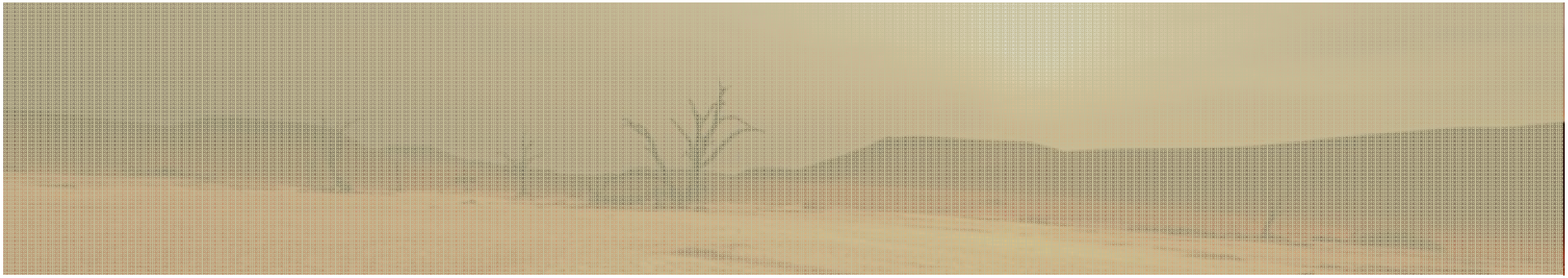

BETWEEN A MUSSEL AND A HARD PLACE:

Using Reservoir Modeling to Optimize Drought Strategies

Presentation developed by

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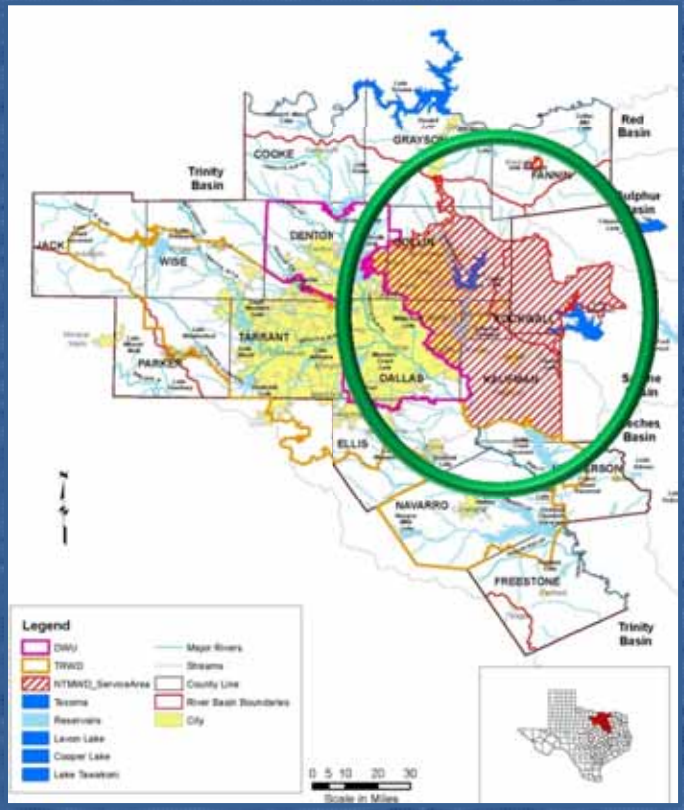
Mike Rickman

FREESE AND NICHOLS

North Texas Municipal Water District

Who are we talking about?

- North Texas Municipal Water District
  - Service Area
    - Drinking water for 1.6 million people
    - 60 cities, towns, SUDs, WSCs
  - Supplies
    - Lake Lavon
    - Lake Texoma
    - Jim Chapman Lake
    - Lake Tawakoni
    - Indirect Reuse
    - East Fork Wetlands

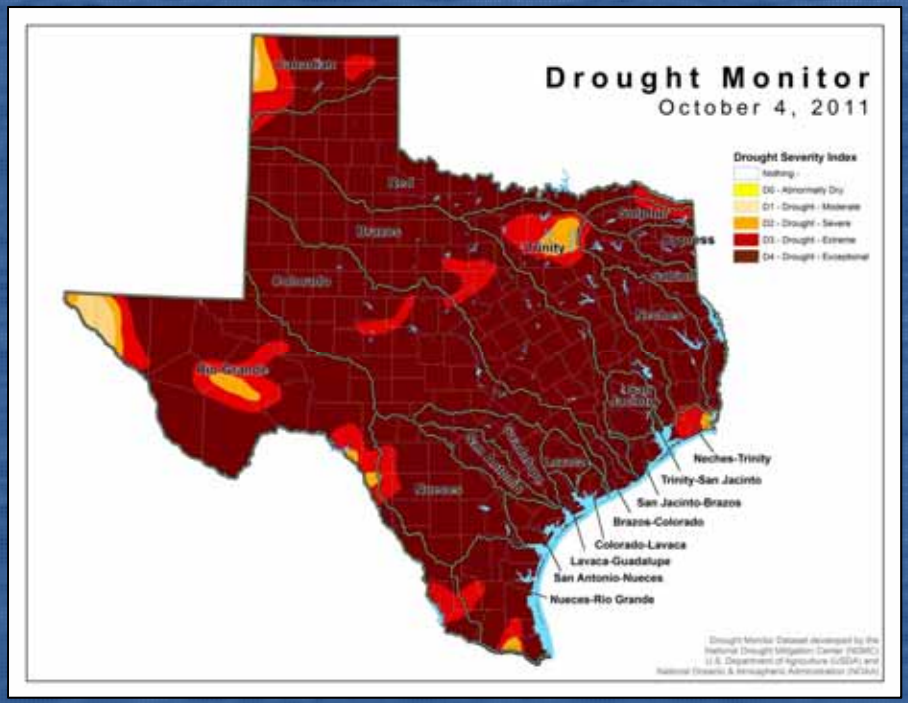


What Happened?

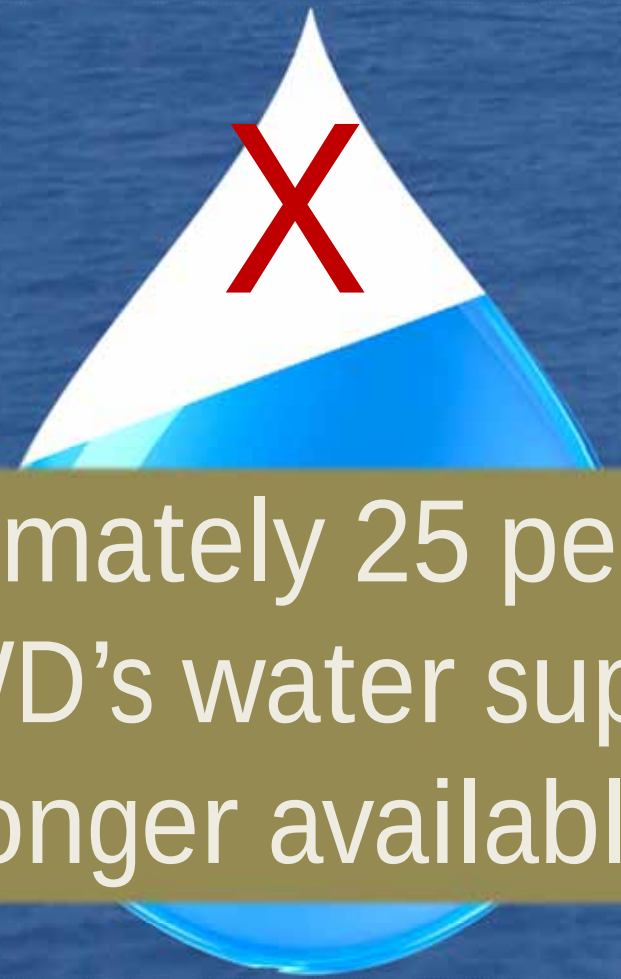
- 2009 – Zebra Mussels found in Lake Texoma

What Happened?

- 2009 – Zebra Mussels found in Lake Texoma
- 2011 – Texas' worst single-year drought in recorded history



Effects on NTWMD Water Supply



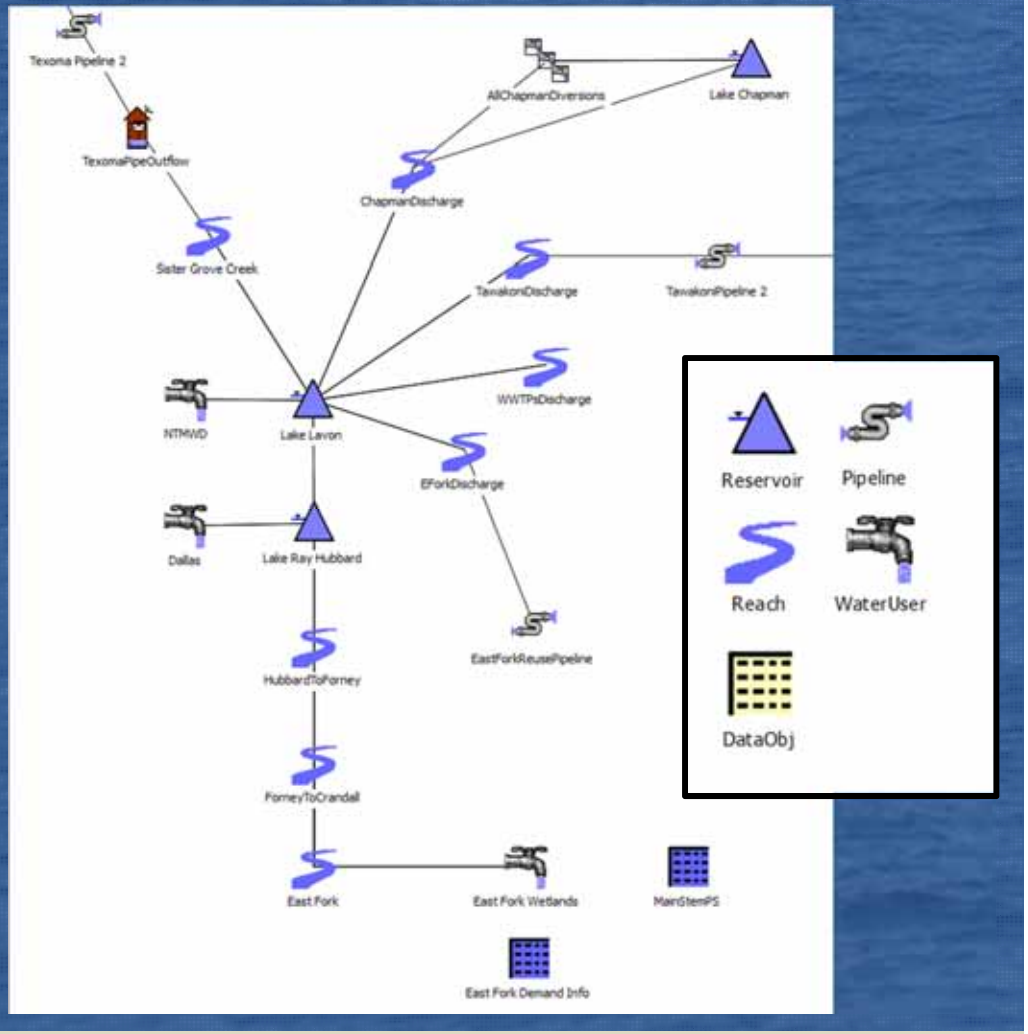
Approximately 25 percent of NTMWD's water supply no longer available

Water Supply Strategies

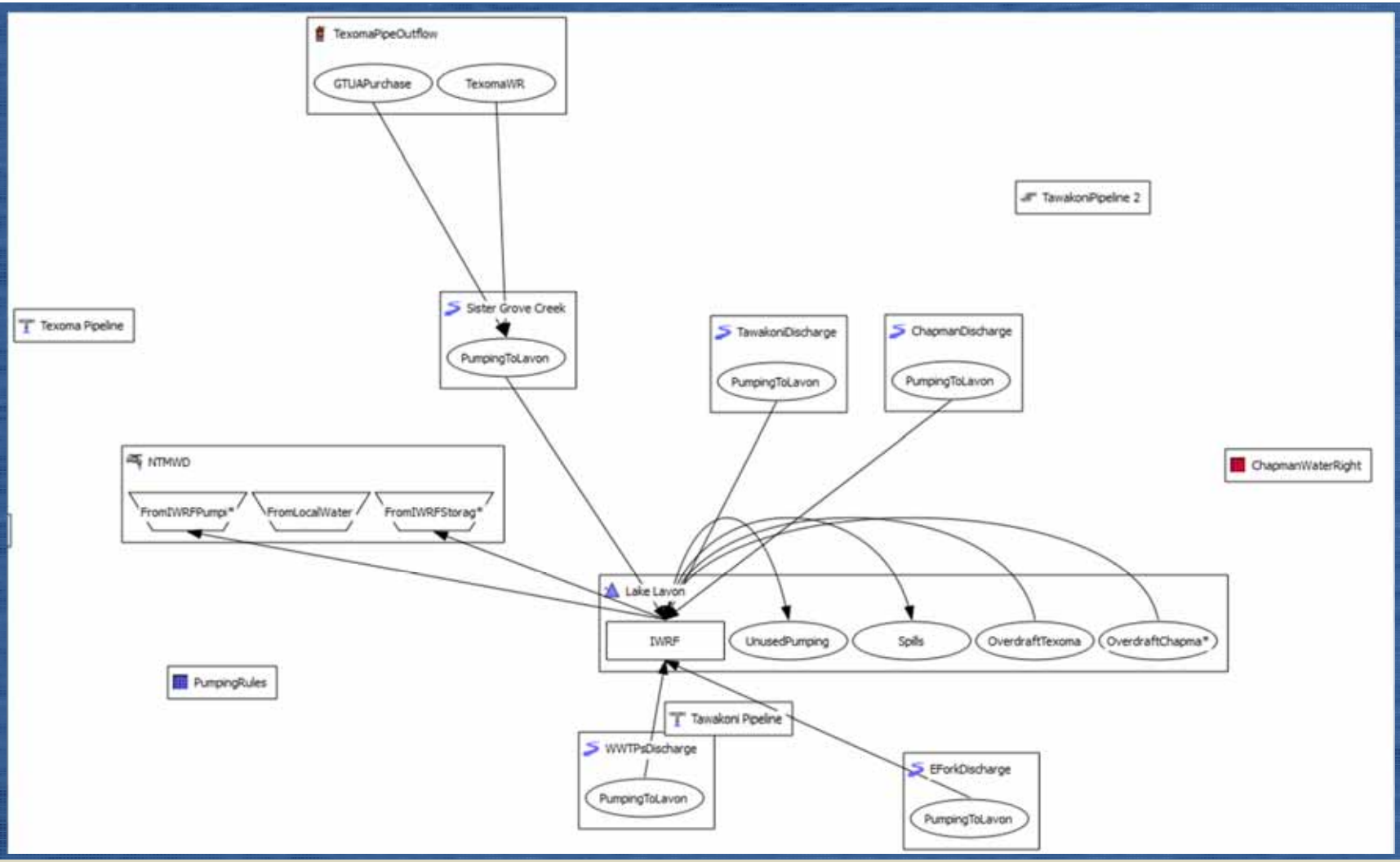
- Implement Drought Contingency Plan
- Design and build Texoma-to-Water Treatment Plant Pipeline
- Purchase 20 MGD from City of Dallas
  - Increasing to 60 MGD when Lake Lavon elevation drops 5 feet
- Monitor Lake Lavon elevations
- Main stem pump station

RiverWare Model

- Modified existing operation model
- 3 reservoirs objects
  - Lake Lavon
  - Lake Ray Hubbard
  - Jim Chapman Lake
- 5 water users objects
- 8 reaches
- 5 pipe objects



RiverWare Model – Lake Lavon Accounting



Model Operation

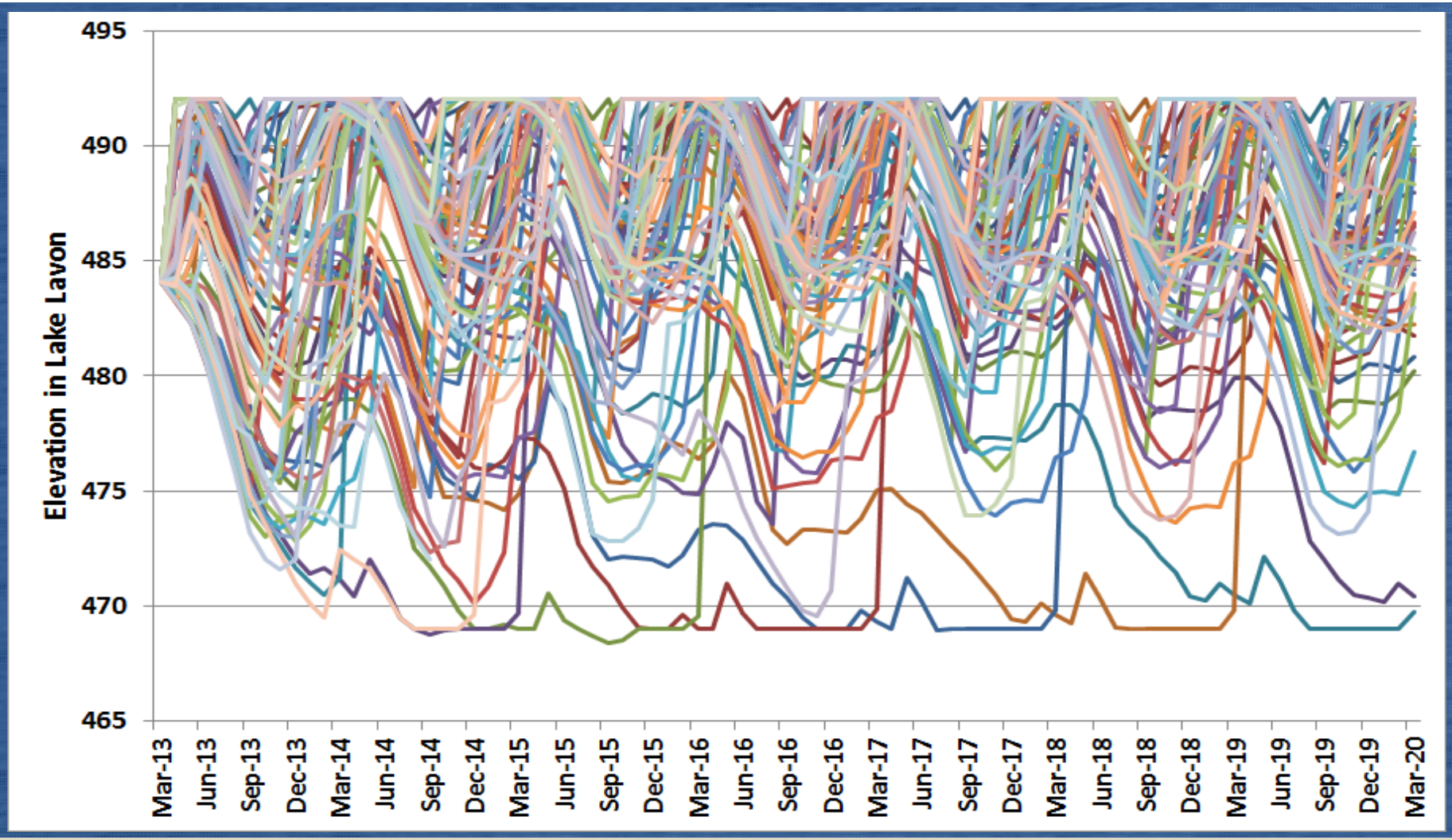
- Consider operation with historical flows (1940-2011)
- Varying Demands
- Varying Operations
- Conditional Reliability Model (CRM)
  - 71 sequences of 7-year hydrology
  - 1940-1946; 1941-1947; … ; 2005-2011

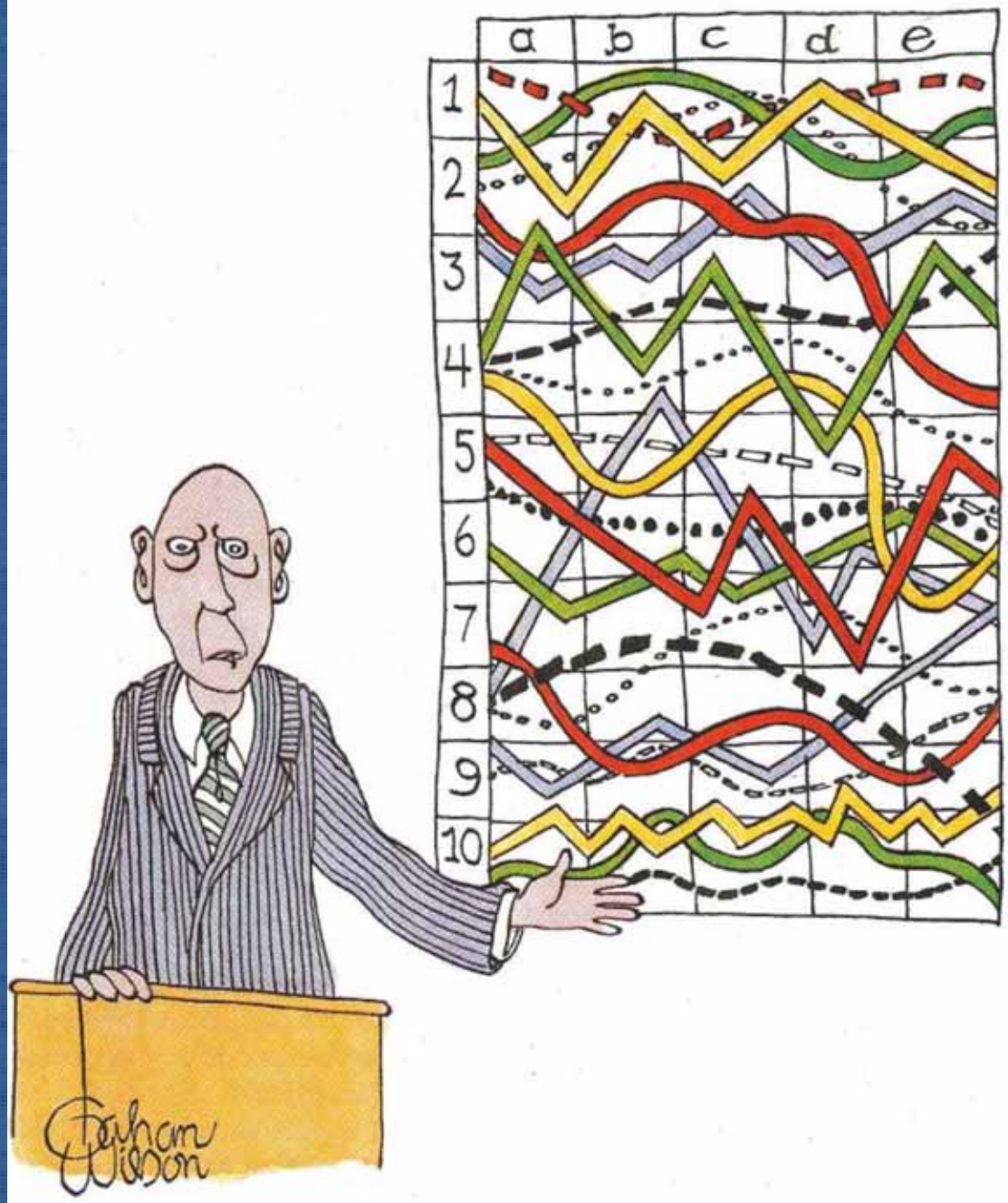
Decision Support Tool

- Strategy Timing (project online dates)
- Strategy Amount
- Budget Estimation
- "What-If" Scenarios

Average Annual Diversion												
	NTMWD Diversion Requested (MG)	NTMWD Total Diversion (MG)	Shortage (MG)	Lavon (MG)[1]	Texoma (MG)	Chapman (MG)	Tawakoni (MG)	East Fork (MG)	Main Stem (MG)	WWTP (MG)	Dallas (MG)	Terrell WTP (MG)
2013	110,328	110,328	0	40,134	0	15,595	10,253	17,880	0	14,919	5,035	6,512
2014	119,854	119,854	0	36,661	17,582	12,553	6,176	18,514	0	14,688	6,372	7,308
2015	124,942	124,942	0	38,705	22,100	12,380	5,871	18,991	0	15,120	4,465	7,308
2016	128,155	128,155	0	42,631	22,885	12,318	2,664	15,345	7,669	15,613	1,707	7,323
2017	130,712	130,712	0	45,251	23,543	12,277	1,538	10,331	14,428	16,037	0	7,308
2018	133,621	133,621	0	46,468	24,270	12,253	1,538	10,604	14,679	16,499	0	7,308
2019	136,427	136,427	0	47,603	24,971	12,263	1,541	10,873	14,881	16,986	0	7,308

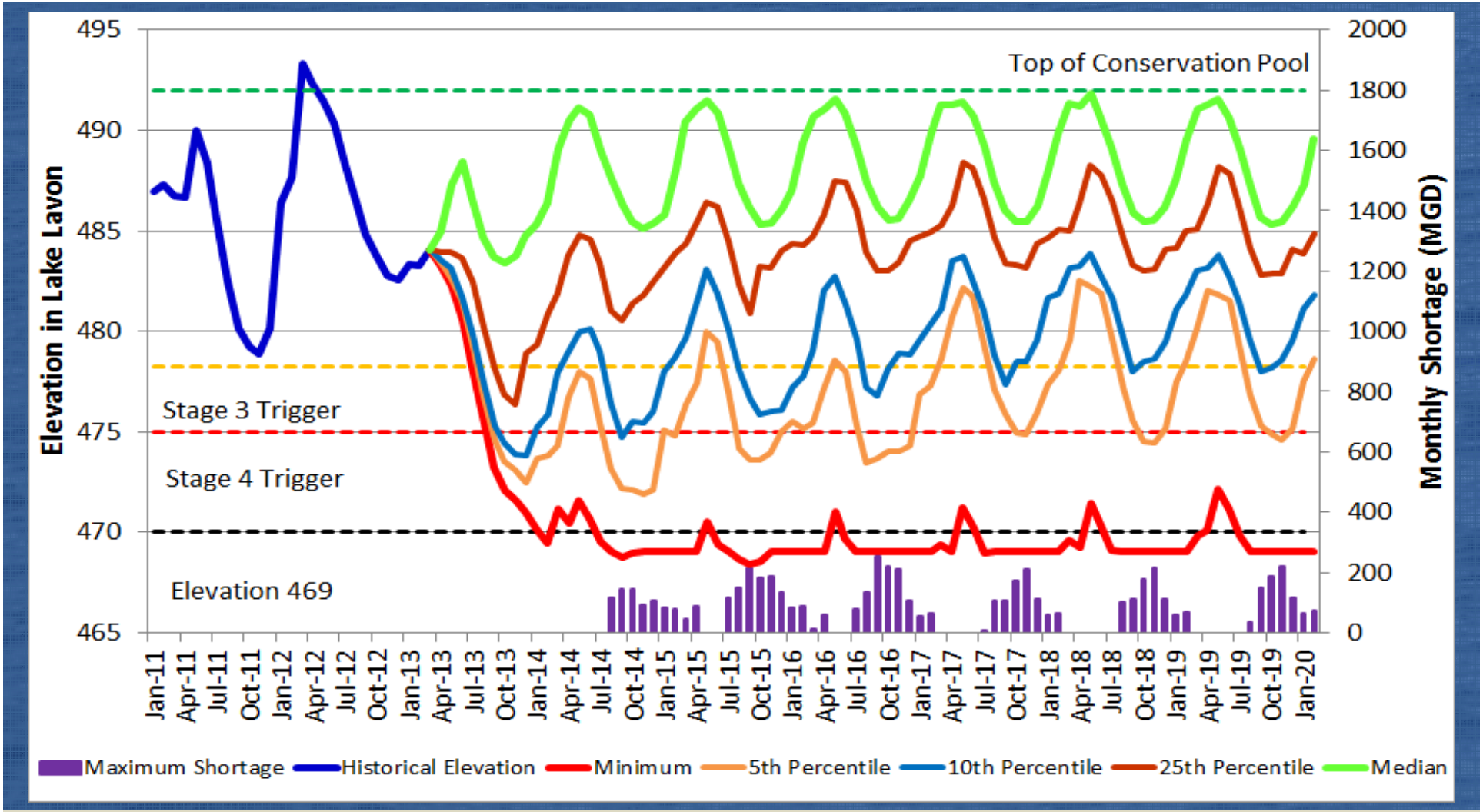
Lake Level Modeling with No Emergency Measures – All Runs (Historical Hydrology)



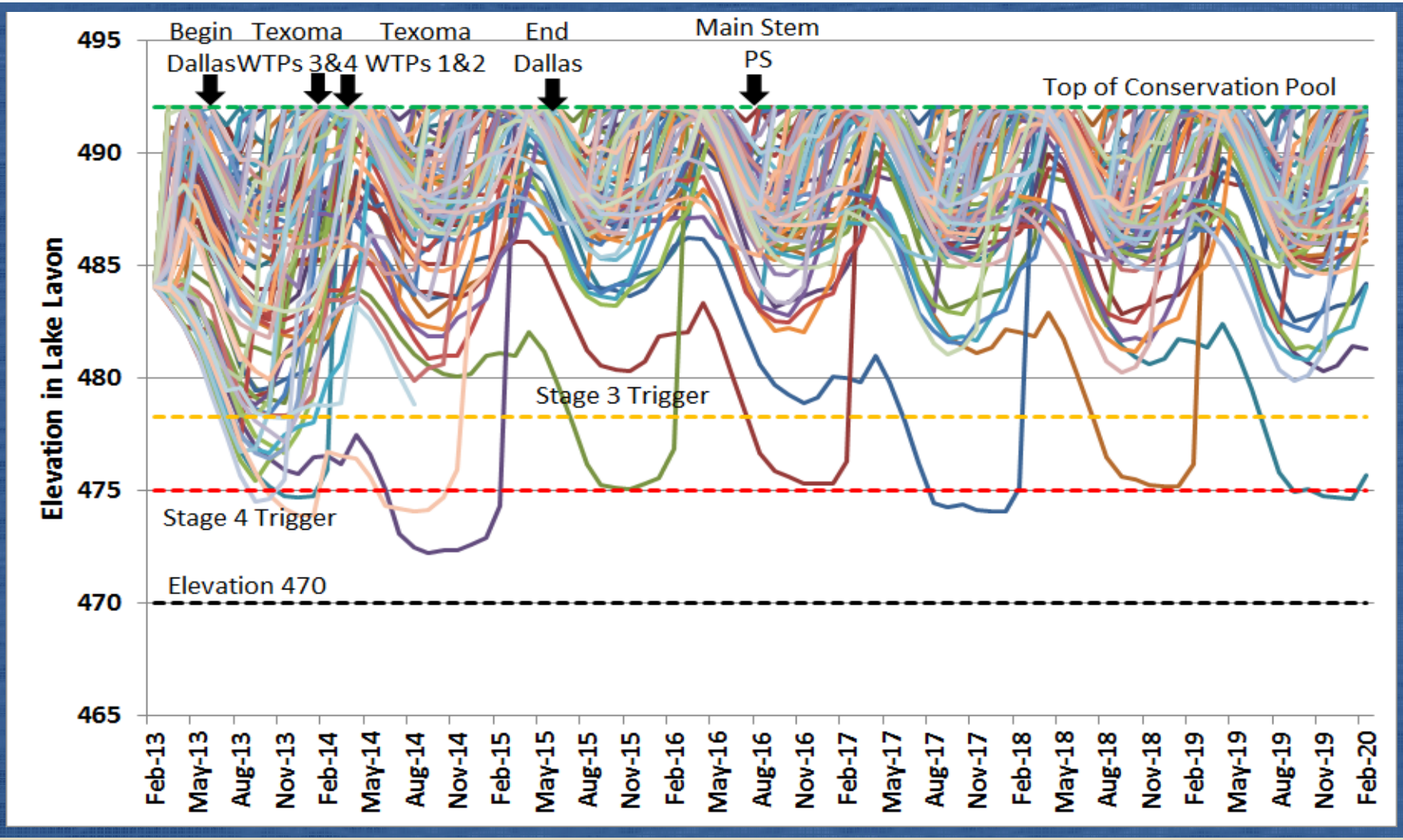


"I'll pause for a moment so you can let this information sink in."

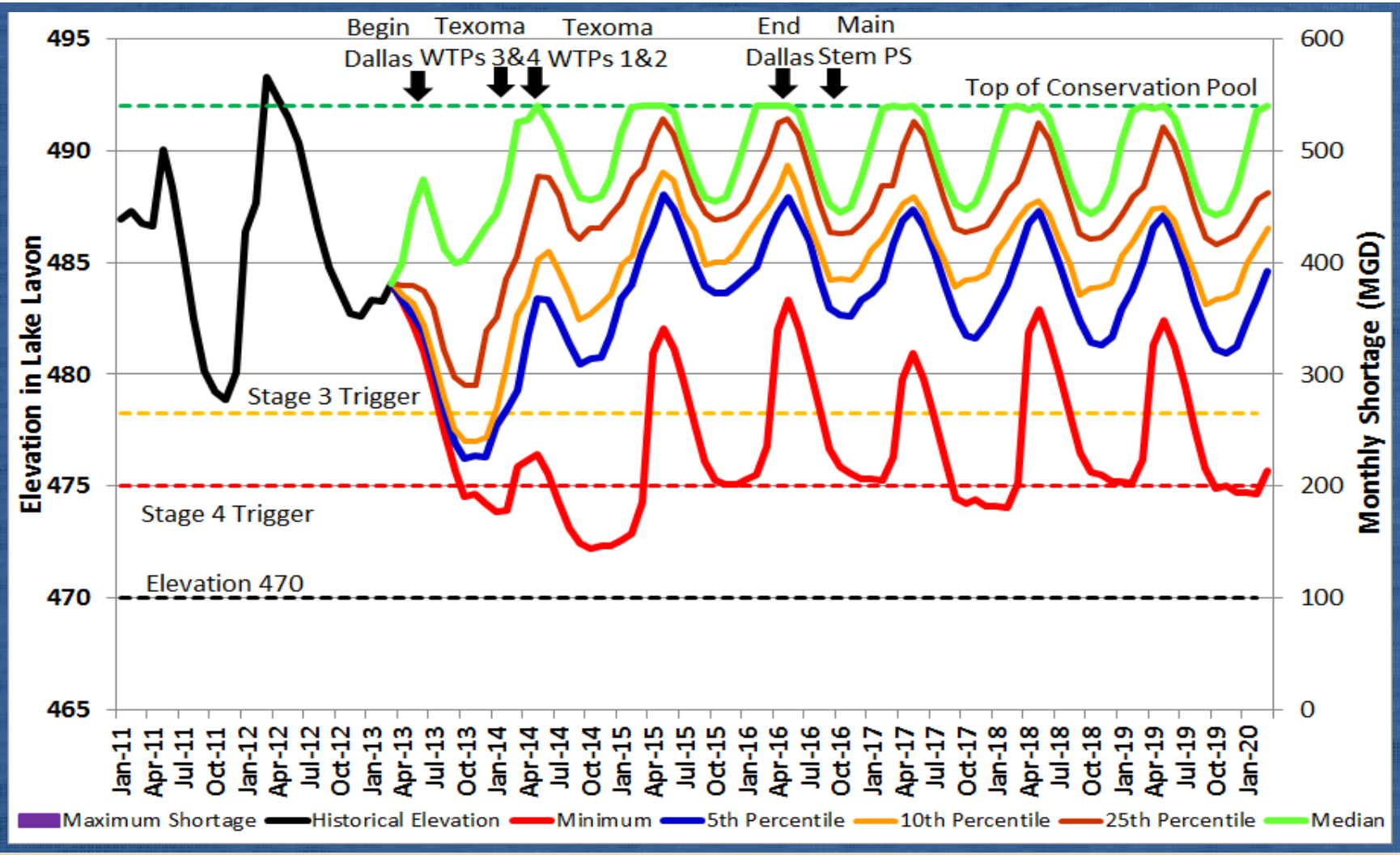
Lake Level Modeling with No Emergency Measures – Statistics and Shortages



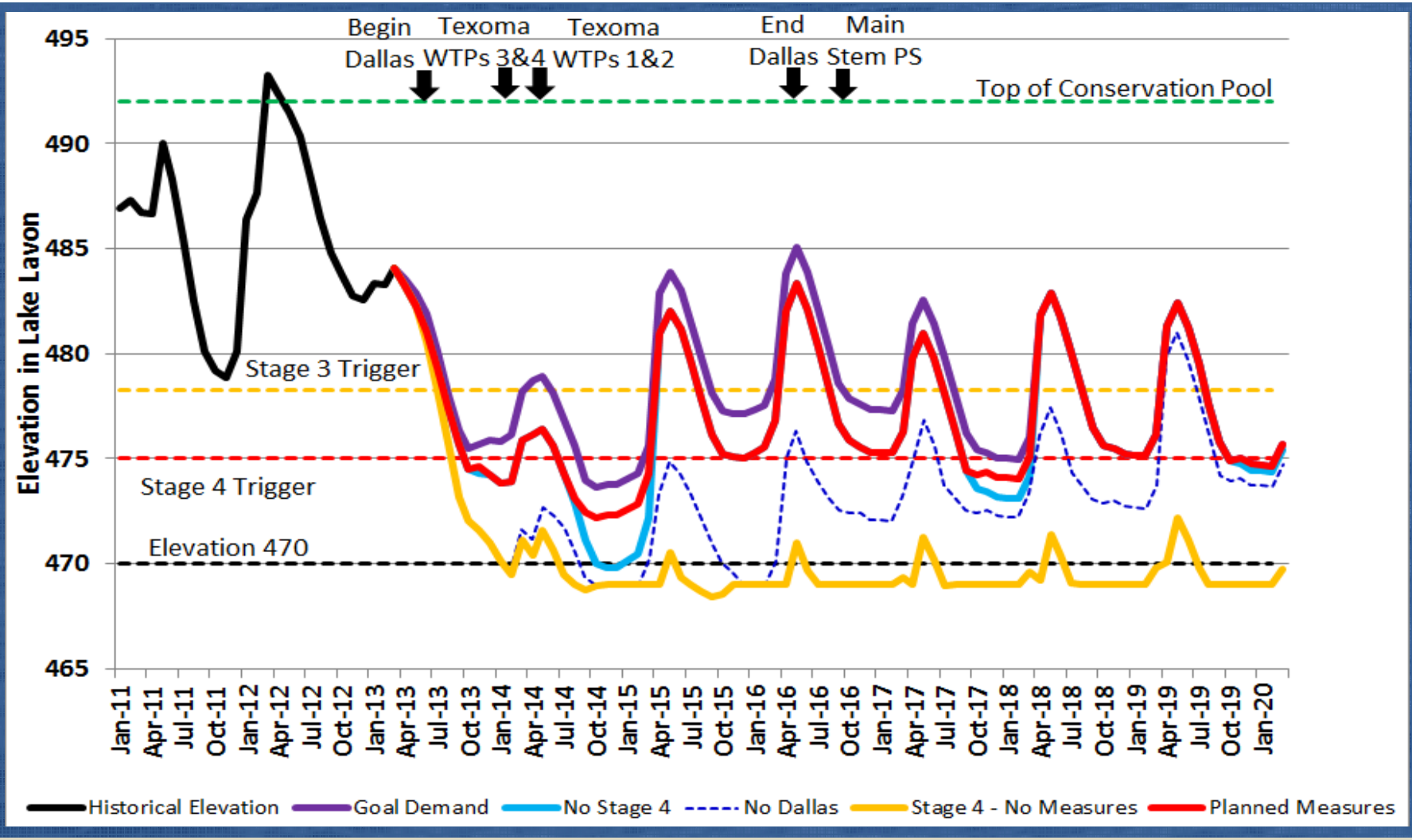
Lake Level Modeling with Planned Emergency Measures – All Runs (Historical Hydrology)



Lake Level Modeling with Planned Emergency Measures – Statistics and Shortages



Lake Level Modeling Comparison of Minimum Levels for All Options



RiverWare Model Evaluation

- Advantages of RiverWare
  - Accounting
  - Alternative evaluation
  - Conditional Reliability Modeling (CRM)
  - Complex RPL rule sets

```
Lavon Demand Info.Stage1 [ ]
  = IF ( @"t" == @"Start Timestep" ) THEN
      1.0
    ELSE
      IF ( Chapman Accounting.EOMAcctStorNTMWD [ @"t - 1" ] / ChapmanData.MaxAccStorNTMWD [ ]
           < Lavon Demand Info.Storage Percents [ 0, 1 ] ) THEN
        1.0
      ELSE
        0.0
      END IF
    END IF
```

Acknowledgements

- Mike Rickman – NTMWD
- Jeremy Rice – FNI
- Tom Gooch, P.E. – FNI

Questions?

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