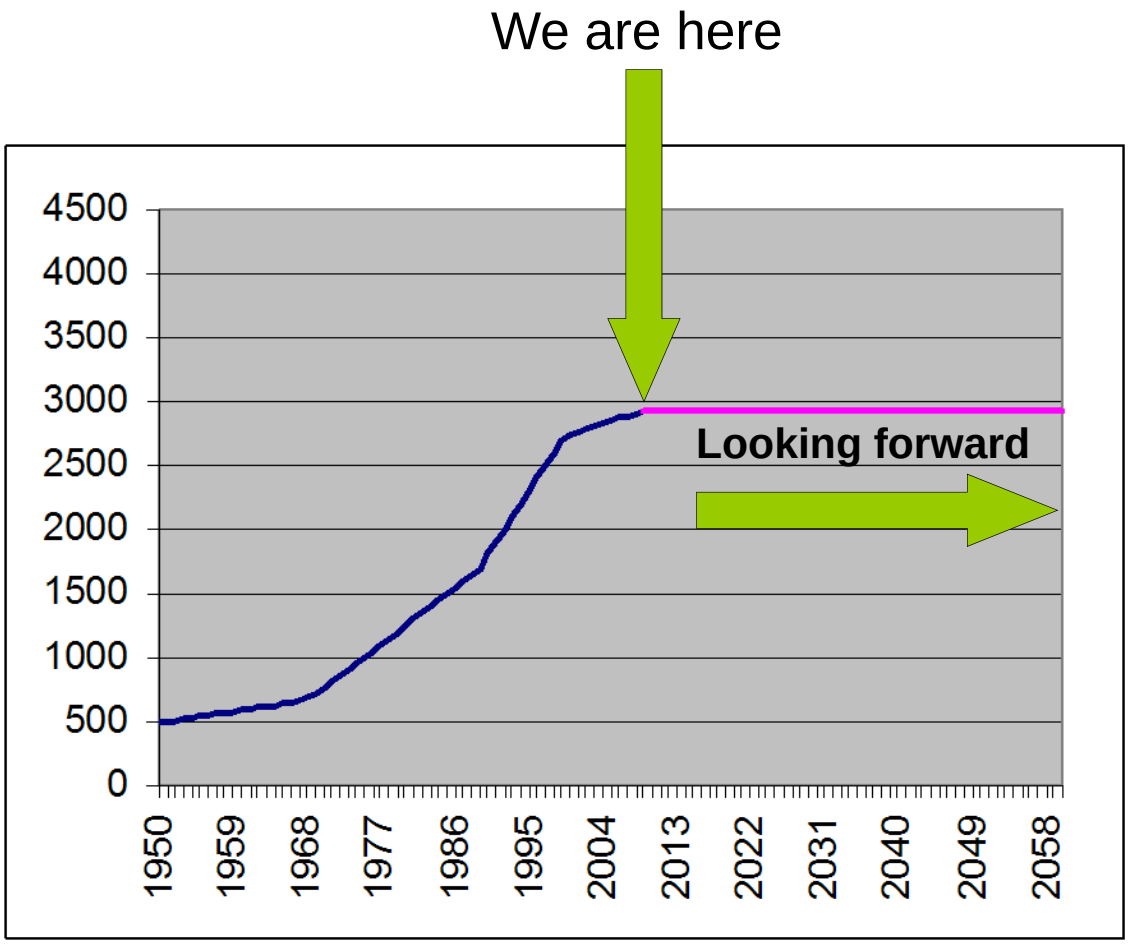


Water Allocation Modeling: What Can We do with it?

- **Simulate current conditions**
  - Looking forward

Current Water Use

- Administration
- Operations

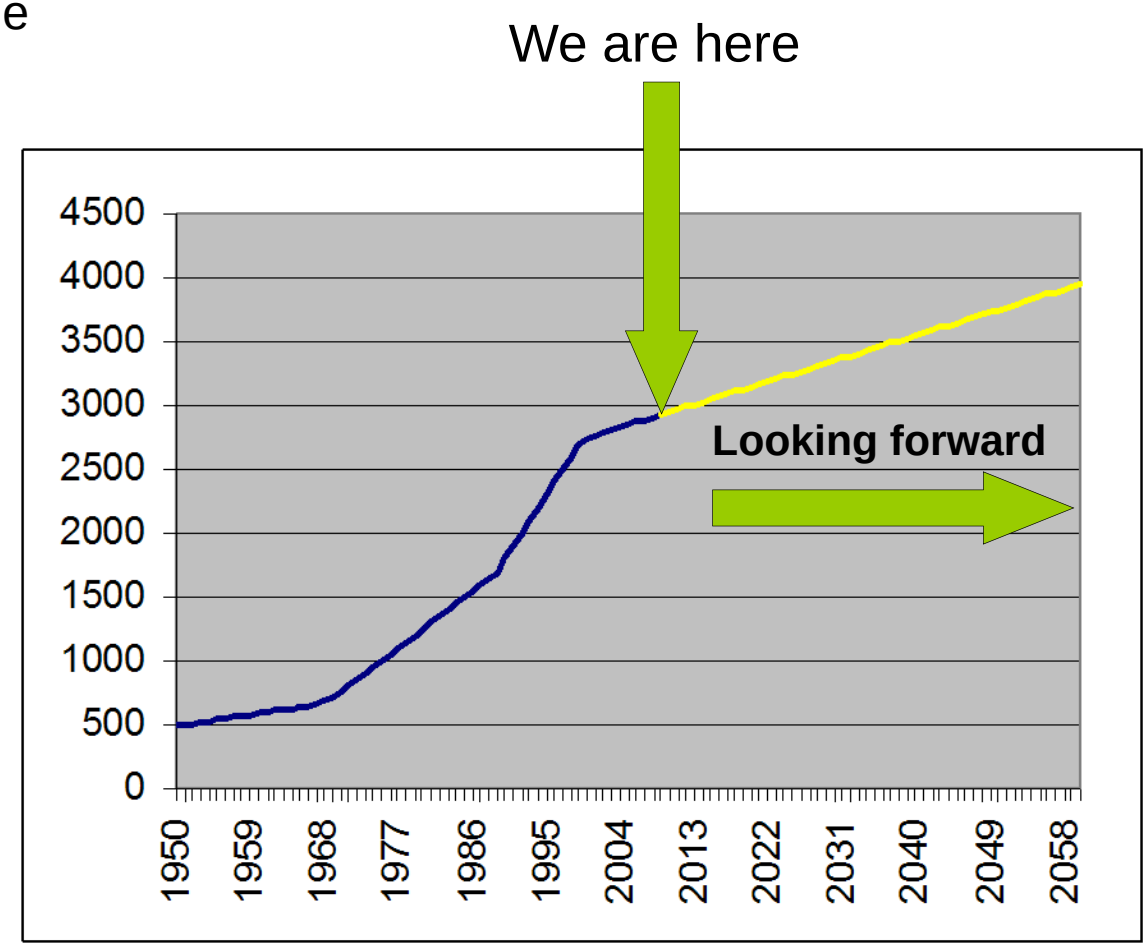


Water Allocation Modeling: What Can We do with it?

- **Simulate growth of water use**
  - Looking forward over time

Growth of Water Use

- Infrastructure
- Water supply
- Operations

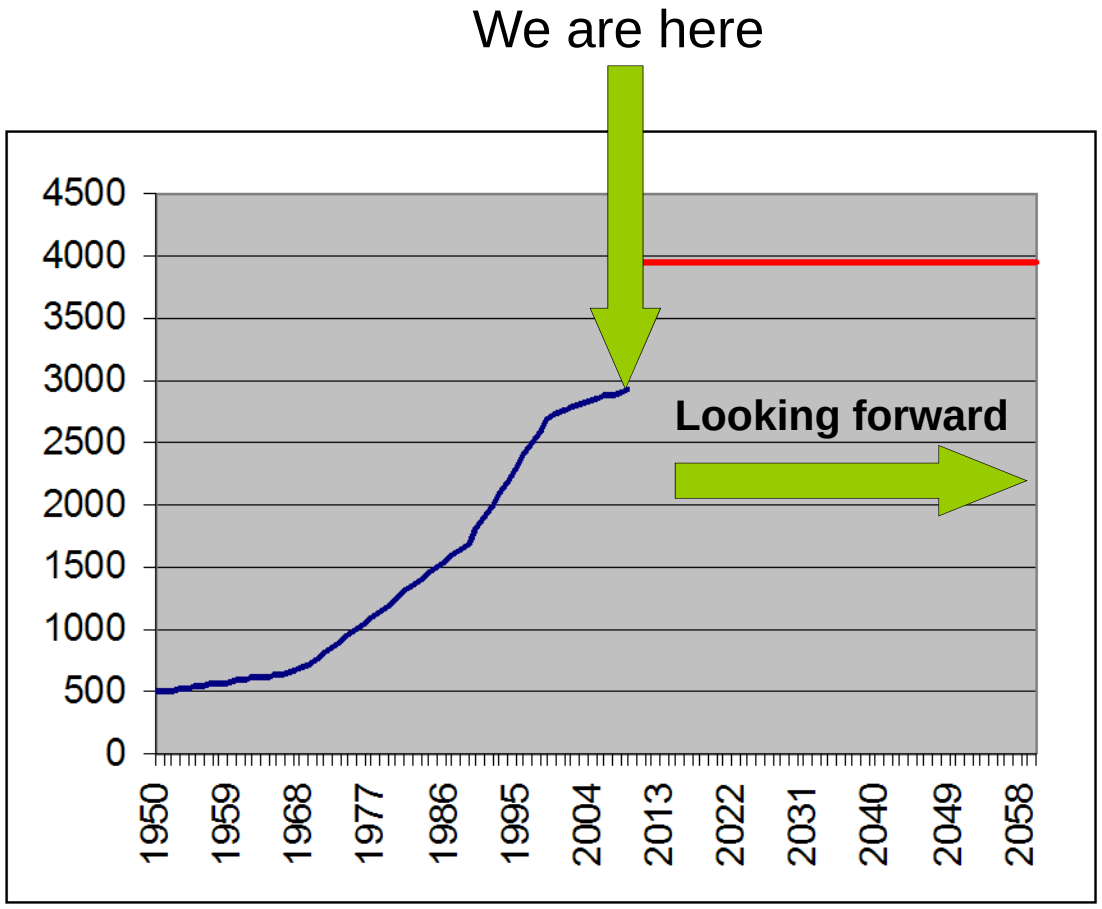


Water Allocation Modeling: What Can We do with it?

- **Simulate Full Permit use**
  - Looking forward to a particular time

Full-permit Water Use

- Permitting
  - Application available water
- Reliability
- Water Supply
- Infrastructure



What flows do we use?

- **“What-if” analyses**
  - Evaluate potential water uses
  - Evaluate potential facilities
  - Evaluate candidate operating practices
- **These require a “clean slate”**
- **“Naturalized Flows”**
  - Remove the influence of
    - Reservoirs
    - Water uses
    - Imports/Exports
- **Alternate hydrology**
  - Extended drought sequences
  - Long-term projections

Blue River Basin

- **Naturalizing Flows**
  - Locate USGS gages.
  - Calculate total historical uses above gages.
  - Add Permit Uses to gage flows to get total inflows.
  - Divide total inflow by drainage area to get acre-feet per square mile.

Blue River Basin

- Naturalizing Flows
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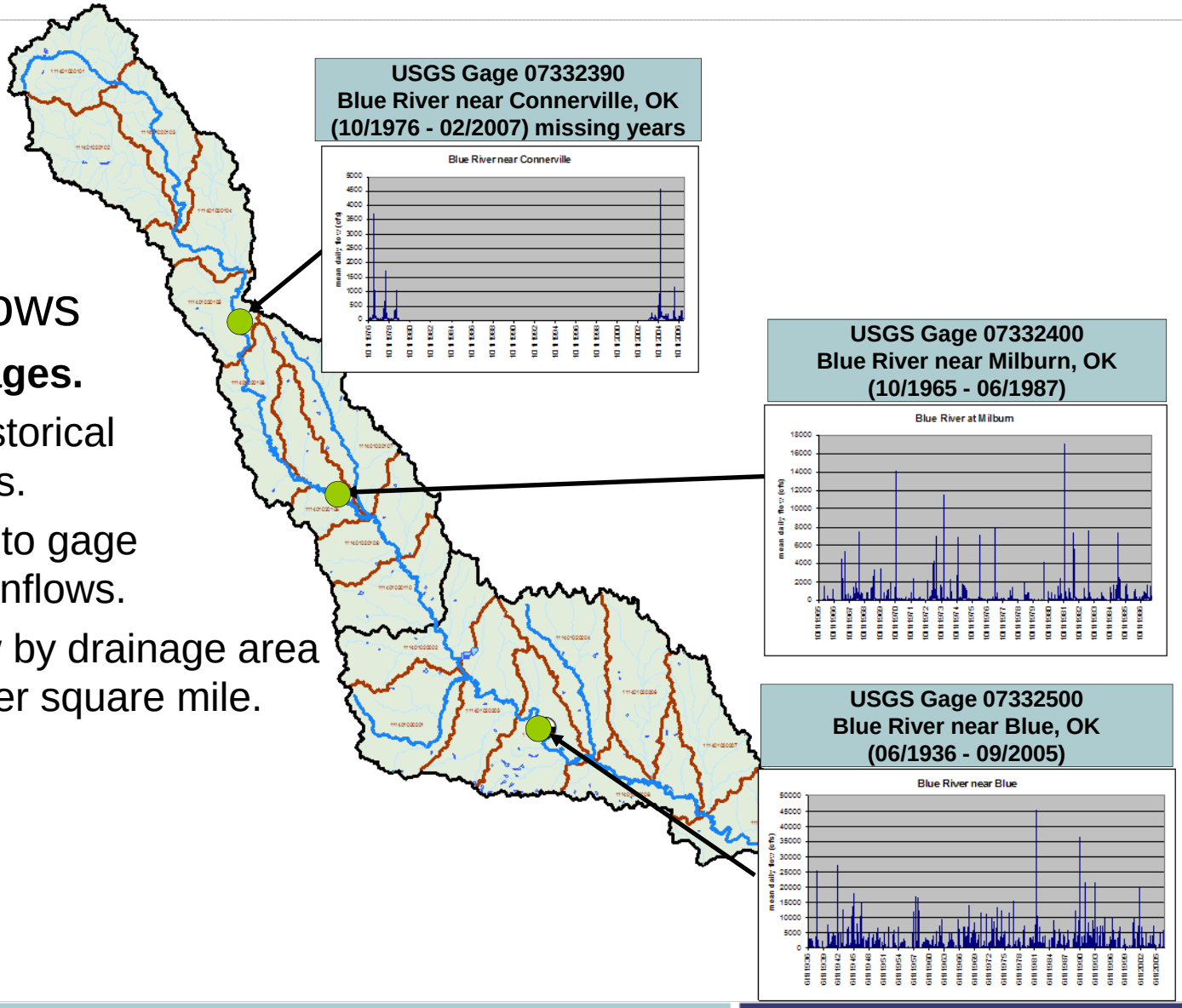

Blue River Basin

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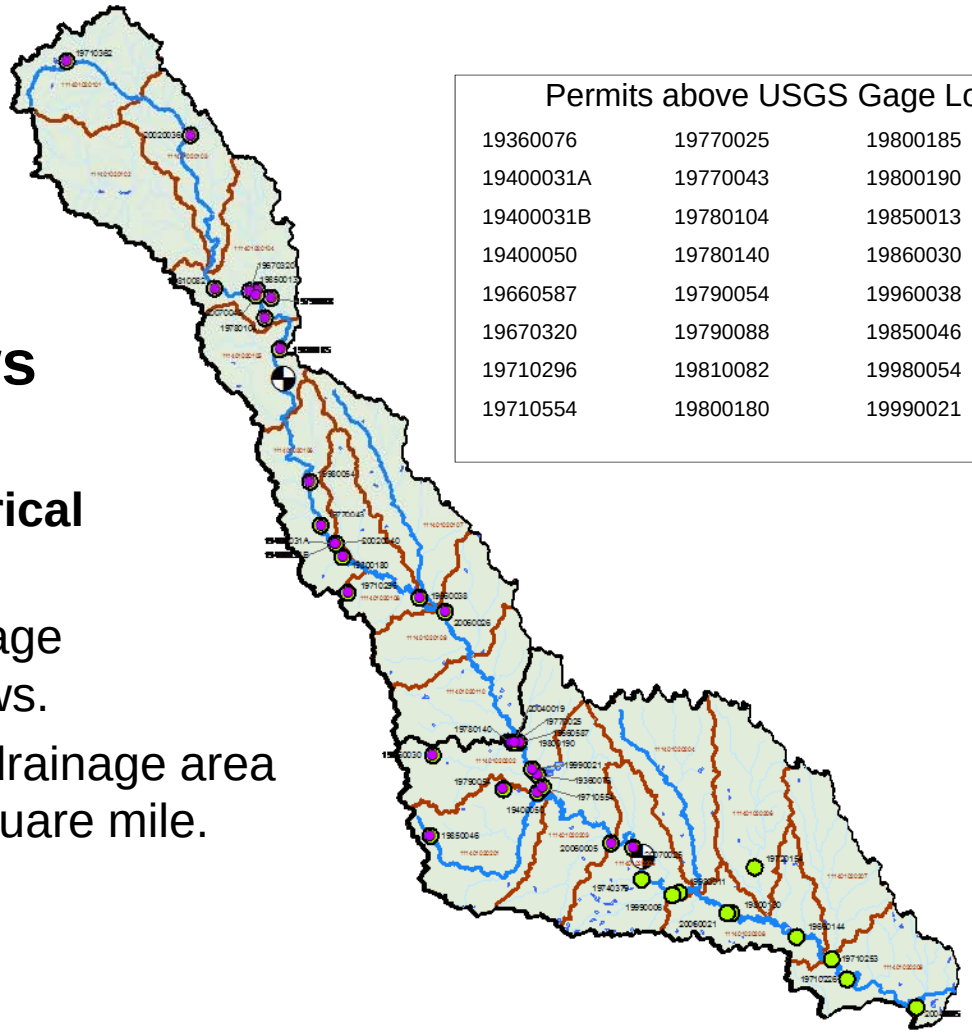
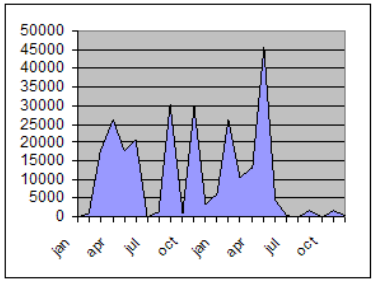


Permits above USGS Gage Locations:

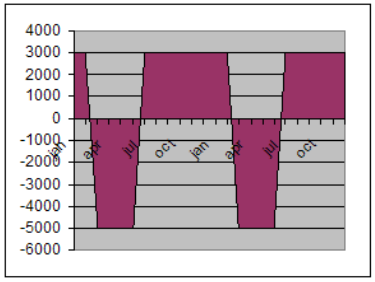
19360076	19770025	19800185	20020036
19400031A	19770043	19800190	19710362
19400031B	19780104	19850013	20020040
19400050	19780140	19860030	20040019
19660587	19790054	19960038	20070048
19670320	19790088	19850046	20060005
19710296	19810082	19980054	20060026
19710554	19800180	19990021	20070025

Naturalizing Flows



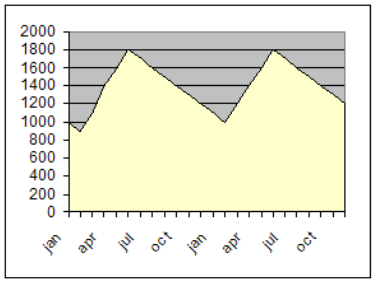
Gage Flow

+



Reservoir Change

+



Evaporation

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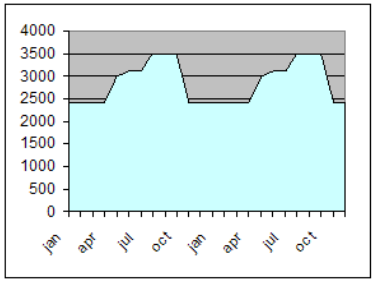
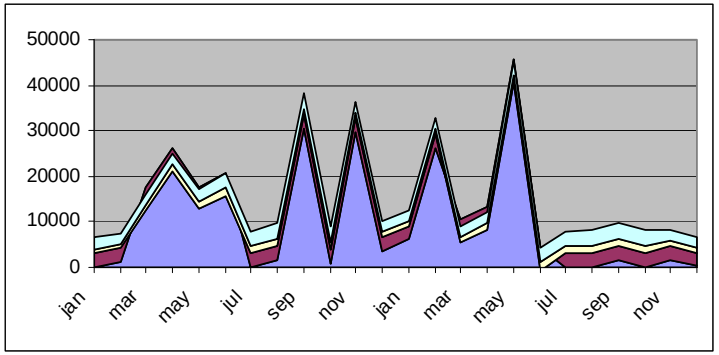


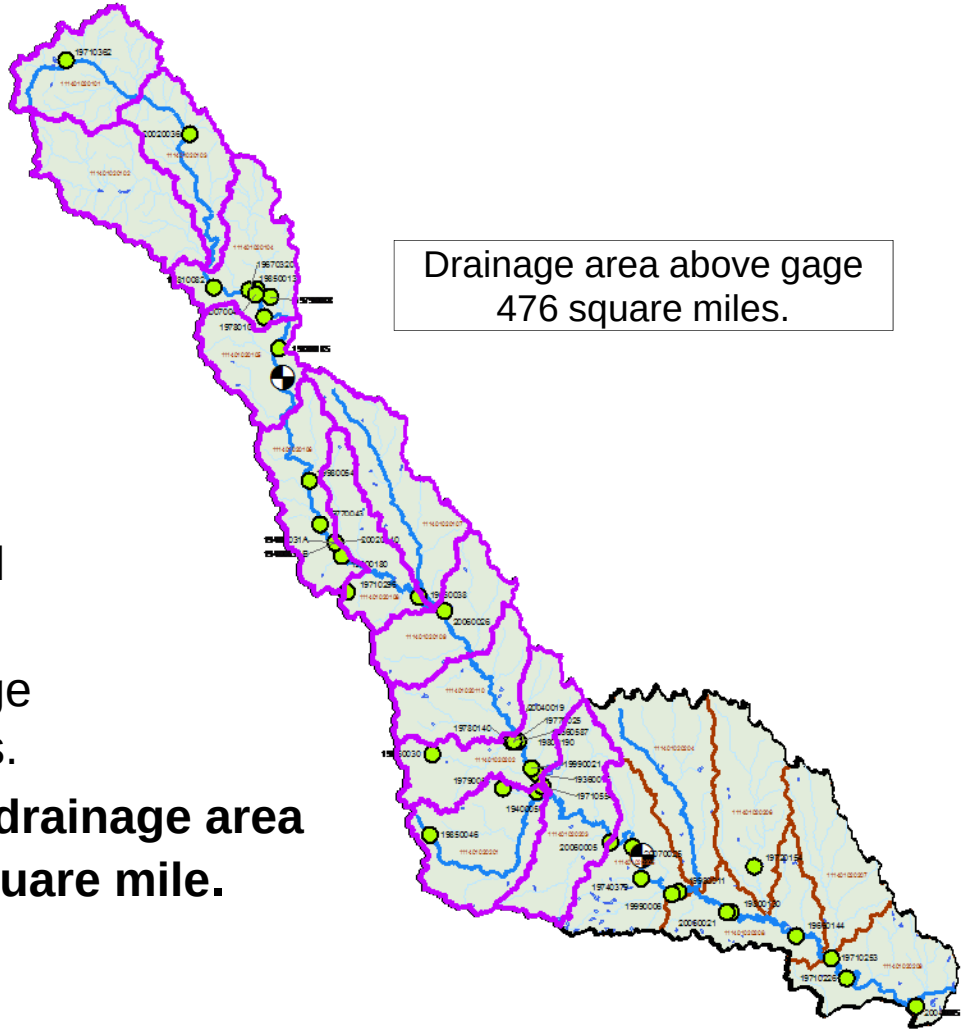
Water Use

=



- **Naturalizing Flows**
  - Locate USGS gages
  - Calculate total historical uses above gages.
  - **Add Permit Uses to gage flows to get total inflows.**
  - Divide total inflow by drainage area to get acre-feet per square mile.

Blue River Basin

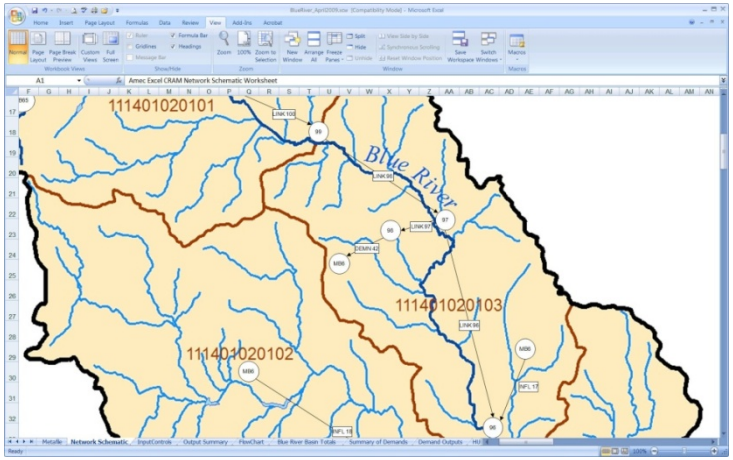


Drainage area above gage
476 square miles.

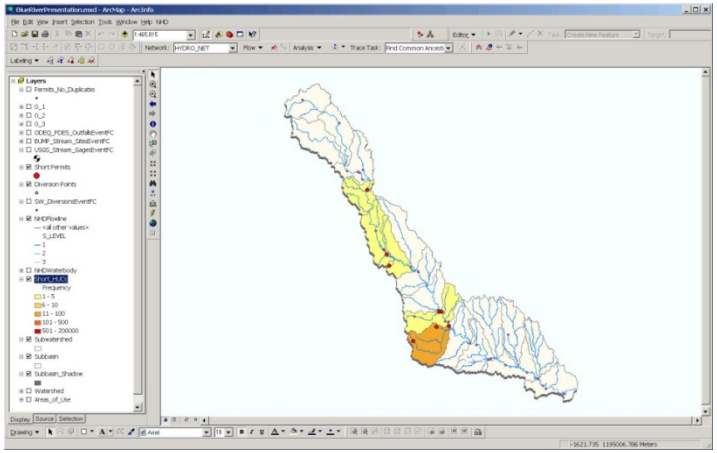
- Naturalizing Flows
  - Locate USGS gages.
  - Calculate total historical uses above gages.
  - Add Permit Uses to gage flows to get total inflows.
  - **Divide total inflow by drainage area to get acre-feet per square mile.**

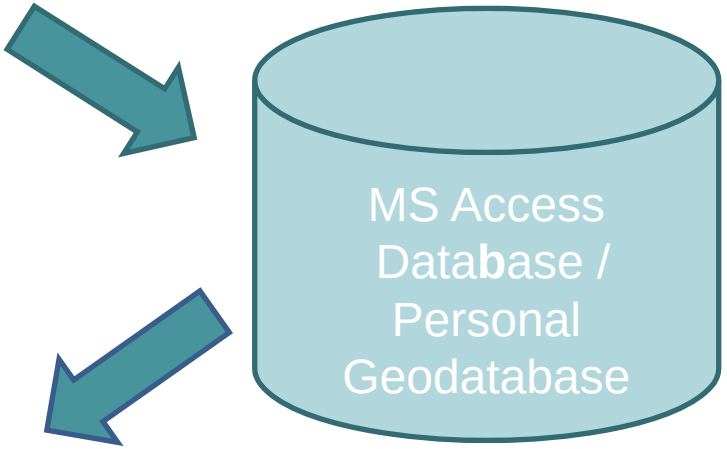
Integration of H2OK and ArcGIS

MS Excel – H2OK Model

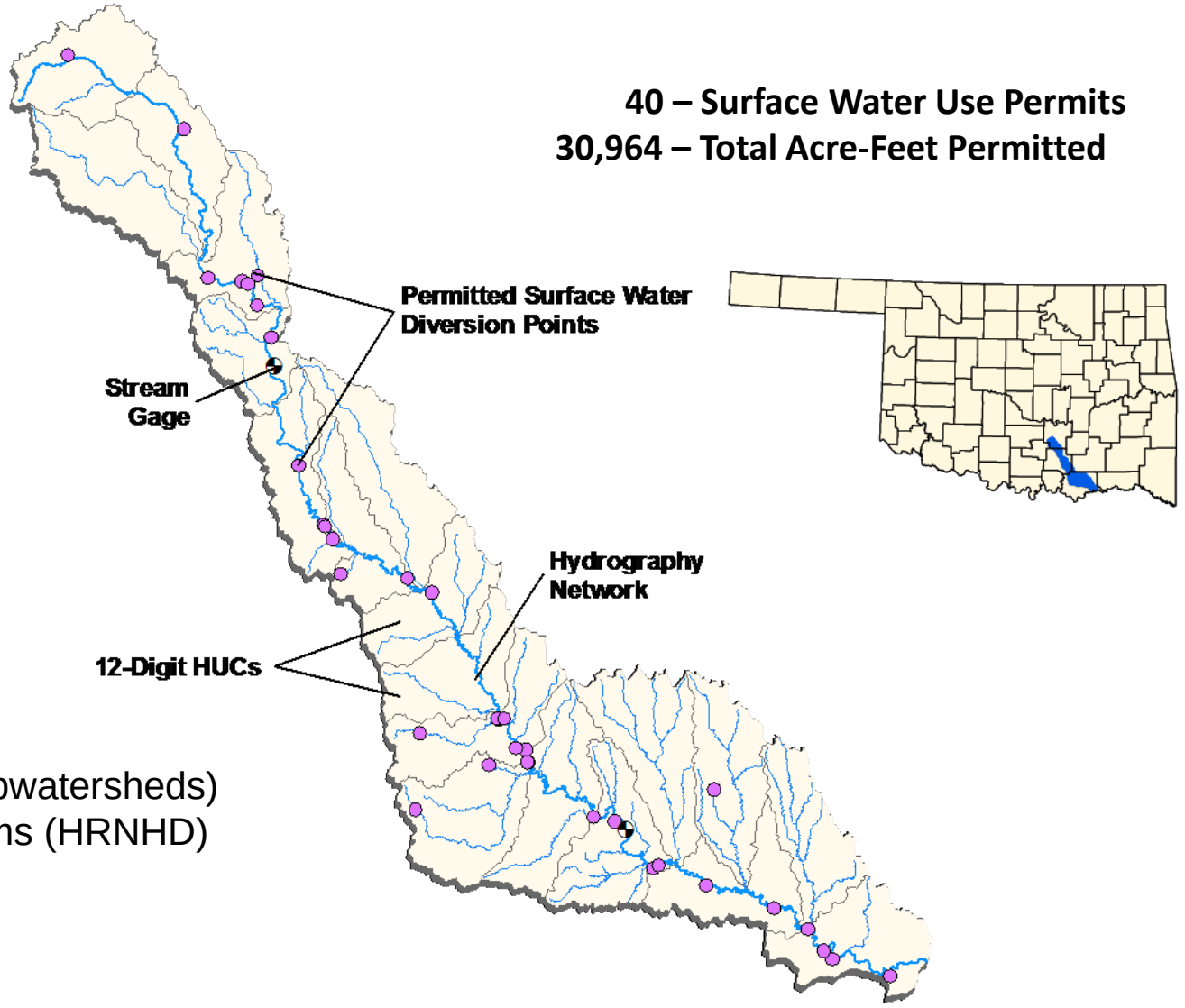


ArcMap – GIS Model





Blue River Basin



- **Blue River Basin**
  - 687 Square Miles
  - 9 12-Digit HUCs (Subwatersheds)
  - 1,800 Miles of Streams (HRNHD)

H2OK Modeling Scenarios

1 = Historic Scenario - uses reported values and average reported use to fill in unreported annual values (water user will have no demand for years prior to date of permit issue)

2 = Full Permit Scenario - permit amount used for all water users for all simulation years

3 = Current Use Scenario - average reported use for all water users for all years

Blue River Period of Record 1950-2008

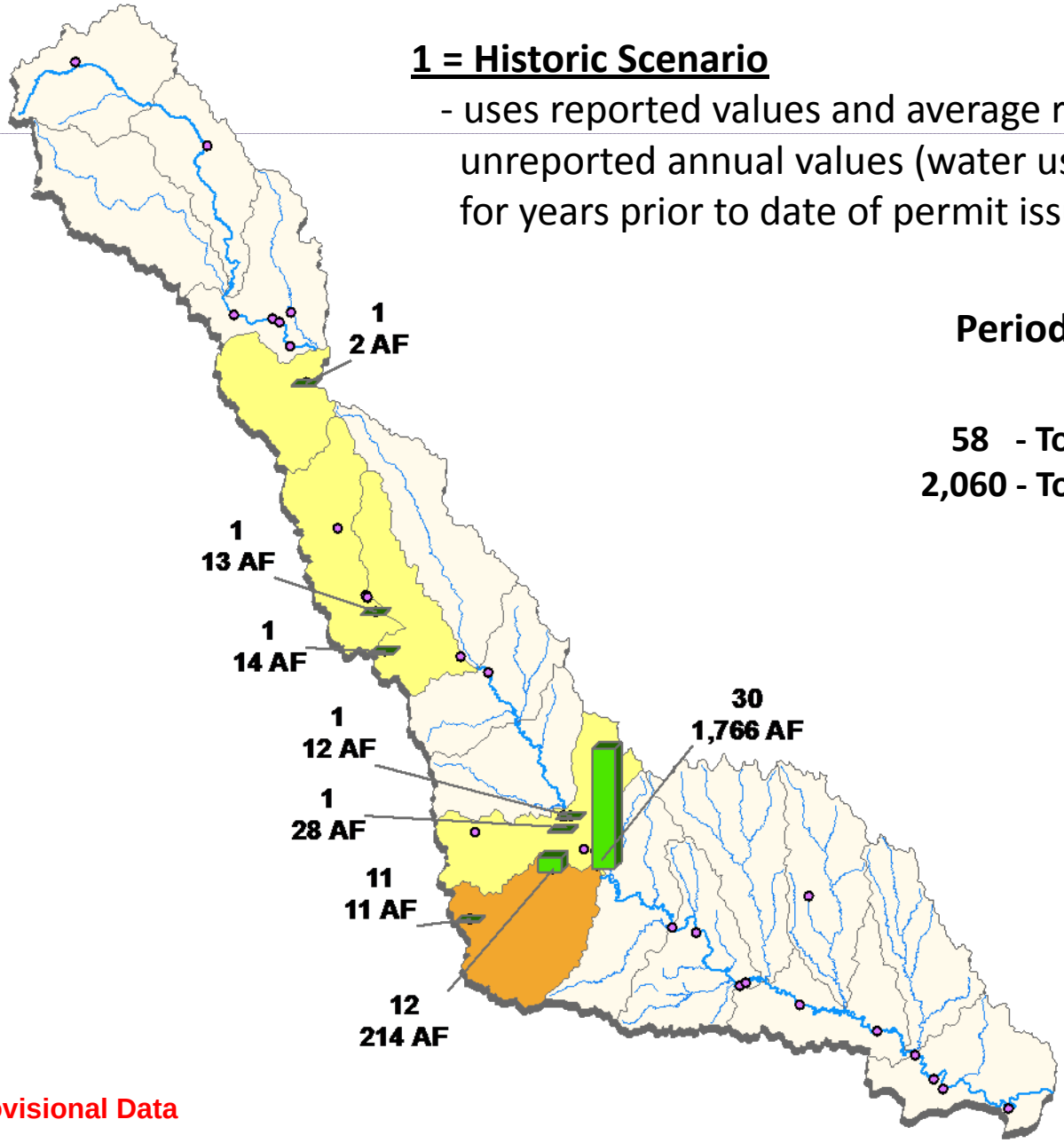
-Model over the entire period of record

-Model for a single year or multiple years

-Model for the mean annual flow

1 = Historic Scenario

- uses reported values and average reported use to fill in unreported annual values (water user will have no demand for years prior to date of permit issue)



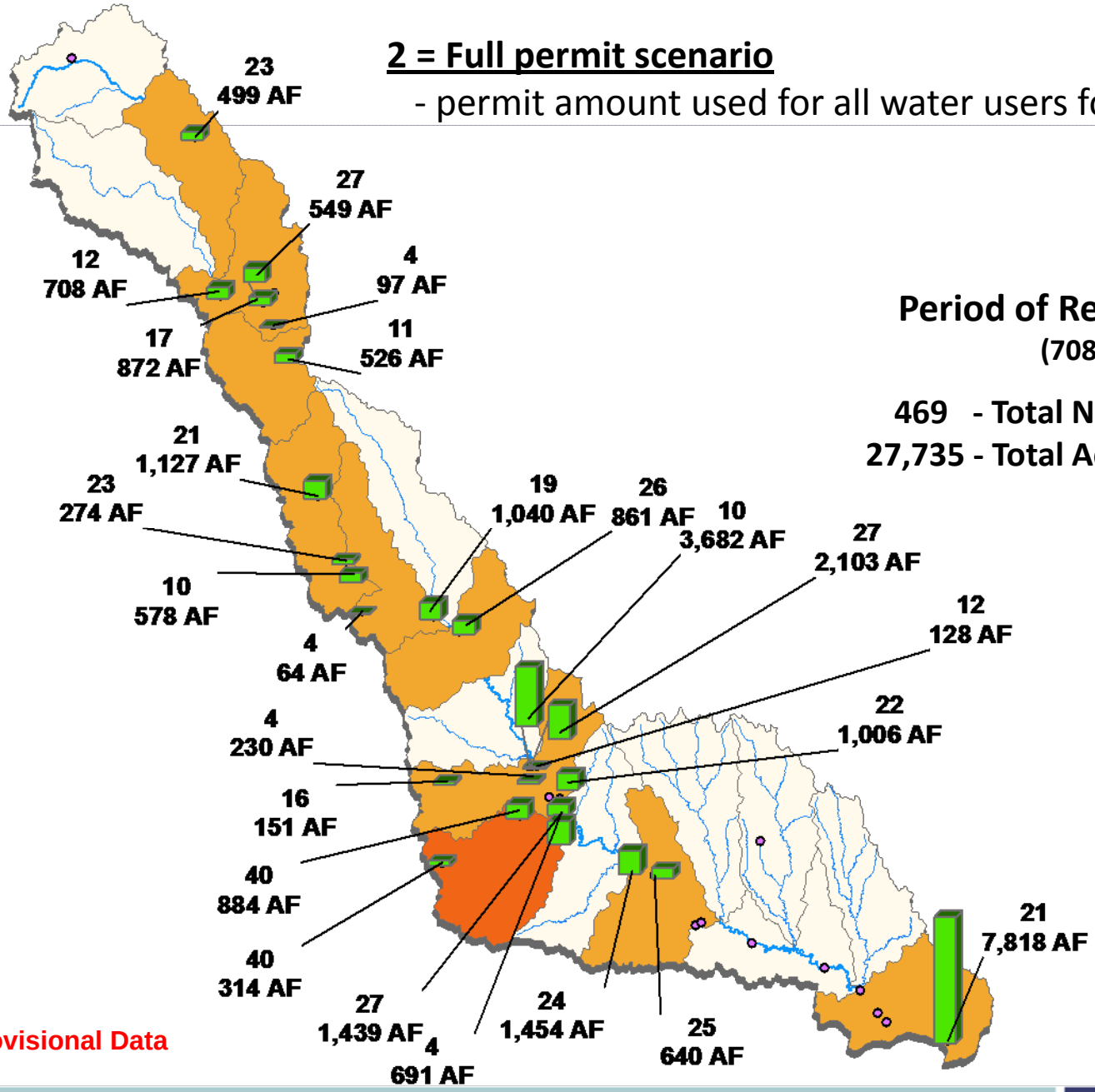
Period of Record 1950-2008
(708 Months)

58 - Total Number of Shortages
2,060 - Total Acre-Feet of Shortages

Provisional Data

2 = Full permit scenario

- permit amount used for all water users for all simulation years



Period of Record 1950-2008
(708 Months)

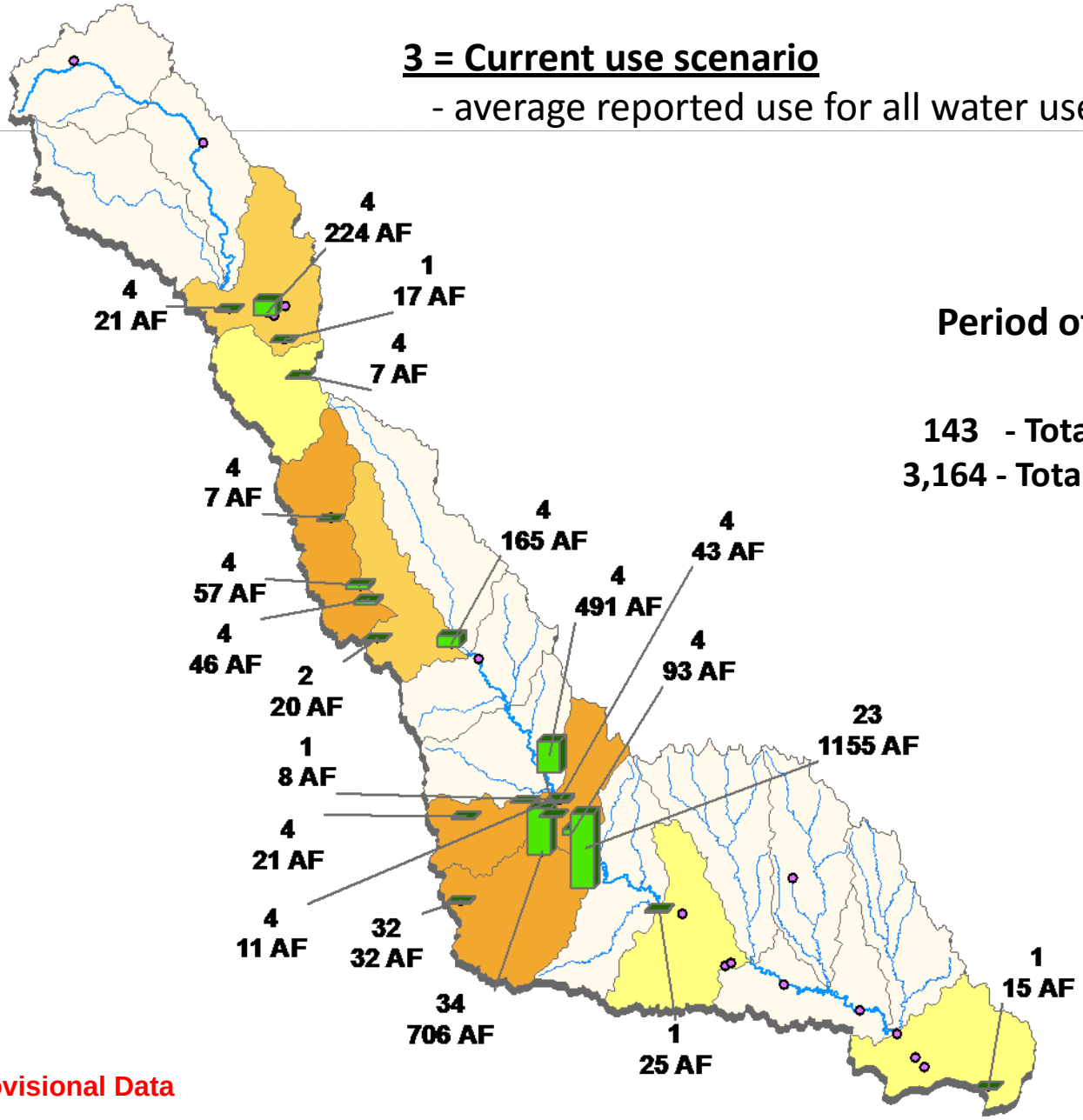
469 - Total Number of Shortages
27,735 - Total Acre-Feet of Shortages

2,200
Total Amount of Shortage
12-Digit HUCs
Frequency of Shortage
1 - 5
6 - 10
11 - 100
101 - 500
501 - 1000

Provisional Data

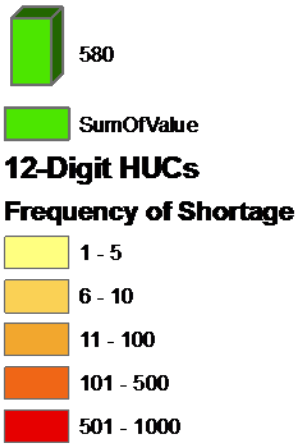
3 = Current use scenario

- average reported use for all water users for all years

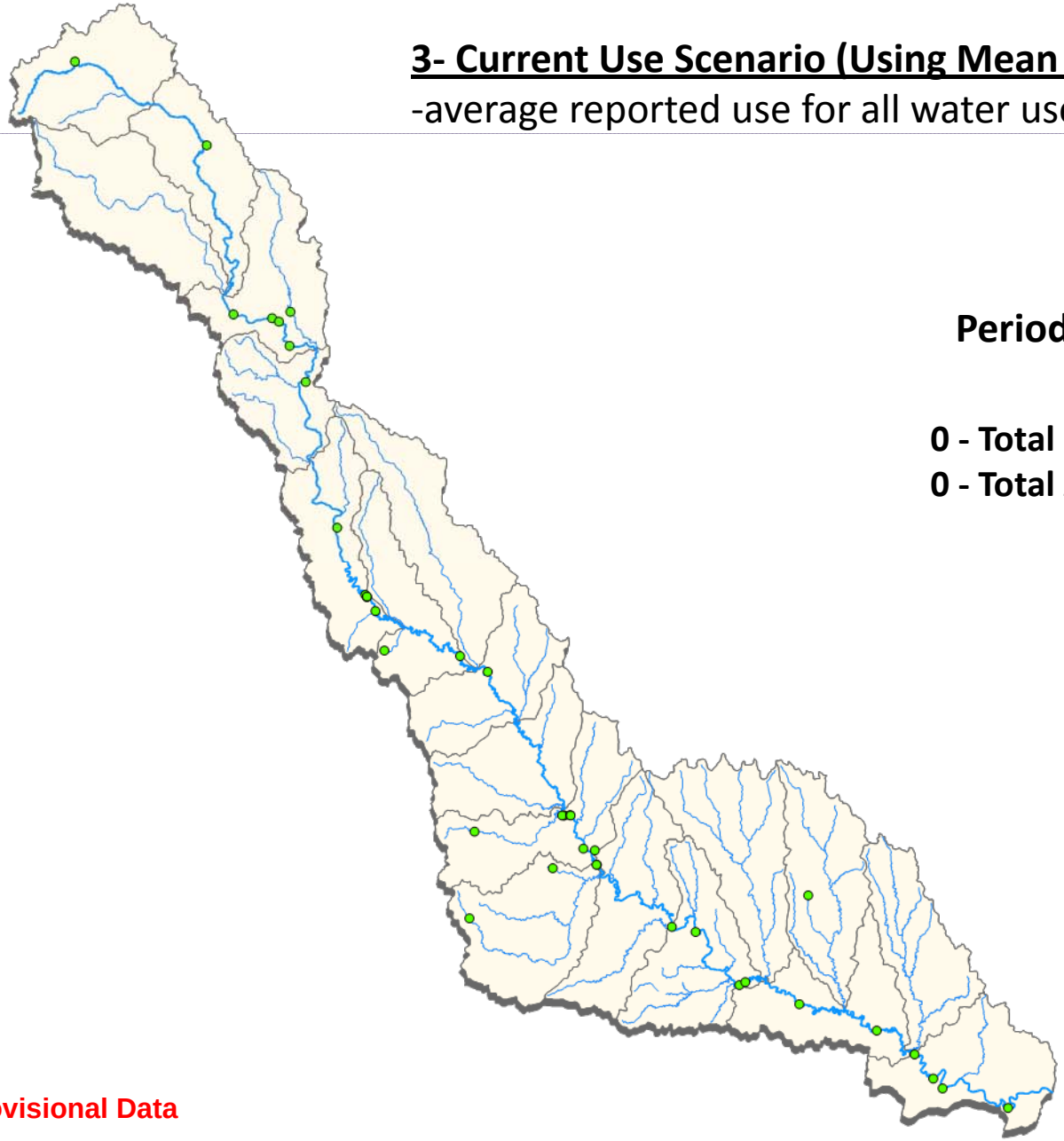


Period of Record 1950-2008
(708 Months)

143 - Total Number of Shortages
3,164 - Total Acre-Feet of Shortages



Provisional Data



3- Current Use Scenario (Using Mean Annual Flow)

-average reported use for all water users for all years

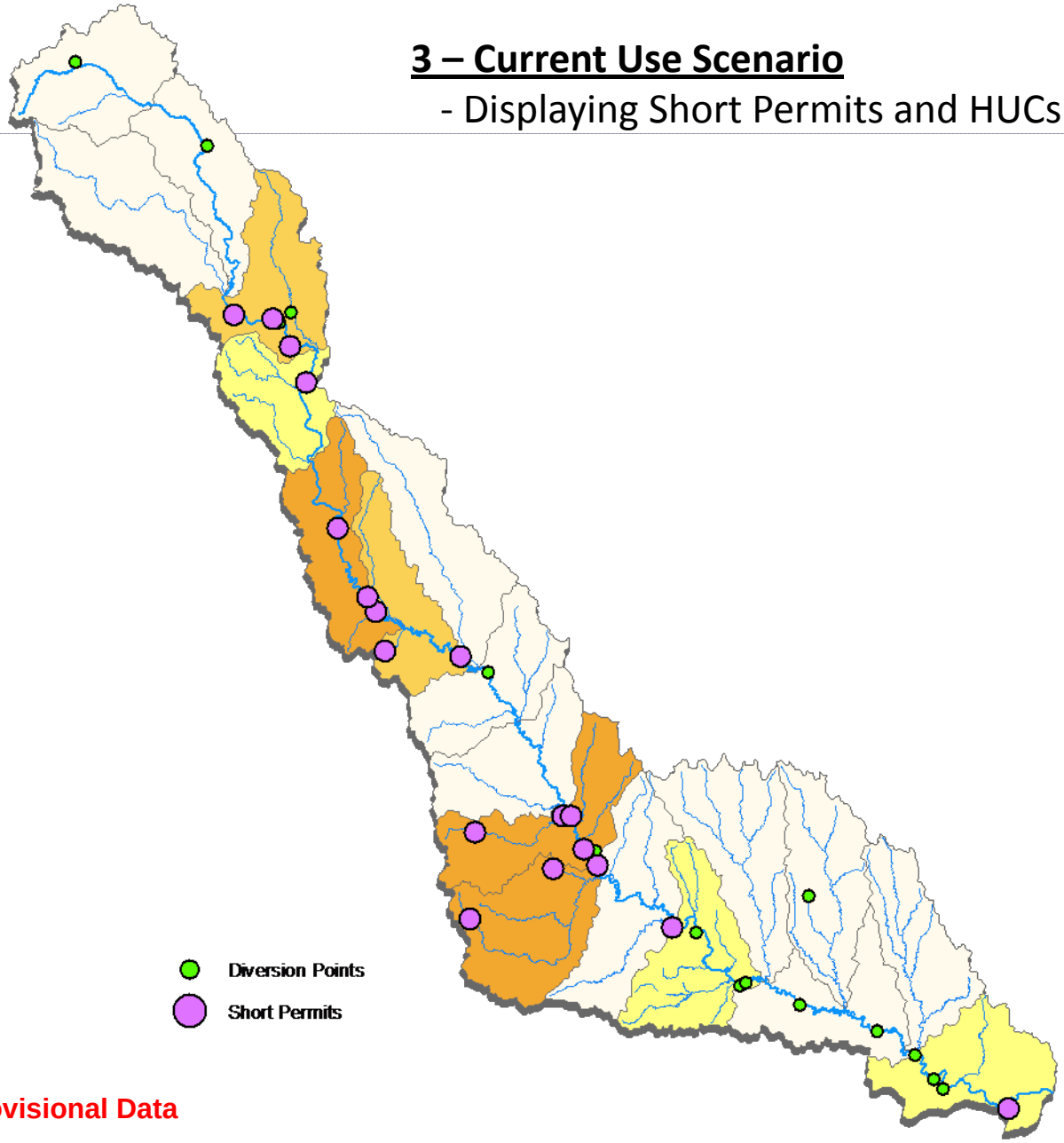
Period of Record 1950-2008
(708 Months)

0 - Total Number of Shortages
0 - Total Acre-Feet of Shortages

Provisional Data

3 – Current Use Scenario

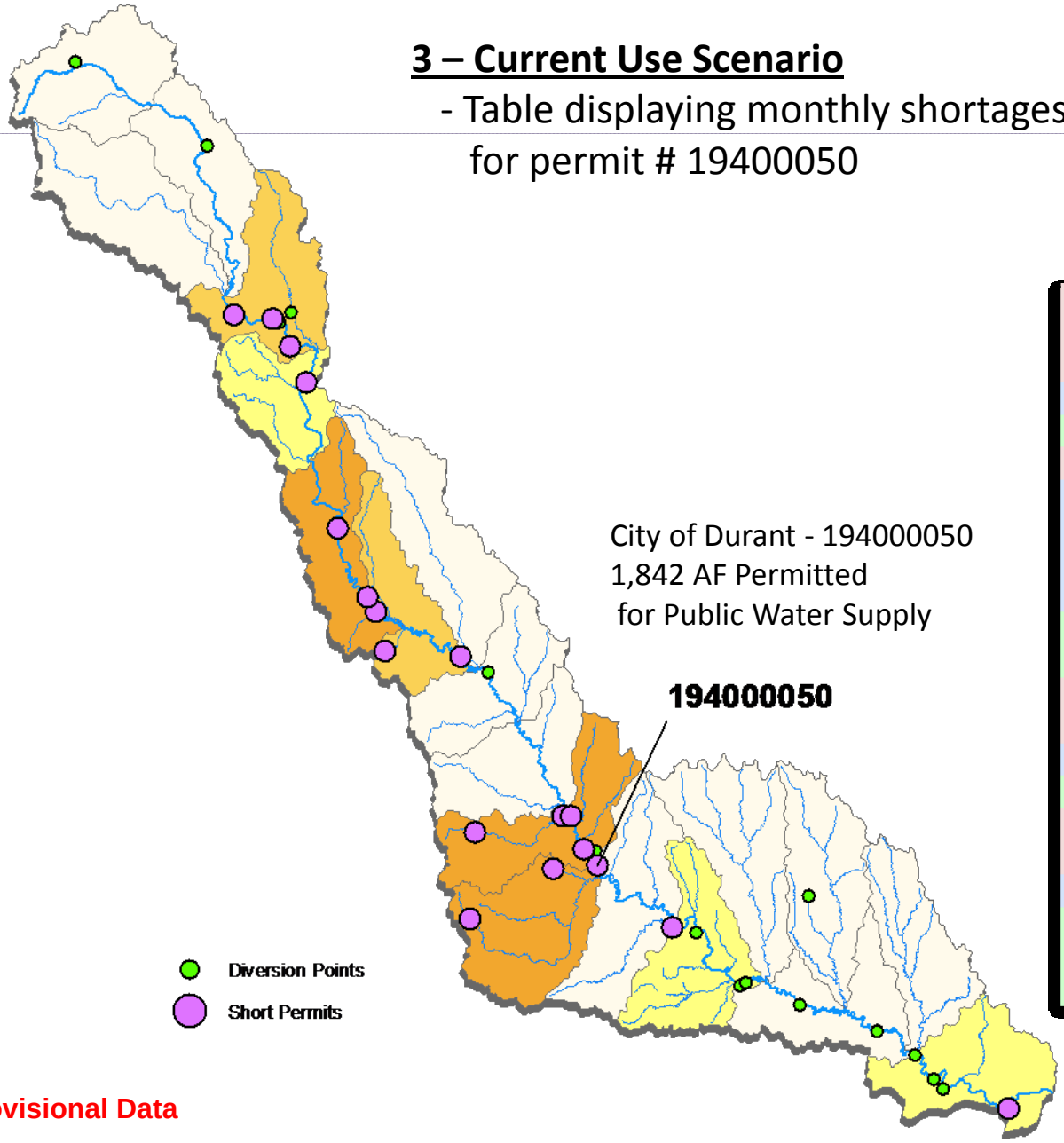
- Displaying Short Permits and HUCs for the Blue River Basin



Provisional Data

3 – Current Use Scenario

- Table displaying monthly shortages from 1950 to 2008 for permit # 19400050



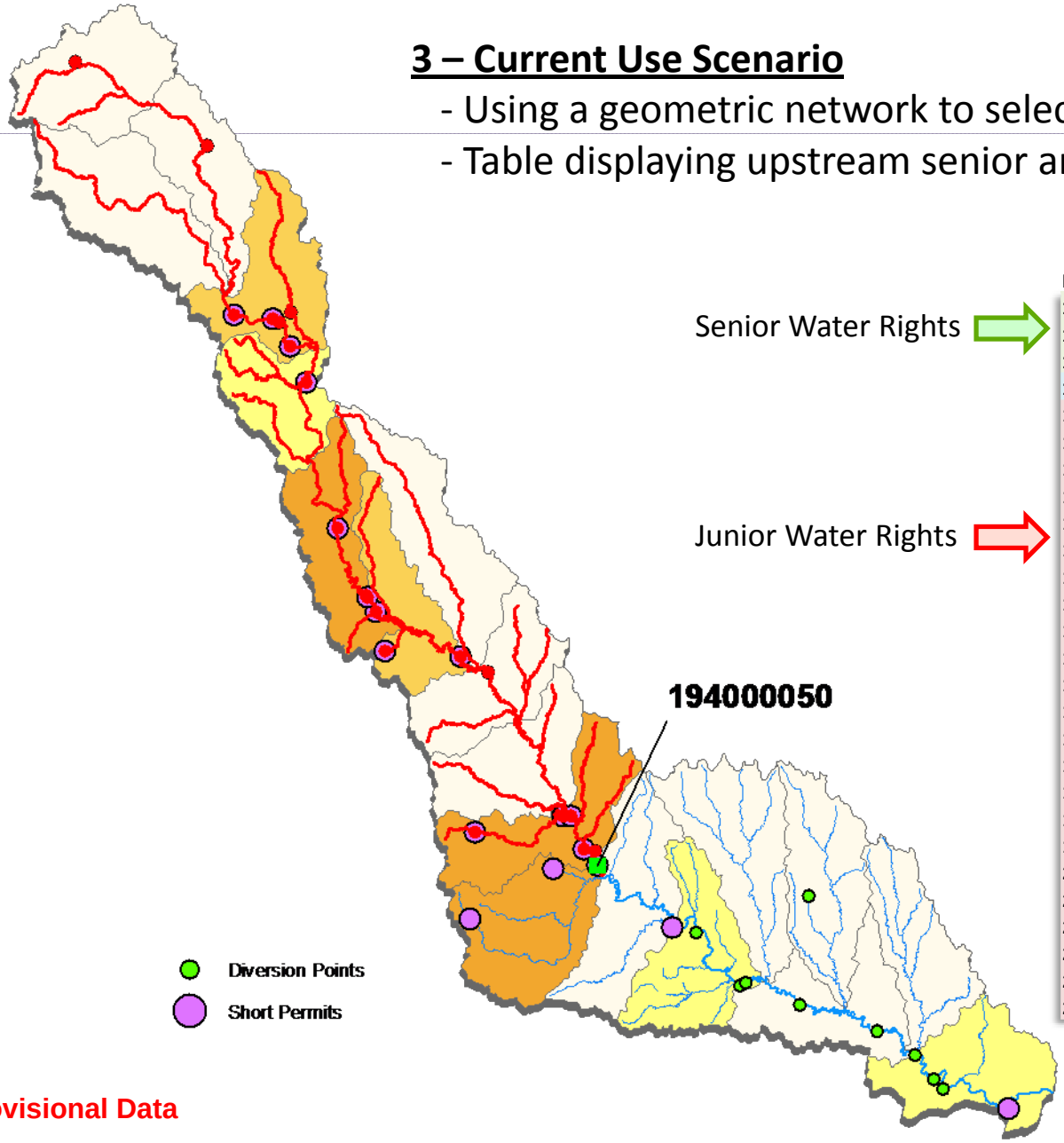
Monthly Shortages

YEAR	MONTH	AMOUNT AF
1963	8	45
1963	9	32
1963	10	25
1964	7	13
1965	8	18
1966	7	9
1967	1	84
1967	2	93
1967	3	75
1967	8	98
1969	8	90
1969	9	67
1970	7	86
1970	8	189
1972	8	11
1976	8	33
2000	8	69
2000	9	57
2003	8	8
2006	7	4
2006	8	74
2006	9	21

Provisional Data

3 – Current Use Scenario

- Using a geometric network to select all upstream permits
- Table displaying upstream senior and junior water rights



Upstream Users

Senior Water Rights

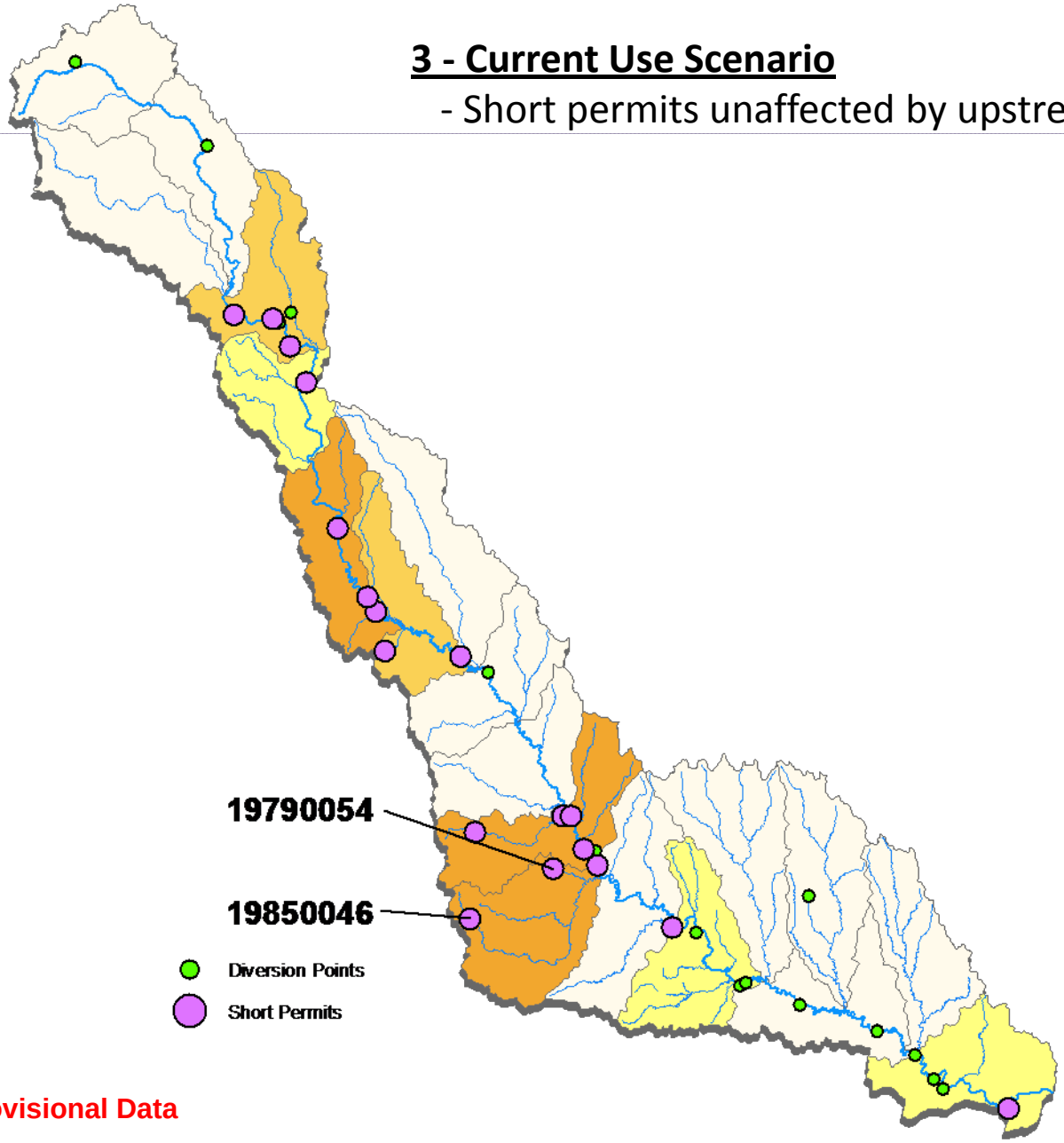
Junior Water Rights

PERMIT NUM	TOTAL AF	DATE FILED	DATE ISSUED
19360076	6,445	10/15/1936	04/13/1965
19400031A	78	02/28/1940	04/13/1965
19400031B	50	02/28/1940	04/13/1965
19400050	1,842	06/03/1940	04/13/1965
19660587	66	09/09/1966	11/08/1966
19670320	25	04/07/1967	06/13/1967
19710296	134	05/18/1971	08/17/1971
19710362	12	06/25/1971	10/12/1971
19710554	4,500	12/31/1971	04/11/1972
19770025	639	02/02/1977	08/09/1977
19780104	129	08/24/1978	12/12/1978
19780140	6,000	10/06/1978	01/09/1979
19810082	320	04/03/1981	07/14/1981
19800180	80	11/17/1980	03/10/1981
19800185	250	11/18/1980	03/10/1981
19800190	56	12/01/1980	03/10/1981
19850013	970	02/08/1985	11/12/1985
19860030	50	07/11/1986	09/09/1986
19960038	340	07/01/1996	02/11/1997
19980054	300	12/23/1998	03/09/1999
19990021	250	05/19/1999	08/10/1999
20020036	113	06/24/2002	12/10/2002
20020040	62	08/01/2002	07/13/2004
20040019	921	06/14/2004	10/19/2004
20060026	175	06/13/2006	09/12/2006
20070048	107	11/26/2007	04/08/2008
20080016	56	05/28/2008	11/12/2008

Provisional Data

3 - Current Use Scenario

- Short permits unaffected by upstream users



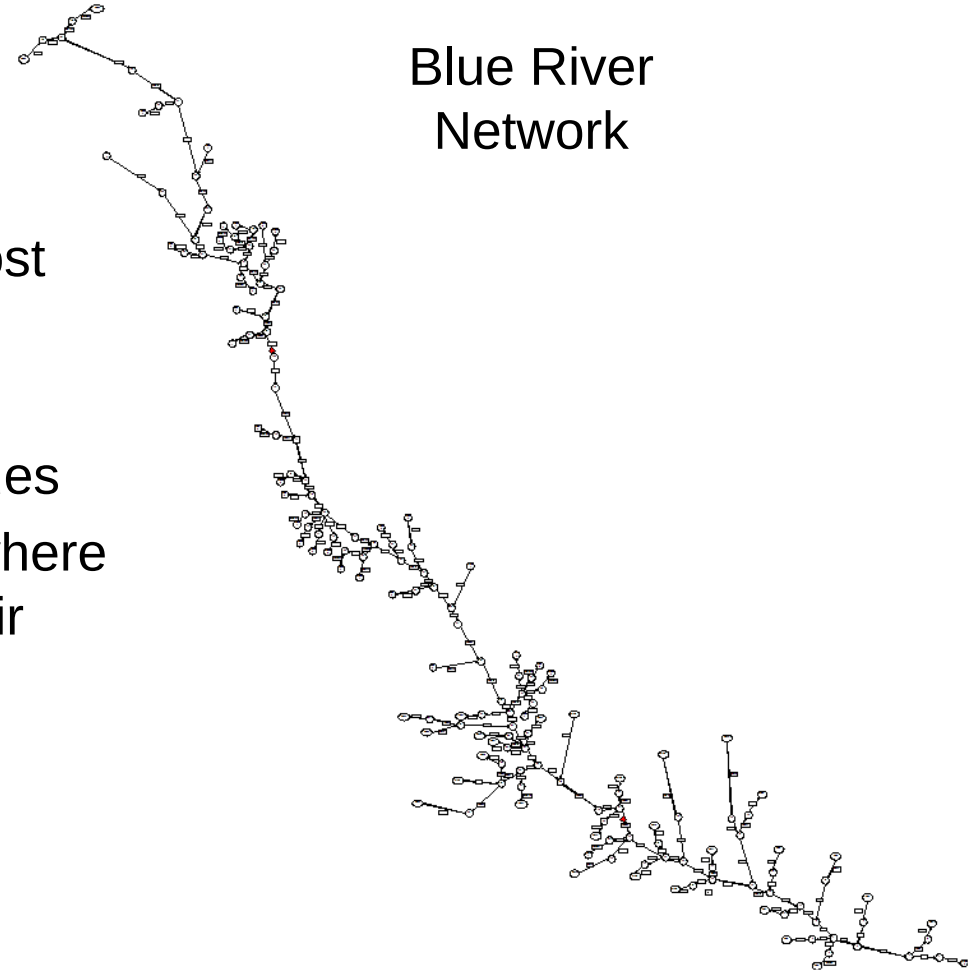
Provisional Data

Why bother?

- Oklahoma has plenty of water
  - In most places
  - Most of the time

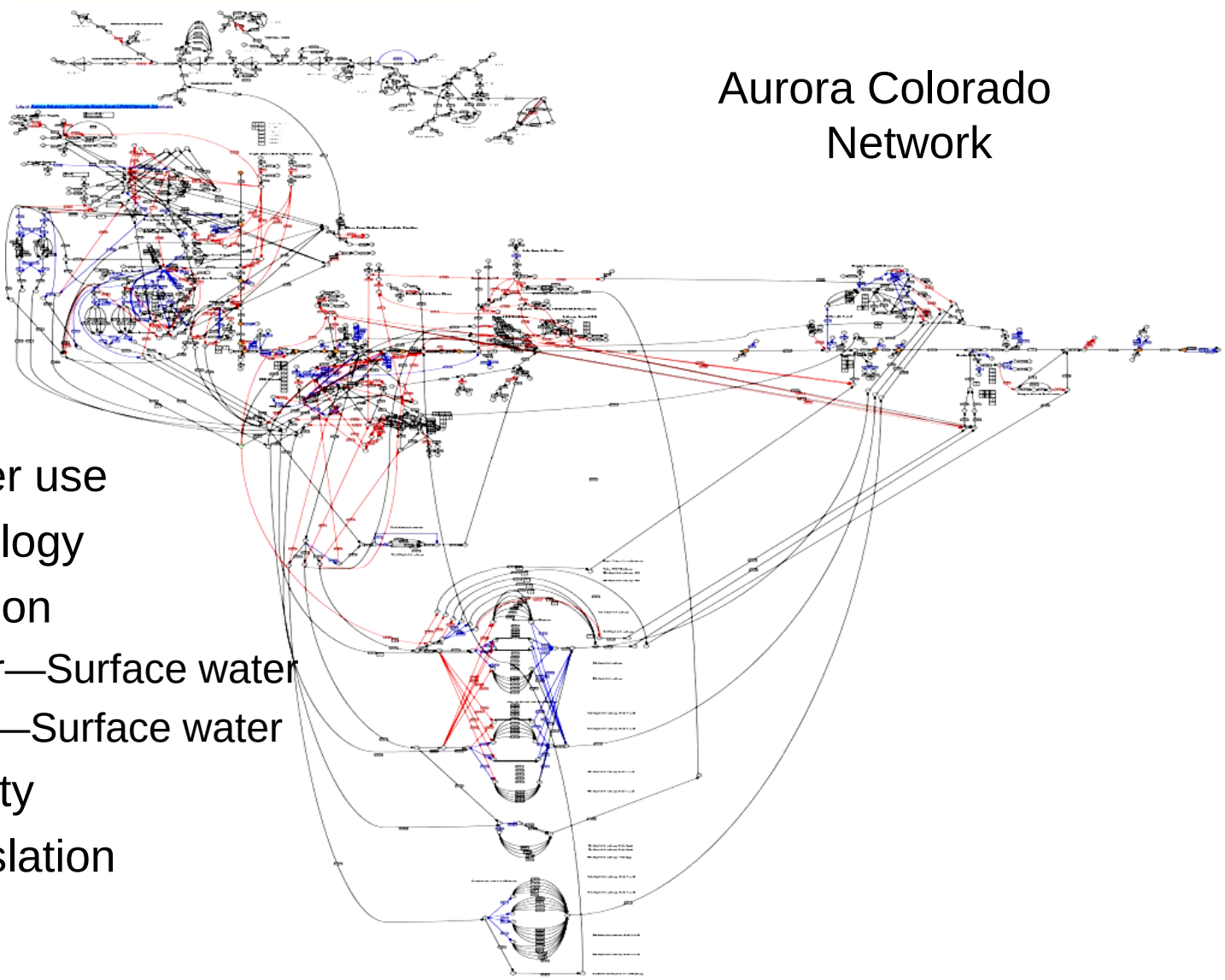
The Present

- Ample water supplies in most places and most times
- Isolated shortages
- Emerging water quality issues
- Some potential situations where groundwater use may impair surface water uses



Blue River Network

The Future? (Based on experience in other states)



Aurora Colorado Network

- Growth in water use
- Different hydrology
- More competition
  - Surface water—Surface water
  - Groundwater—Surface water
- More complexity
- Litigation/Legislation

Future Uses of Water Allocation Modeling

- Permitting
  - Determine reliability of water supply (applicant and OWRB)
  - Evaluate impact of water use on senior water rights
    - Determine need for active administration.
- Administration
  - Day-to-day operations
  - Evaluating practices
- Planning
  - Water users
  - OWRB
  - Infrastructure, operations, hydrology, drought, policy

Water Rights Administration—Essential Tools